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ROLE OF TECHNOLOGY TRANSFER MECHANISMS IN STIMULATING INNOVATION

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Abstract. Innovation has gained importance in many societies and economies owing to its significant impact on efficiency and quality of life. The efforts of many countries to spur innovation demonstrate that innovation has gained momentum, especially in the past few decades. To improve the innovative capacity of countries and to ensure that society gets the maximum benefit of the research function of universities, it is important to transfer the knowledge generated by universities to industry through commercialization of research. This paper discusses technology transfer mechanisms which facilitate commercialization of research by transforming the research conducted by universities and research institutions and putting them in a form which is usable by technology seekers, such as SMEs, start--ups and the government. The article analyzes the effectiveness of the technology transfer mechanisms in stimulating innovation as well as the financial framework needed to facilitate innovation-based entrepreneurship.

Key words: innovation, technology transfer, research, start-up

INTRODUCTION

Creating innovation-based economy is central to the competitiveness of nations in the 21st century. Literature is in consensus on the role of academic/research institutions, the government and the business sector – the three elements also referred to as the "Triple Helix" – in stimulating innovative activities. Some researchers have also included the fourth leaf to the clover (called the "four-leaf clover" model), the fourth element being the organizations acting as catalysts of innovative activities [Guth and Cosnita 2010]. These catalysts, which include such mechanisms as technology transfer offices (TTOs), research parks, innovation centers, etc., facilitate the speed and effectiveness of the transfer of knowledge and technology from academic and research institutions to the industry.

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This article addresses how technology transfer mechanisms can stimulate innovative activities in a country. The second section of the paper discusses the open innovation model and its importance in stimulating innovation. The third section includes analysis of technology transfer mechanisms. The role of universities and research institutions in technology transfer process is discussed in the fourth section. The fifth section of the paper analyzes the importance of access to start-up financing. The conclusion is presented at the end.

OPEN INNOVATION MODEL

Because of its significant impact on efficiency and quality of life, innovation has gained importance in many societies and economies. The efforts of many countries to spur innovation demonstrate that innovation has gained momentum, especially in the past few decades. There are several indexes that measure innovation on a national level or globally. The Global Innovation Index measures the level of innovation in a country and is generated by Boston Consulting Group and The National Association of Manufacturers and the Manufacturing Institute. Other innovation indexes focus on a specific region, such as *Oslo Manual*, which focuses on North America, Europe and other rich regions around the world as well as Bogota Manual, which measures innovation in Latin America and Caribbean countries.

There are many definitions of innovation used in literature. Innovation refers to the creation of the new or the rearranging of the old in a new way. "Open innovation", coined by Henry Chesbrough, is a paradigm which assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology [Chesbrough 2003].

The central idea behind open innovation is that, in a world of widely distributed knowledge, companies cannot afford to rely entirely on their own research, but should instead buy or license processes or inventions (i.e. patents) from other entities. In addition, internal inventions not being used in a firm's business should be taken outside the company (e.g. through licensing, joint ventures or spin-offs) [Chesbrough 2003].

Core to innovation is the concept of technology transfer. The second section of the paper discusses the technology transfer model and the mechanisms of technology transfer.

TECHNOLOGY TRANSFER MECHANISMS

To ensure the maximum benefit of research function of universities to society, it is not enough to generate knowledge. It is also important to transfer that knowledge to industry through commercialization of research. The function of technology transfer takes place when the research conducted at universities is transferred to companies which use the findings of research and commercialize it. Universities, whether government funded or private, can increase their contribution when the knowledge they generate is transferred to industry and thereby ultimately benefit the society.

As illustrated in Figure 1, although large companies may have their own research and development (R&D) departments to generate the new technology they need, not all companies have enough resources to finance the R&D function. This is especially true for most of the small and medium enterprises (SMEs) and new business ventures (start-ups). According to the model of open innovation, these technology seekers can and should adopt ready technology produced by technology generators, such as universities, research institutions and R&D departments of large companies through a process called licensing in.

