From Academia And Research Organizations To The Market: Ways And Means

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Universities and the Economy

The role of the university in economic development has been a core topic in innovation economics over the last decades.[1] In 1957, Robert Solow wrote his seminal article, featuring the prominent role of technology in the aggregate production function,[2] technology has come to the forefront as a premier production factor driving economic growth and development. Corporations are the engines transforming technology into business. The origins and growth of the corporate R&D function in the beginning of the 20th century mark the onset of the endogenous character of modern science and technology development. Following decades of research into the economics of science and innovation, the complementary nature and the dynamic interactions of large firms and young innovative companies along the innovation value chain have mobilized deep and diverse attention.[3] The role of complementarities and interactions, however, is not limited to large firms and young innovative companies. Since the 1970s, the complementarities and the interactions between the worlds of science and business, *i.e.,* the industry-science links, have come to the forefront of economic theories on innovation.

Theoretical and empirical work in innovation economics provide rich and strong support for the added value of the use of scientific knowledge in creating and maintaining industry-science relations. Those relations positively affect innovation performance. The "Triple Helix" model,[4] which came to prominence in the technology policy literature of the second half of the 1990s, points to the beneficial effects of multiple and multifaceted relationships between industry, academia, and government.

At the same time, though, empirical evidence, especially in Europe, highlights that the flow of basic research into economic exploitation is not without obstacles of its own, *i.e.* the so-called "European Paradox." As a consequence, the development of professional knowledge or technology transfer organizations (the so-called KTO's or TTO's), building bridges between academia and industry, has been subject to the detailed scrutiny and attention of economists and policy makers. This academic technology transfer function definitely is part of the answer to the many challenges, at the same time opportunities, as described in the European Paradox. It is worthwhile therefore to observe, map and understand the development and professionalization of this new function in academia as well as its role and instruments.

Stimulated by the TTO's, various interaction mechanisms and pathways have originated between the worlds of science and business. They stimulate and guide the translation of knowledge and technology into application and use. Typically, a portfolio of formal instruments has come into use, as described in the variety of studies mentioned in the footnotes to this section:

- Young innovative companies created by researchers, focusing on exploiting the science base generated at the research institute;
- Collaborative, co-creation research, *i.e.* the phenomenon of defining and conducting R&D projects jointly between business and science institutions, either on a bi-lateral basis or on a multi-lateral basis;
- Contract research as well as know-how based consulting services offered by academic scientists and commissioned by industry;
- Development of comprehensive and sophisticated Intellectual Property Rights (IPRs) schemes by science, both as a tool indicating its technology competence, as well as serving as a base for licensing inventions to business. Those IPRs are not limited to the creation of patent portfolios, but they further include the protection of design topologies, the establishment of frameworks for Material Transfer Agreements (MTAs), the protection of databases, the property rights on tissue banks, trademarks, etc.;
- More recently, we also see increased co-operation in graduate education, advanced training for enterprise staff, as well as the systematic exchange of research staff between companies and research institutes.

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Strengthening the multiplicity of formal relationships, we observe is a rich variety of informal contacts, gatekeeper processes and industry-science networks of a personal nature. Coupled to flows of human capital, they offer ways to exchange knowledge between business and academic research, which are more difficult to quantify, but are nevertheless highly relevant and can act as a catalyst for further formal contacts.

Many recent empirical studies based on validated linkage indicators, uniformly suggest an intensification of the interactions

1. For a more detailed overview, review and elaboration of the concepts and insights listed in this section of our paper, see also K. Debackere, "The TTO, An Organizational Innovation To Facilitate Technology Transfer," in D. Liebaers and D. Dunlop (eds.), *University Technology Transfer and Academic Entrepreneurship, World Scientific Reference on Innovation* (D. Siegel, Series editor-in-chief), (2018), 23-41.

2. R. Solow, "Technical Change And The Aggregate Production Function," *Review of Economics and Statistics*, 1957, Vol. 39(3), (1957), 312-320.

3. P. Andries and Debackere, K., "Adaptation And Performance In New Businesses," *Small Business Economics*, 2007, Vol. 29: 81-99.

