University in the Innovation System

Academia-Industry Collaborations and Intellectual Property Rights

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***Abstract* - In a world where possessing raw materials or manufacturing commodities are not sufficient for long-term economic success, innovativeness and a knowledge-based economy form the basis for prosperity. In this report, we discuss the link between a nation's higher education system and its ability to bring about and foster innovativeness and economic growth. In particular, we will concentrate on the roles that universities play in the national innovation system. Some of the questions we address include: How strong a link is there between the education system and nation's innovativeness? How important is industry-academia collaboration? From the perspective of a knowledge-based economy, what would an ideal university be like? To answer these questions, we summarize key findings from the literature. The aim of this report is to present the key factors and decisions that should be considered in future higher education strategies.**

Keywords - higher education, university marketization, innovation system, industry-academia collaboration, Intellectual Property Rights

I. INTRODUCTION

The academic world is facing substantial changes in its operational environment globally. The enrolments in tertiary education have increased 75% globally since the year 2000 [32]; and at the same time, there is an ongoing general trend of cutting costs. These factors are driving the development called *university marketization*. Universities are involved in the generation of economic wealth: a survey of Stanford alumni by Eesley and Miller [7] revealed that if all companies having their roots in the university would form a nation, it would comprise the world's tenth largest economy! Even though the success of these companies is not typically based on technology developed at the university, it emphasizes the role of university in educating talented individuals who can create wealth that benefits the society. Indeed, societies increasingly expect their universities to directly serve the needs of the society rather than promoting science and education for the sake of science itself. This means that universities are expected to respond more rapidly to changes in the needs of industry, educate more people in areas that bring more profit to the society, participate actively in solving global economic and environmental challenges, and, increasingly, educate people with bright ideas to start new successful businesses.

However, outlining "the correct mission" or "the best strategy" for a university in the depicted situation is challenging. Basic research based on curiosity cannot (and should not) be sacrificed for commercial values, because basic research is the foundation for both solving big problems such as climate change and for new technological innovations that also create economic growth. On the other hand, collaboration with other societal actors (industry, non-profit organizations, and government) plays a crucial role in applying science and transferring knowledge. The traditional knowledge transfer and interchange between universities and big companies have created many success stories in developed countries, but this will not be enough to ensure future prosperity. The strategies of universities also depend on where they are located, so that, for example, universities in the different countries or regions may need very different strategies.

In this report, we discuss the role of university in the national innovation system.. Also, the intellectual property rights (IPR) laws are a crucial way for academy and industry collaboration and how efficiently potential ideas in academia transfer to commercial use. Effective IPR practices transfer the best ideas from academia to new businesses without disturbing the inventor's scientific work, but at the same time secure the inventor's share of the economic benefits. One additional way to increase knowledge transfer is to simply educate entrepreneurial skills to more students and graduates.

We note that even though we touch upon some other aspects of universities' new role in the unpredictably changing global landscape, we mostly treat universities as sources of innovation and economic wealth, which can be directly measured. Furthermore, we do not discuss fields, such as the arts, social and human sciences, whose economic effects the current instruments do not measure holistically and as such their economic impact is probably underestimated in different indices. Other roles of higher education such as solving the big problems (climate change, healthcare), and civilizing the society are simply deemed out of scope consider this report as well.

II. MULTIPLE ROLES OF UNIVERSITIES

What is the role of universities in the innovation system? In the Global Innovation Index [14] (see Fig. 1) there are five inputs that enable innovative activities:

1) *Institutions,*
2) *Human capital and research,*
3) *Infrastructure,*
4) *Market sophistication, and*

5) Business sophistication.

The index is calculated from two main output pillars:

1) Knowledge and technology, and

2) *Creative outputs.*

The input from universities is included under the pillar of Human capital and research, which contains Education, Tertiary education, and R&D. In what follows, we elaborate further the role of universities in the national innovation system.