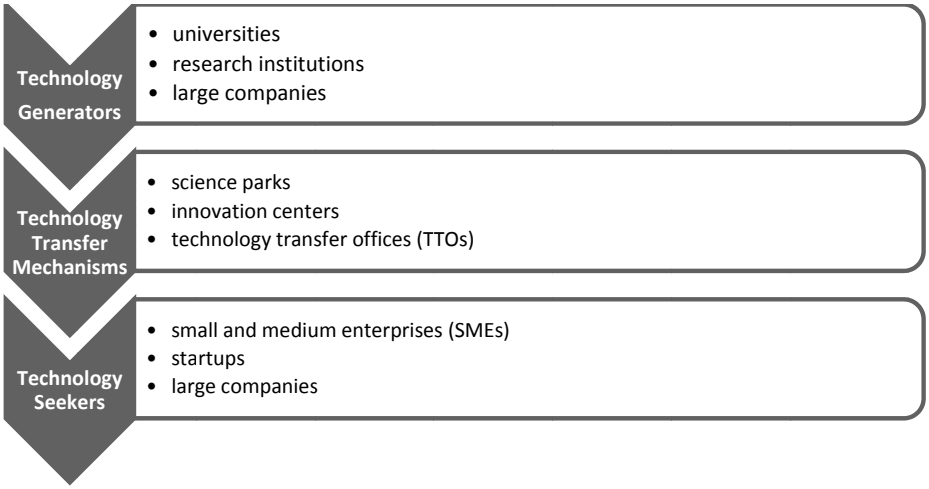

Fig. 1. The technology transfer model

Source: Own elaboration.

In order for technology seekers to more effectively benefit from the technology generated by universities and research institutions, there are technology transfer mechanisms which "translate" the research conducted by universities and research institutions and put them in a form which is usable by technology seekers. The mechanisms of technology transfer may be university-based entities or privately owned firms. The two common types are: (i) technology brokerage companies that facilitate an interaction between technology generators (universities and research institutions) and technology seekers (companies and SMEs), and (ii) technology transfer offices (TTOs) of universities which take the results of research conducted at the university and take steps to commercialize.

The suitability of technology for commercialization is measured by technology readiness level (TRL), which may range from 1 to 10. The higher the TRL, the more ready the technology is to be used by the industry. Technology transfer mechanisms, such as TTOs and science parks, help commercialize research by providing support for obtaining patents for the new technology generated at universities, and helping to find initial investment. These technology transfer mechanisms incubate new start-ups which are created on the basis of the research generated at universities and thus facilitate the commercialization of the research.

As Figure 2 shows, the findings of research at R&D departments of companies as well as research generated at universities need to be transferred from concept to product or process in order to qualify to be innovation. One of the challenges faced by the technology transfer mechanisms is deciding which research can be commercialized. Since the process of technological change takes time and financial resources, it is very important to choose a research which can generate a high return. Skills of technology transfer offices are very crucial at this stage – they need experts who have an understanding of the market as well as skilled engineers who understand the process of turning new ideas (invention) into products (innovation). Diffusion refers to scaling the new product to a larger market, where returns would be higher.

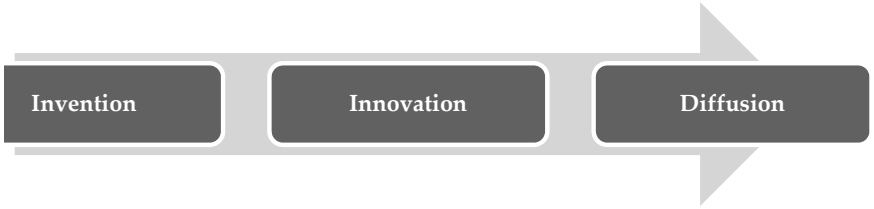

Fig. 2. Original model of the three phases of the process of technological change
Source: Own elaboration.

ROLE OF UNIVERSITIES AND RESEARCH INSTITUTIONS IN TECHNOLOGY TRANSFER

Universities and other higher education institutions (HEIs) are an important source of new scientific knowledge. Industry can gain access to this knowledge or resource by developing formal and informal links with higher education institutes [OECD 1981, 1993]. The university and industry (U-I) relationship is not new, but it has become more formal, frequent and planned, mainly since 1970s. It has also aroused growing interest by governments and policy makers, from both developed and developing countries, who still regard it as an under-utilized scientific-technological resource. The implicit argument of this reasoning is that universities, as generators and repositories of scientific knowledge and expertise, could transfer, through articulated mechanisms, at least part of such a stock to companies [Vedovello 1997].