4. H. Etzkowitz and Leydesdorff, L., "The Dynamics Of Innovation," *Research Policy*, 2000, Vol. 29: 109-123.

between universities and industry over time.[5] For instance, empirical work has shown that the number of scientific references in corporate patents nearly tripled throughout the 1990s, although they are rather concentrated within a limited number of patent classes. So-called "science-based technologies" (defined as those fields with frequent references to the scientific literature) are biotechnology, nanotechnology, photonics, information technologies, and advanced materials technologies. These science-based technologies are strong contributors to technological progress, as measured by the increase in patent activity in these fields.

Accompanying this trend is a change in the institutional environment, with the advent of public policies designed to encourage the commercial exploitation of scientific discoveries. Universities and public research organizations (PRO's) are now expected to be more than mere producers of basic knowledge. The know-how they generate should be transferred better and quicker into application and use. The observed surge in academic patenting in the U.S. is mostly attributed to the Bayh-Dole act of 1980, which gave U.S. universities the right to license inventions from federally funded research. The Stevenson-Wydler act did the same for PROs. On the demand side, companies look more intensely towards the public science scene as an external knowledge source allowing and enabling the rapid and privileged access to inventive activity. Universities and PROs are also searching for new funds to compensate for the increasing constraints of public funding. As a result of such diverse trends, both material and immaterial, science and business have become intertwined in so-called open innovation ecosystems.[6]

But, the highly uncertain and non-codifiable nature of scientific know-how results in high transaction costs and systemic failures in the market for this know-how, posing challenges to the organization of industry-science links. A factor that has received ample attention as a necessary condition for smooth science-business links is the presence of well-articulated intellectual property rights regimes. From a governance perspective, the allocation of ownership to the academic sector has provided universities with both an obligation and an incentive to exploit the market potential of their research activities. The internal allocation of incentives (*i.e.,* between the institution and the individual researcher) is an important element in that endeavour, though its articulation and implementation is often left at the discretion of the research organization.

A major issue universities are facing in this context is whether their researchers have sufficient incentives to disclose their inventions and to induce their cooperation during the development efforts following license agreements. The university needs to have proper license frameworks and contracts in place as well as a clear incentive scheme specifying the share for the inventors in the royalties or the equity to be allocated (*i.e.,* when it comes to the creation of a spin-off company rather than closing a license deal). This presence of a proper incentive scheme helps alleviate moral hazard problems and related agency issues.

Even when disclosure is stimulated by appropriate incentive schemes, not all academic inventions will be patented and licensed by the university, which may have to "shelve" inventions. This relates to another problem in the market for technology transfer, namely the asymmetric information between science and business on the value of the inventions. Firms can typically not assess the quality of the invention *ex ante*, while the TTO may find it difficult to assess the commercial potential and profitability of certain inventions. Proof of concept studies and incubation activities are therefore more and more present in academic settings.

A partner's lack of understanding of the other partner's culture, as well as conflicting objectives among partners, can also impede good industry-science relations, notably the conflict of interest between the dissemination of new research findings versus the commercial appropriation of new knowledge.

In order to develop and professionalize the academic TTO, attention must be paid to the *organizational structure and embeddedness* of TTO's within their host institutions as a condition for successful industry-science links. Universities with a strong track record in science-business interactions often apply a rather decentralized model of technology transfer, *i.e.,* the coordinated responsibilities for transfer activities are executed in the close proximity (managerial, physical and intellectual) of the research groups and the individual scientists. Closely linked to such model is the presence of adequate administrative support that allows the researchers to concentrate their science, while having all administrative and contractual issues associated with the transfer activities (such as legal agreements, financial issues etc.) handled by the specialized function. This specialized support definitely also includes the exploitation of research results and inventions via spin-off creation and via patenting and licensing; *i.e.,* areas where specific legal and marketing know-how and skills are needed.