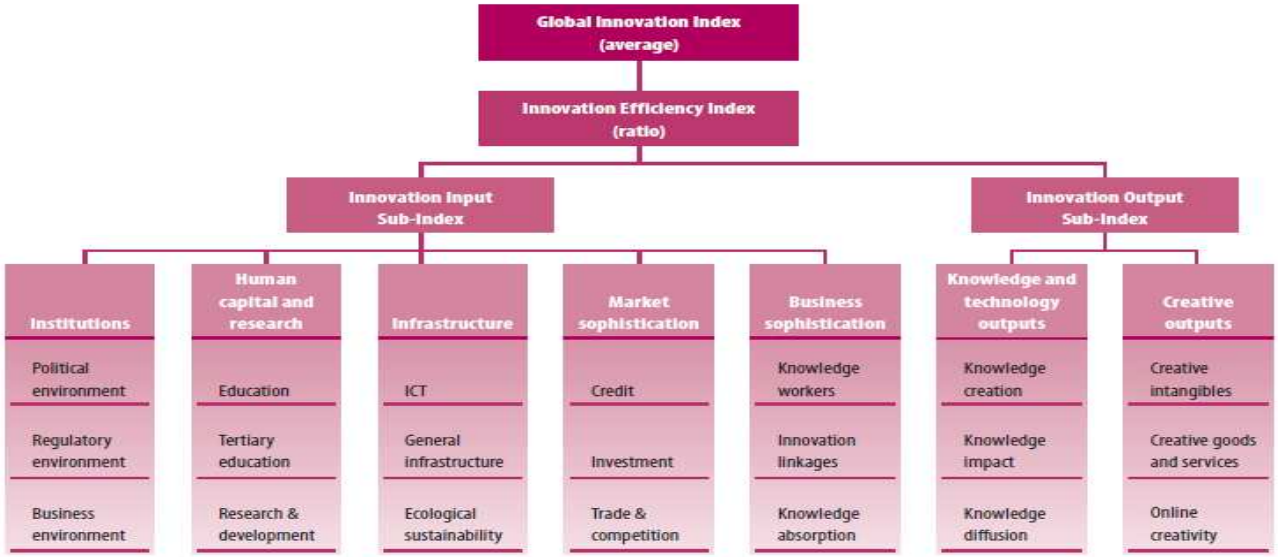

Fig. 1. The Global Innovation Index Framework [14].

Jeffrey, Michael and Scott. [16] define the national innovative capacity as "the ability of a country as both a political and economic entity to produce and commercialize a flow of new-to-the-world technologies over the long term". The industry, universities and various government sectors all play major roles in the national innovation system by interacting with one another. In this system, universities are seen as actors that affect the creation, development, and diffusion of innovation [25]. Within this broader definition, universities place the knowledge base for capacity building of professionals in a wide spectrum of fields. Also, beyond maintaining basic science education, universities are generators of new ideas through their research departments. Naturally, research and development (R&D) practices are prominent sources of innovation.

Betts and Lee [3] present five mechanisms through which universities can boost national R&D:

1) *University as Trainer* – the university's role in providing a steady supply of skilled graduates to the local economy.

2) *University as Innovator* – direct generation and commercialization of knowledge by universities working fairly independently of the private sector.

3) *University as Partner* – university as partner provides technical know-how to firms through agreements.

4) *University as Regional Talent Magnet* – the presence of a university in a region increases the attractiveness for talented innovative entrepreneurs, scientists and engineers.

5) *University as Facilitator* – the university can facilitate networking among those involved in the high-tech community from the private and public sector.

We emphasize that innovation often occurs outside academic environments as a result of inventive thinking and creative experimentation [25]. As the different roles listed above show, however, universities can play many roles, such as in providing a forum for the exchange of ideas between different R&D communities (facilitator), in making research outputs more accessible to researchers in industry than to government research laboratories (innovator) and, more importantly, in training future industrial researchers (trainer, talent magnet) [16].

There are many approaches on how the higher education system should be utilized to foster innovation. One approach is the so-called *linear model* [25], which means that by expanding public funding to enhance basic research, the university can be a critical contributor to economic growth. Mowery and Sampat [25] explain that expanding basic research funding is both necessary and sufficient to promote innovation. On the other hand, they also argue that funding basic research is quite an inefficient means for improving innovation performance.