In addition to technology transfer offices (TTOs), there are other mechanisms used as channels for transferring results of research carried out at universities to industry. These mechanisms are referred to differently in different parts of the world: research parks in the USA, science parks in the UK etc. Other names include technology parks (technoparks), technology incubation centers, technopolis, etc. Despite differences in the names, they serve the same purpose – to facilitate the commercialization of the results of the research carried out at universities.

Research parks (or technology parks) are widely accepted as one of the most effective mechanisms for transfer of knowledge from university to industry. Westhead [1997] claims that science parks reflect an assumption that technological innovation stems from

scientific research and that parks can provide the catalytic incubator environment for the transformation of "pure" research into production.

According to Felsenstein [1994], many countries have established technoparks with two main objectives. The first objective of a science park is to be a seedbed and an enclave for technology, and "to play an incubator role, nurturing the development and growth of new, small, high-tech firms, facilitating the transfer of university know-how to tenant companies, encouraging the development of faculty-based spin-offs and stimulating the development of innovative products and processes". The second objective is to act as a catalyst for regional economic development or revitalization and to promote economic growth.

A study was conducted in Spain which analyzed the factors that made some universities more successful than others in technology transfer, mechanism used to generate spin--offs. The study which included 47 public universities analyzed the impact of the nature of university research, the amount of research funding and the research quality of the academic staff on the number of spin-offs generated by the universities. The findings of the research indicated that creation of research based spin-offs generated by universities depend on such factors as the availability of incubation services and the focus of research. The universities with strong focus on engineering and life sciences tend to create more spin-offs because both applied nature and the technology regime of their research output make it more easily marketable. With regard to funding, although total funding does not play a key role in the spin-offs activity, the amount of industry-funded research is positively related to the production of spin-offs [Pazos et al. 2012].

Despite the belief that science parks are effective seedbeds for innovation-based new start-ups, the research on the impact of research parks on the creation of new technology-based firms (NTBF) is not in consensus. Effectiveness of the vehicles of technology transfer is impacted by resources possessed by these mechanisms. The four types of resources mentioned in literature as conditions for effective transfer of knowledge and technology from universities to industry: institutional resources, human capital, financial resources and commercial resources [O'Shea et al. 2005].

Another key factor that impacts the creation of innovation based start-ups is the availability and ease of access to start-up financing. Traditionally, it has been hard to attract debt financing due to high level of risk associated with start-ups. The other alternative – equity investments are also not very easy to reach. Therefore, some governments have created special grant programs to stimulate the creation of new technology-based start--ups. The next section discusses different types of financing available for innovation based new ventures.

ROLE OF START-UP FINANCING IN STIMULATING INNOVATION-BASED ENTREPRENEURSHIP

Financing new ventures created through commercialization of research have always been challenging. The main reasons include absence of credit history, lack of steady cash flow, and significantly high risks associated with new ventures. Generally, for financing start-ups there are available equity and debt sources.

Sources of equity financing

Equity financing is very important in the process of commercializing research due to accessibility. Unlike commercial banks, equity investors are less risk averse and therefore suit well for new technology based start-ups which involve significantly high levels of risk. The major disadvantage of equity financing is that founders of the start-up usually have to relinquish part of ownership and give up partial control. The three main types of equity financing available for start-ups include *business angels*, *venture capitals* (VC) and *initial public offerings* (IPO).

Business angels are experienced and wealthy individuals who invest their personal capital in start-ups. Angel investors generally spend between $10 and $500 thousand in a single company and are looking for companies that have the potential to grow 30 to 40% per year before they are acquired or go public [Gimmon et al. 2011]. Most cited cases are investment received by Apple from Mike Markkula, former executive at Intel, who invested $91 thousand in 1977 and personally guaranteed another $250 thousand in credit lines. When Apple went public in 1980, his stock in the company was worth more than $150 million [Thoma 2009].

In addition to funding, angel investors also contribute with their rich experience and network. This was the case with angel investor of Google Andy Bechtolsheim – cofounder of Sun Microsystems, who invested $100 thousand in 1998 after its cofounders Larry Page and Sergey Brin showed him the early version of Google's search engine [Batelle 2005].