Given a decentralized model of technology transfer, the creation of a specialized and dedicated TTO within the university is instrumental to secure a sufficient level of autonomy for developing professional relations with business. This approach enables a good "buffer" against possible conflicts of interest between the commercialization agenda and the research and teaching activities in academia. A dedicated TTO also allows for specialization in supporting services, most notably the management of intellectual property and business development. A high degree of strategic, financial and managerial independence further facilitates the relations with third parties, such as venture capitalists, investment bankers and patent attorneys.

The TTO further is instrumental to mitigate the asymmetric information problem typically encountered in markets for scientific knowledge. TTOs have an incentive to invest in mechanisms to spot academic inventions and to sort profitable from unprofitable ones. The costs to develop this capability can be overcome if the size of the invention pool is large enough so that the TTO can exploit economies of scale and scope when mobilizing this expertise. Looking at the multiple benefits the TTO can deliver, there is the issue of scale at smaller institutions that often lack the resources and technical skills to effectively support the structural arrangements and the investments required to operate a TTO at an optimal level. Strategic collaborations with colleague institutions may offer a way forward. At all times, there is the need to maintain close enough relationships and contacts with the researchers in the different departments, further supporting the need for a decentralized but well structured and centrally coordinated TTO operation.

Whereas basic research can be channeled from academia to industry either through collaborative research schemes and contracts or via licensing arrangements of patented inventions or proprietary know-how, spinning-off is the entrepreneurial

5. K. Debackere and Veugelers, R. "The Role Of Academic Technology Transfer Organizations In Improving Industry-Science Links," *Research Policy*, Vol. 34 (2005): 321-342.

6. H. Chesbrough, "Open Innovation," *Harvard Business School Press*.m (2003).

route to commercialize academic research. The latter transfer route has attracted significant attention in the current wave of start-up and new venture creation policies designed and developed in many countries.

New technology ventures originating in academia act as a bridge between curiosity-driven academic science and market-driven corporate innovation. They have the potential to introduce technological disequilibria that change the rules of competition in existing industries. This is the Schumpeterian process of creative destruction. Those startups enable a multitude of experiments with often competing "dominant product-market designs" and "business models," only a few of which will ultimately survive and thrive. Hence, they are the gene pool from which new industries may emerge in the longer run. Academic entrepreneurship in biotechnology is probably the most striking example when it comes to describing this phenomenon. Universities can play a critical role in this process, as their science is a breeding ground for new venture creation.

In order to venture (or to spin out startups) effectively and efficiently in the Triple Helix, universities have developed and grown their own entrepreneurial capabilities, both within the academic researcher community and within the student community. They have professionalized their participation to the innovation process through the activities and instruments offered by their TTOs.[7] As already highlighted and described more extensively in earlier work, the rise and growth of the TTO function in academia can be marked by three stages of development.[8] We repeat and summarize them briefly.

During the period 1980-1995, academic TTOs operated mainly as "isolated islands of technology transfer activity" within the university. Technology transfer occurred; it was tolerated and situated at the periphery of the academic activity spectrum. No solid TTO business model existed and TTO activities were confined to the legal aspects of contract development and contract monitoring. TTO performance was not taken into account when assessing academic performance of individual scientists. This *"stage 1 mode of operation"* lasted well into the mid-nineties. It was characteristic of the first generation of TTO activities. Their impact and their visibility within the university were still quite limited.

From 1995 onwards, we see the advent of a second stage or generation in TTO development. Rather than being situated at the periphery of academic activities, the TTO now becomes the centerpiece in the fulfillment of the so-called "third mission" of the university. TTO activities are now deployed university-wide, and the professionalization of the TTO operation occurs rapidly and effectively. Integrated business models appear, encompassing professional and university-wide IP (Intellectual Property) management practices, the management of a complex and diverse contract portfolio (both bilateral and multilateral contracts), and business development through spin-off creation, including a proactive stance towards having an impact on regional development. Technology transfer now has become the third mission of the modern research university, alongside education and (of course) frontier research. TTO achievements are fully taken into account when assessing academic performance, both at the institutional level and at the individual level. This *"stage 2 mode of operation,"* also called the university-wide activity of the TTO, developed during the years 1995-2005 and can still be observed at many universities around the globe. TTO impact and visibility have increased rapidly during this second generation of TTO development.