Another view of the role of university research in the national innovation system is focusing on the *contrasting norms* between academic and industrial research. University researchers have been giving significant contributions to the technology development as well as basic research in the industrial laboratories. Mowery and Sampat [25] point out

that the norms of academic research differ significantly from industrial research. For academic researchers, it is crucial to be the first to publish and disclose in order to gain professional recognition and advancement. In the industry, however, secrecy and limitation of disclosure are considered important for competitive advantage.

In the third conceptual framework by Mowery and Sampat [25], research is carried out in a more *interdisciplinary, pluralistic, networked innovation system*. This approach is different from previous models that mainly concentrated on companies and university research without considering the links to other research institutes. The third framework gives the possibility to associate with greater inter-institutional collaboration and more interdisciplinary research. This can increase diversity inputs to the innovation process, and it reflects the modern innovation system.

The last conceptual framework is *the role changing model*, which has increased interaction among institutional and industry actors. In addition to a linkage between an institute and industry, each party can also take the role of the other. Thus, universities can pursue entrepreneurial tasks and companies can have an academic role in sharing knowledge (with each other, or by publishing) and giving high-level training. This model allows a more industrial role for a university to apply, and industrial activities are imitated at university simulation laboratories.

In light of all frameworks mentioned above, the link between university and other institutes and companies seems to be critical. The interaction between university and industry has been growing, and this has brought along changes in internal norms, rules, and the culture of the university. As networking and collaborative innovation processes are both increasing, the role of IPR to support the innovation process and commercialization is emphasized, as will be discussed next.

III. ROLE OF IPR IN INDUSTRY-ACADEMIA COLLABORATION

According to Maskus [22], IPR – together with taxation, investment regulations, production incentives, trade policies, and competition rules – comprise the regulatory system that is essential for how much foreign direct investments a nation is able to attract. There is also empirical support, e.g., [20] indicating that strong IPR legislation increases foreign investments. So IPR is important for national success at large. But here we limit the discussion to how IPR can foster (or hinder) industry-academia relationships and university-based innovativeness.

IPR is essential in combining the openness and publicity of academic research with university marketization [4]. The first big question related to commercialization of research is who owns the rights to research results that are achieved with what we call *open research*, i.e., research without external partners involved. Here, one general trend has been that universities take institutional ownership [35] of inventions and pursue commercialization through centralized offices. In Finland [24], the researcher has the primary rights to inventions created under open research. It seems, however, that most commercially successful innovations are made under a *collaborative research* agreement (‘*contract research’*). This typically involves external funding coming from an external actor (a company) that also dictates liabilities related to the research. In layman’s terms: research is collaborative if there is an external party who provides funding and can (even partially) decide what is being researched and how the results can be published. In the case of Finland, the institution (university) owns the primary IPR. In this setting, the only way an external party can gain the IPR is a separate contract that defines how IPR are shared.

Indeed, in the latest university reforms [8], governments have encouraged and enhanced the link between universities and industrial innovation. This creates complex institutional landscapes that influence the creation, development and dissemination of innovations. Even though measuring and characterizing all of the impacts of universities in the national innovation system is a cumbersome task (as also pointed out by our interviewees), we will exemplify how IPR can influence industry-academia collaboration and, in particular, we illustrate how IPR rules could be agreed in such projects. Because covering all possibilities on how collaborative contracts should be designed is out of the scope of this paper, we limit ourselves to an illustrative example. (For an extensive analysis, see Hertzfeld, Link and Vonortas [12]. Furthermore, we provide some ideas on how sophisticated contracts could be designed for the purpose of creating new incentive structures in industry-academia projects.

We consider a joint-research project between three parties: the university, a university researcher, and an external party (e.g. a company). All parties agree that they jointly elaborate common exploitation rules allowing each partner to exploit the industrial-academy collaboration outputs. These rules will be based on, for example, a European Commission contract and the collaboration agreement. Next, it is discussed which are the key things to agree on.

A. Definition of knowledge ownership at different project stages.

First, the ownership of knowledge can divided into three different stages:

- *Background (pre-project) knowledge* – pre-existing knowledge, which was brought and contributes to the collaboration project by each partner before the project starts;
- *Foreground (during-project) knowledge* – the knowledge developed during the collaboration project;
- *Sideground (post-project) knowledge* – the knowledge further developed based on the outcome of the collaboration project afterwards – or within the project but outside the scope of the project.