Venture capital is an investment by venture capitalist (VC) firms. They are typically formed as limited partners who raise funds in order to invest them into promising high--technology-based start-ups. Unlike angel investors who invest in earlier stages, VCs come in later stages. There are multiple rounds of venture capital funding [Barringer and Ireland 2012] as described in Table 1.

Table 1. Stages (rounds) of venture capital funding

Stage or Round	Purpose of funding
Seed funding	Investment made very early in a ventures' life to fund the development of a prototype and feasibility analysis
Start-up funding	Investment made to firms exhibiting few if any commercial sales but in which product development and market research are complete
First stage funding	Funding that occurs when the firm has started commercial production and sales but requires financing to ramp up its production capacity
Second stage funding	Funding that occurs when a firm is successfully selling a product but needs to expand both its capacity and its markets
Mezzanine financing	Investment made in a firm to provide for further expansion or to bridge its financing needs before launching an IPO or before a buyout
Buyout funding	Funding provided to help one company acquire another

Source: Own elaboration.

Initial public offering (IPO) is the initial sale of a firm's stocks to public. Angel investors and VCs reap returns on their investment during IPOs. By selling stocks, the firms raise equity capital which is important to finance current and future operations.

Sources of debt financing

Although there are various forms of debt financing the most popular ones for start--ups are single-purpose loan and line of credit. Other types include peer-to-peer lending, vendor credit and factoring – a transaction where one firms sells its accounts receivables to a third party in exchange for cash.

Unlike equity financing, where the new venture does not need to pay back the loan, it debt financing, new ventures are usually required to pay back the principal amount and interest. This is a major disadvantage for new start-ups which are usually in dire need of cash. Advantage of debt financing is that the new venture does not share ownership with other parties.

CONCLUSIONS

Many developing nations around the world which are investing in stimulating their innovation potential and developing their national innovation policy, cannot afford to miscalculate the importance of technology transfer mechanisms. In addition to the other three leafs of the four-leaf clover – the industry, the government, and academic institutions, the technology transfer mechanisms serve irreplaceable role of a bridge between technology generators and technology seekers. While there are multiple mechanisms which serve as catalyst to transfer knowledge and technology from universities to industry, the literature is not in consensus regarding their role.

Besides the establishment of the four elements mentioned above, it is vital to ensure that the new ventures, which are formed as a result of commercializing research generated by technology generators, have access to startup financing so they can transform into a sustainable business. Due to the risk-averse nature of debt financiers, such as commercial banks, innovation based startups usually target equity financiers including angel investors and venture capitals.

Finally, role of universities and research institutes are significant in creating a national innovation system. Since not all businesses have capacity to generate technology, research produced by universities serve an important role as a source of knowledge. Many universities in developed countries have established research parks (or technology parks), a trend which is being imitated by universities in developing countries. The role of these mechanisms is to bridge universities to industry by translating the research conducted by universities and research institutions and put them in a form which is usable by technology seekers.

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ROLA MECHANIZMU TRANSFERU TECHNOLOGII W STYMULOWANIU INNOWACJI

Streszczenie. Innowacje przyciągają uwagę wielu społeczeństw z powodu znaczącego wpływu na efektywność i jakość życia. Wysiłek wielu państw aby zachęcić do innowacji sprawił, że zyskały one impet w ostatnich dekadach. Aby poprawić zdolność absorpcji innowacji i zapewnić społeczeństwu maksimum korzyści z badań uczelni, ważne jest, żeby transfer wiedzy przez nie generowany do przemysłu odbywał się przez komercjalizację badań. W artykule omówiono mechanizm transferu technologii, który wspomaga komercjalizację badań uniwersytetów i instytutów badawczych poprzez nadanie im formy, która byłaby użyteczna dla podmiotów poszukujących innowacyjnych technologii, takich jak: małe i średnie przedsiębiorstwa, przedsięwzięcia start-up i rząd. W artykule analizuje się efektywność transferu technologii w stymulującą innowację, jak również finansowe warunki wspomagające przedsiębiorczość bazującą na innowacjach.

Słowa kluczowe: innowacje, transfer technologii, badania, start-up

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