More recently, we observe the development of yet another, ever more inclusive, activity pattern of the TTO within its academic context. This *"stage 3 mode of operation"* can be summarized as the "inclusive TTO operation." Rather than "just" being the centerpiece of the university's third mission operations, the TTO activities now diffuse and interweave across and alongside the two core missions of education and research. The TTO is becoming fully embedded within the university while technology transfer activities generate a variety of spillovers (cognitive or intellectual as well as financial) towards the education and research activities of the university. The omnipresence of the TTO throughout the full internal value chain of the university turns it into a truly and fully inclusive activity. This third stage or generation of TTO development is expected to take full effect in the decade to come. It will further heighten the impact and the visibility of the TTO operations in academia.

In conclusion of this section, this evolutionary model visualizes the path-dependent nature and growth of the academic TTO over the last decades, including its position, its impact and its visibility within academia and along the Triple Helix innovation value chain. This model also exemplifies the prominent role of today's university in the new economics of technology and on the modern innovation policy scene.[9] In line with current evolutionary thinking, our economy is in a constant process of flux and change, with activities developing in a context that is never completely familiar to the actors, nor perfectly understood by them. There is no theoretical optimum since the range of possibilities for economic action is continuously changing, generally growing, but in ways that cannot be predicted or specified in detail. Universities as well as PRO's and their respective TTO operations have become important and visible agents in this evolutionary process. So, time to delve deeper into the nature and the variety of university-industry transactions and the instruments that support them.

1. Transfer Through R&D University-Industry Collaboration

As the *Lambert Review* has noted some years ago "the most effective forms of knowledge transfer involve human interaction and puts forward a number of ways to bring together people from businesses and universities."[10]

In contract research, a company contracts with the university researchers to undertake a specific piece of research on its behalf. The objectives of the research are defined by the company, and the goals are commercial, not academic. The contractor is fully covering the research costs and IP protection and bears all the risks for the research. The business will receive the results of the research but is not actively involved in the work. It is estimated that in Europe there are around 50,000 new research contracts each year, which bring to the university a large part of the academic

7. B. Van Looy, P. Landoni, J. Callaert, B. van Pottelsberghe, E. Sapsalis and Debackere, K., "Entrepreneurial Effectiveness Of European Universities: An Empirical Assessment Of Antecedents And Trade-Offs," *Research Policy*, Vol. 40, (2011), 553-564. 53-564.

8. K. Debackere, "The Rise Of The Academic Technology Transfer Organization," *Review of Business and Economics*, Vol. LV(2), (2010): 175-189.

9. D. Foray, "The New Economics of Technology Policy," (Edward Elgar, Cheltenham, UK, 2009).

10. Lambert Review of Business-University Collaboration, Final Lambert Report, Dec 2003.

R&D financing by industry.[11]

The results are usually owned by the company, but the academic partner also gains some benefit (in addition to the fee income) because contracts often provide access to novel compounds and, although the findings might have to remain confidential, the tacit knowledge may be useful in shaping new hypotheses for other basic research projects.

Consulting agreements involve consultancy work by university professors and/or researchers who provide expertise to an industry partner in exchange for payment, often on a personal basis, if allowed by the university's policy. The resulting IPRs are most of the time owned by the company, with limited rights of the researcher to publish his or her results. The IP ownership of developed results may also be shared, depending on the Institutional IP Policy of the academic institution and terms of the agreement. It is estimated that there are around 150,000 consultancies each year[12] in European countries.

Collaborative R&D is certainly the most important means for transferring fundamental knowledge between university and industry.

In collaborative research, the business and university researchers work together on a shared problem, usually addressing fundamental scientific issues. Collaborative research agreements are concluded by two or more parties that wish to cooperate to develop and possibly commercialize a new technology. The parties invest their human, physical and financial resources, assets (including background IPRs) and skills.[13] They jointly define the objectives and legal framework of the collaboration.

The research projects are generally initiated through "a call for projects"[14] and co-funded by business and the university or a public sector body.