B. Usage of IPR

Second, the basic rules of IPR ownership and usage in different stages of knowledge creation need to be agreed on. A typical way to agree on the ownership of knowledge, reflecting the time dimension discussed above:

- Regarding any original contribution or *background knowledge* brought into the collaboration, the contributing member owns the IPR.
- Regarding any new *foreground knowledge* generated during the project, as a result of a cooperative activity, the IPR belongs jointly to the members contributing to this knowledge.
- Regarding any *sideground knowledge* generated based on the result of the project, the IPR belongs to the member that developed this knowledge.

Of course, there are other ways to agree on the IPR. For example, it can be agreed that all IPR related to direct project-related new knowledge in the *post*-project stage are transferred to the project and thus become jointly-owned or company-owned knowledge.

The rules related to usage should also govern potential revenue sharing. These shall be defined before or during the project in the collaboration agreement and with detailed conditions related to ownership of the project results. The main goal of the collaboration agreement is to set the ground rules for individually or jointly exploiting the outcome of the collaboration project to ensure that each partner‘s tangible and intangible investment in the project are protected.

- Various scientific and technological developers participate in the collaborative research, development and integration team. While working together in the development of the project objectives, they can also develop, or co-develop, their own independent, but integrated, applications that could be exploited separately.
- Property rights related to single activities are very clearly split between those partners who can claim ownership of stand-alone activity or part of it.
- Because a project is a collaborative venture, participants will agree among themselves on allocation of the project results. Thus, the IPR ownership of the results related to the integrated project solution will be shared between contributing members considering their bearing of project costs.
- Other arrangements, such as sublicensing, are subject to the owner’s approval.

As mentioned earlier, IPR is one of the most critical and complicated factor in the industry-academy collaboration. The above is only one example as a suggestion on how IPR can be considered and agreed on in a collaboration project. With clear IPR access and rights, that will maximize the sources and pre-knowledge that would be brought into the project, protect each partner’s tangible and intangible investments, and ensure that the outcome of the projects would be properly and efficiently exploited. As a new and attractive avenue, the use of options is briefly presented next.

C. Option contracts

Options could be utilized in industry-academia projects to share risks and provide incentives. Options are mostly used in financial markets, but they are increasingly used in other areas, such as private contracting between companies. Here we discuss the use of option contracts for R&D collaboration – an idea which is already widely applied in internal operations (e.g., Dixit and Pindyck [6]; Luehrman, [21]). As an example of a collaborative contract, Uppsala University uses options in their innovation support framework [33]. For example, they have established a company called UU Projekt AB, which can contribute funding to cover the patent application costs. They also help cover project management costs of an R&D project. In the project, however, specific milestones are agreed on beforehand, where both of the parties have an *abandon* option for the project.

The main motivation for the use of options is the uncertain nature of research projects, which can hinder many good opportunities when one of the parties (here, the university, researcher, or an external party) is not willing to participate due to high financial risk and uncertainty about the end result. Note that the relevant risks are not only financial. For example, the researcher can carry the risk of not being able to publish results. As an example of a direct IPR option, consider a contract where the company has *the right but not the obligation* to decide on IPR usage only after the main results are achieved. For example, it can decide whether the university or the researcher gets the IPR, or whether the results are handled as trade secrets. While this is naturally attractive for the company, the academic partners would need an incentive to participate. In this case, the company should have different costs relating to its options: (a) it could release the IPR without cost (other than the project cost itself), (b) it could pay a lump sum (say, 100,000€) for the IPR but allow publishing of the results that do not endanger commercialization, or (c) it could claim the results as a trade secret and pay a lump sum plus a percentage of all generated revenue for the academic partners. In this way, the academic side gets rewarded either by a publication or financially, whereas the company decreases the risk of losing critical IPR or paying too much (in a commercial sense) for useless new knowledge. We acknowledge that this kind of contract might be cumbersome to establish, but the basic principles should be applicable to projects of this nature.