It is estimated[15] that there are in Europe 20,000 new collaboration projects each year (and around 75,000 in place at any time). Whereas the contract projects last some months, collaborative R&D lasts on a longer period (three-five years or longer) and mobilizes greater financing.

The R&D collaboration raises most of the concern between university and industry around three main issues:

- Dissemination and commercialization: While researchers may be keen to disclose information to gain priority, firms may wish to keep secret or appropriate the information.
- IP sharing: It is often difficult to agree the ownership of IP in research projects that have been funded by both universities and industry because the sponsors have different interests in the rights to exploit and use the IP. Universities say that they need ownership to ensure that their future research is not held back. Industry argues that it needs ownership to protect the investment which will be required to develop the IP into a commercial product.
- Revenue sharing: The appropriation of collaborative project outcomes focuses the challenge of collaboration and imbalances in this appropriation are associated with negative evaluations.[16] Some surveys point out that distributional conflicts are often accentuated by the "unrealistic expectations" held by universities about the commercial potential of university research.

In this context, the nature of the relationship between the partners is critical: trust, experience in collaboration, understanding the partner, flexibility, adaptation, are all essential for a successful relationship.[17]

The complexities of IP management in modern knowledge ecosystems: the world of multiparty contracts in the world of precompetitive research. All around the world the countries support the development of R&D and innovation programs. These programs make calls for project[18] and deliver financial grants to support the university-industry collaboration. These initiatives have led to a framework of rules and prescriptions especially about the dissemination of the project result and the sharing of IP between the partners.

The *Lambert Review* has already suggested that "research collaborations might be made easier to agree if model contracts could be developed on a voluntary basis to cover the ownership and exploitation of intellectual property,"[19] especially for SMEs participation.

In this regard, European Union has been leading the way in the design and development of multiparty innovation consortia in its successive research and innovation programs (Seventh Framework Programme (FP7), Horizon 2020, Horizon Europe in preparation) as it should promote alliance between several partners (the European project consortium often regroups five or six partners) from different European countries—with various legal background and various status—and to attract SMEs in the scope of innovation. A set of models, rules and principles have been published, namely the DESCA model[20] *(Development of a Simplified Consortium Agreement)* and the Grant contract model,[21] to facilitate the negotiations, to avoid endless and imbalanced discussion on the management of the alliances and to insert the European innovation goals.

All these forms of collaboration face the core issues of IP, which is the precondition to the possibility to work together. The EU regulation[22] has been set up by the EU parliament and EU Council:

- The contribution and "prior art" from each of the partners

11. Knowledge Transfer from Public Research Organizations, European Parliament, Nov 2012.

12. Supra note 2, EP Report.

13. WIPO

14. See for examples "Funding and Tender Opportunities," European Commission, *https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/* or National Science Foundation.

15. Supra note 2, EP Report.

16. Bekkers, R. & Bodas Freitas, I. M. (2010). "Catalysts And Barriers: Factors That Affect The Performance Of University-Industry Collaborations." Conference paper presented at the 13th International Schumpeter Society Conference in Aalborg, Denmark, June 21–24, 2010.) *https://www.researchgate.net/publication/241872040_Catalysts_and_barriers_factors_that_affect_the_performance_of_university-industry_collaborations*.

17. See Hiroyuki Okamuro • Junichi Nishimura, Impact of university intellectual property policy on the performance of university-industry research collaboration, J Technol Transf (2013)

18. See for examples "Funding and tender opportunities" European Commission, *https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/* or National Science Foundation.

19.Supra note 1.

20. *http://www.desca-2020.eu/*.

21. *http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-amga_en.pdf.*

22. Regulation (eu) no 1290/2013 of the european parliament and of the council, 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 (2014-2020)."

must be carefully assessed in order to structure an appropriate and fair legal agreement between the partners. The ownership of background should not be affected by the project.

- About the output of the collaboration, "ownership of the foreground should stay with the party that has generated it, but can be allocated to the different parties on the basis of a contractual agreement concluded in advance, adequately reflecting the parties' respective interests, tasks and financial or other contributions to the project."

As "open innovation, open science and open to the world"[23] become the strong line of the European programs, the "grant contract" of the European Commission makes mandatory the broad dissemination of knowledge created with public funds, by taking steps to encourage open access to research results (via Gold or Green access), but at the same time enabling, where appropriate, the related intellectual property to be protected. The principle is[24] thus that open access policies should not affect the freedom to choose whether to publish or not, nor do they interfere with patenting or other forms of commercial exploitation.

In the U.S. Cooperative R&D agreements (CRADAs) between federal laboratories and nonfederal partners (*e.g.*, with businesses, universities, nonprofit organizations, and other nonfederal organizations) also provide a method for contracting.

2. Transfer Through Conferences and Publications

Conferences: Conferences illustrate the trade-off between dissemination and exploitation of research results.

Conferences are places where many academics and researchers "test" their ideas, put them out there for the audience, in order to receive critical responses. According to "*www.science-community.org*" 4,4625 conferences have been held between 2009 and 2018 in all thematics that represent more than 4,000 conferences a year! (In this number however the number of "predatory conferences"[25] could have increased as organizing conferences have become a profitable business.)

The IP laws consider that an oral presentation is a disclosure of the invention and therefore prevent filing a patent. This imperative has been attenuated in some jurisdictions like the U.S., where a one-year grace period exists—but as many inventions, especially those coming from the fundamental research, are of worldwide use, this exception is not really worthy.

For inventors at academic institutions, university technology transfer offices may advise on the best conduct to protect and disseminate their invention. Even if it could seem to be easy to take the precaution to file a patent before to disclose the invention, but for the fundamental research coming out from universities, the patent timing is not so obvious. In some fields such as computer science and electrical engineering, peer-reviewed conferences are important channels for a faster dissemination of research results.

Publications

Publishing scientific knowledge is considered as one of the most common and rapid ways of dissemination.

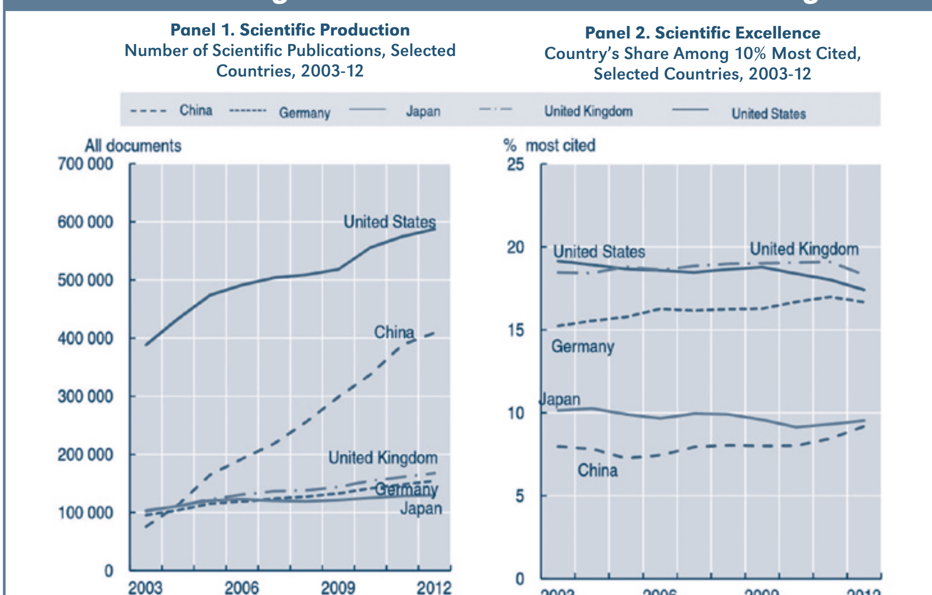
Since the beginning of the 21st century, the total number of scientific publications has been multiplied by more than two to reach around 1.8 million in 2015. The countries' share has evolved at the same time toward a slowing of U.S. and an acceleration of China. As for conferences, publication has become a business and raises problems of cost and quality.