IV. SUMMARY

To summarize the discussion above, universities play a critical role in the national innovation system as a workforce trainer, as a source of innovation, as a collaborative partner, as a talent magnet, and as a facilitator in innovative networks. In particular, it was discussed how important industry-academia collaboration is and how IPR can have a big impact on collaborative partnerships. According to the experts we interviewed, sharing IPR is not a minor detail in industry-academia collaboration; rather, it can be a major

obstacle for many companies, which results in avoiding joint projects with academics. If the legislation emphasizes the rights of the university, the result can be that many potential ideas and inventions are left to universities, which in general are not very successful in the commercialization of inventions [35]. The ways IPR impacts industry-academia collaboration and, in general, university-based innovativeness seems twofold. First, the mechanism how IPR is shared within the university can have an impact on the commercialization of potential inventions. Arguably, if a person owns the IPR, there is a greater probability for commercialization in the form of entrepreneurship. Second, there seems to be room for improvement in how the results from joint projects can be shared between academic and industrial partners. Here, the current trend seems to be that the role of the university as IPR owner is emphasized through legislation. Whether this is the right direction, considering innovations and national competitiveness, remains an open question. We have presented some key factors that play a big role in establishing these partnerships, and we have also presented some ideas on how IPR sharing and commercialization could be further improved.

We also note that while setting IPR in place is a *necessary* condition for such partnerships, it is not *sufficient*. This means that even though academic collaboration would be a possibility for a company, it does not mean that it is an attractive possibility. Indeed, more understanding of why companies should pursue academic joint projects is needed. For example, developing better indicators to measure the utility of such projects could create more opportunities for industry-academy interactions. In general, more information is also needed on measures of industrial-level capacity, investment, and innovation creation.

V. CONCLUSIONS

Knowledge transfer between academia and industry is an important and timely issue throughout the globe. So-called university marketization has already started driving universities towards more institutional autonomy and accountability, and this is taking place together with the global trend where universities are also expected to bring concrete profits to society in the short run. Essentially this means that universities are required to create new profitable businesses in the surrounding society mainly through commercialization of innovations. In addition, many developing nations are trying hard to become knowledge-based economies in order to get their share of the most valuable segments of international industries such as innovation and branding, which usually require educated and innovative people. This increases knowledge competition between nations and also creates differing requirements for universities in different regions of the world.

In this report we studied the higher education system and its innovative capability, with particular focus on academia-industry collaboration. We presented the ongoing trend of university marketization and discussed its overall effects. Then, different frameworks for academia-industry collaboration were covered, and IPR-handling practices that would create more incentives for commercialization were suggested.

We found that measuring the impact of universities on creating new business value is very difficult, because many knowledge transfer mechanisms are indirect and have different timescales. Therefore as a conclusion we suggest that all concrete knowledge transfer through collaboration projects and entrepreneurial activities is valuable, and in this report we presented different frameworks where collaboration between universities and industries can be made more effective.

One of our key findings was that IPR-handling practices and regulations are crucial for increasing the knowledge transfer between academia and industry, and that establishing effective IPR practices is challenging. There is a lot of room for improvement in developing these practices in such a way that they create a successful collaborative environment that attracts people both in industry and academia. It seems that unsatisfactory IPR practices and regulations can make other means to increase university-industry collaboration ineffective. We expect already scientifically productive nations to gain a significant competitive advantage in global competition in the future if they can find effective tools to increase their university-industry cooperation, and developing effective IPR frameworks plays a key role in this. Nations with no world-class universities may also be able to attract foreign investors and researchers better than their peers if they can offer tempting frameworks and practices for fruitful academia-industry cooperation.

We emphasized already in the introduction that developing higher education is a multi-objective task, and our approach focused mostly on one objective: how universities can contribute to innovativeness and knowledge-based economic growth. However, we acknowledge that universities are also required to increase understanding of the world, contribute to well-being, respond to global and societal challenges, and civilize the society, among other things. Thus, in the future, more studies that account for the higher education system and all of its roles as a whole are needed: how universities can complete all the above-mentioned tasks and still be an active part of the economic system. As our final conclusion, we do not fear that increasing universities' economic impact through facilitating industry collaboration and educating entrepreneurship would threaten other important tasks of universities, as long as nations understand that their higher education systems have many different purposes that are all crucial to their wealth in its entirety.

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