Scientific publications are subject to copyright, which only protects the expression of original ideas and not the research finding as such. Actually publication is only antagonist to trade secrets but not to IP protection. See Figure 1.

Publications are at the heart of the open-access problem as, contrary to patents, they are not freely accessible, and the cost of access could prevent to use them. This closed-access model is challenged by the broad movement of pervasive digital information and open-science commitment—which is a worldwide trend being discussed in several international fora, including the OECD and UNESCO.

For the development of innovation, the European Union has

Figure 1: Scientific Production Has Increased Worldwide But Rankings Of Excellence Are Slower To Change



Note: Scientific production/Output/Number of documents is the total number of documents published in scholarly journals indexed in Scopus (whole counts of all document types by author affiliation). Excellence indicates the amount (in %) of an institution's scientific output included in the set of 10% of the most-cited papers in their respective scientific fields. It functions as a measure of high-quality output of research institutions. Albeit imperfect, this indicator is commonly used to capture research excellence.

Source: OECD (2015b), *OECD Science, Technology and Industry Scoreboard: Innovation for growth and society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

23. *https://ec.europa.eu/digital-single-market/en/news/open-innovation-open-science-open-world-vision-europe.*

24. Commission recommendation on the management of intellectual property in knowledge transfer activities COM 2008 1329.

25. Predatory Conferences Undermine Science And Scam Academics, *Huffpost*, 2/10/17.

made a priority for a better access to scientific information: *"Research results, including both publications and data collections, need to be circulated rapidly and widely, using digital media. This accelerates scientific discovery, enables new forms of data-intensive research and allows research findings to be systematically taken up by European business and industry: affordable and easy access to scientific information is particularly important for innovative small businesses."* [26]

The vision underlying the Commission's strategy is "that information already paid for by the public purse should not be paid for again each time it is accessed or used, and that it should benefit European companies and citizens to the full."

The open access for publications may take two ways:

- The **"Gold" open access** (open access publishing) where payment of publication costs is shifted from readers (via subscriptions) to authors. These costs are usually borne by the university or research institute with which the researcher is affiliated, or by the funding of the public body or entity (UE program for example) supporting the research.
- The **"Green" open access** (self-archiving) where the published article or the final peer-reviewed manuscript is archived by the researcher in an online repository before, after or alongside its publication. Access to this article is often delayed ("embargo period") at the request of the publisher so that subscribers retain an added benefit.

Currently it is estimated some 20 percent of all scientific articles are available in open-access form, 60 percent of which follow the "Green" model.[27]

It could seem that the old debate opposing publication and patenting is outdated, as it is easily possible to file a patent before publishing (the priority date preserve the inventor), and many studies have shown that there is a positive correlation between the number and the quality of publications and the number and quality of patents for a scientist.

Publication could be also a way to secure freedom to operate if a patent filing is not appropriate. Further, where multiple parties are racing for patent protection, the lagging party may choose to publish their findings prematurely to limit the availability of a patent for the leading party.

Once a patent application has been filed, the calculus governing the extent of disclosure changes, as extensive disclosure after filing a patent application may bar future patent applications in the field.

3. Transfer Through Commercialisation

Licensing

The transfer of research results to the industries and the market does not concern only the patented technologies but more and more "unpatented materials"[28] as software, copyright, data, designs, know-how and even trademarks. These forms of IP represent now a larger part[29] of university and public research organization licensing. For instance, "a significant number of university-developed technologies are licensed as technical know-how without having been patented. Universities often also license inventions for which a patent application has been filed but has not yet been granted."[30]

Licensing is often the quickest and most successful way of transferring IP to industry, and has the advantage of using existing business expertise rather than building this from scratch. However as quoted in the EP Report "Exploiting IP through formal transactions alone is generally considered to be of lesser importance by industry." The cause of that situation has been analyzed: embryonic stage of the technology, high failure rate, dissatisfaction with the licensing policies of academic institutions[31]…Thus successful licensing activity is concentrated in few universities and in few domains.[32] Licensing practices vary considerably between institutions and fields of technology (exclusivity, royalty sharing, express license…).

In the last years efforts have been focused on implementing proof of concept fund and developing better industry-university cooperation and understanding of each other's needs.

It should be noted also, that the pricing of the license is a problem for the university as there is no—and there will never be—foolproof method to valuing IP. The recent decision of the U.S. courts has also increased the perplexity.

Spin-offs

University Spin-offs are defined as new firms created to exploit commercially some knowledge, technology or research results developed within a university. The creation of spin-offs is considered an important avenue for commercialization of new technology, particularly when the nature of the technology is such that no current player in a particular market would be willing to take the risk of taking a given invention to market (WIPO).

Further interest in university spin-offs sky-rocketed some years ago, when Google's initial public offering in 2003 returned over $330 million to Stanford University. This return was generated via Stanford's equity interest in the nascent venture rather than through a conventional royalty agreement, triggering a new era in negotiated deals with spin-off companies as other universities sought to replicate the extraordinary return.

Seed funding and partnership with venture capital has developed everywhere and the number of spin-off launches have increased significantly (in the U.S. for example, between 1980 and 2014, nearly 5,000 companies were launched and nearly 4,000 jobs were created according to AUTM).

The studies done[33] shows that these companies have the same level of success after some years as the general population of start-ups.

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26. Towards better access to scientific information: Boosting the benefits of public investments in research COM(2012) 401 final *https://ec.europa.eu/research/science-society/document_library/pdf_06/era-communication-towards-better-access-to-scientific-information_en.pdf*

27. Supra note 2.

28. See for example the diversity of inventions offered on the University of Oxford site: *https://innovation.ox.ac.uk/technologies-available/technology-licensing/.*

29. For the US Fed Lab there were more than 16,800 licenses for "other IP" and 3950 invention licenses (NSB National Science Board | Science & Engineering Indicators, (2018).

30. WIPO.

31. Ahmad D. Rahal, Ph.D, "University Technology Buyers: A Glimpse Into Their Thoughts?" *J. Technol. Manag. Innov*., 3(1), (2008).

32. The leading 10% of universities accounted for approximately 85% of licence income and the majority of income is generated from patents and licences in the biomedical field (EP Report precited).

33. Fernando Almeida, "Insights And Perspectives From A Literature Review On University Spin-Offs," *Management Research And Practice*, 10(2), (June 2018).

Material transfer agreements

These agreements transfer physical assets and tangible research materials from the university to the companies that intends to use them for the purpose of their own research. The transferred assets may include patented materials transferred through a license, biological materials, chemical compounds or software.

4. Conclusion

The different forms of transfer do not concern the same type of knowledge, and they are not to be compared. When it comes for early stage research, which is the case for the most Universities' research output, it is generally, but not always, insufficient to enable a firm to use it. Further input from researchers could be required to support a commercial development. "More generally, the empirical literature and our case studies, demonstrate that businesses make use of a range of KT mechanisms simultaneously and at different times reinforcing the conclusion that KT mechanisms are complementary rather than substitutes."[34]

Observations like these thus support the complementary role of academia and industry in modern innovation systems, whereby universities' specific role is and remains to focus on the more basic, curiosity-driven, longer-term side of the R&D spectrum. Industry-science links do and should respect that logic. In addition, strong associations between scientific productivity and patent activity exist, both at the level of the individual researcher and at the level of the institution. In the various studies reported in this paper, the more prolific scientists emerge as the ones who are more likely to patent. A similar relation holds at the level of universities. Hence, there is little doubt that universities that engage in effective technology transfer can and do so on the basis of their excellence in science; while their excellence in science is further fed by the experience and insights their scientists gain through their interactions with industry. University-industry links therefore are a matter of rigor and relevance. The rigor that comes along with and is characteristic of excellent scientific work and the relevance that deep industry problems and challenges bring to the science agenda. Industry-science links are therefore also at the origin of deep intellectual, cognitive spillovers between academia and industry. This is a true, core contribution to the advancement of academic science. Advancement that will always be critically dependent on the scientists' curiosity and fascination leading to the emergence of major, game-changing advances, and supported by a dynamic and professional TTO. ■

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34. EP Report mentioned (2).