TECHNOLOGY TRANSFER IN COUNTRIES IN TRANSITION: POLICY AND RECOMMENDATIONS

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Technology Transfer in Countries in Transition: Policy and Recommendations

Chapter 1: Introduction, background and implementation

1.1 What is Technology Transfer and who benefits from it?

"Technology transfer" – what is it? Formal definitions taken from prestige academic sources[1] are not very different from definitions given by popular WEB sites, e.g.: 1. "Assignment of technological intellectual property, developed and generated in one place, to another through legal means such as technology licensing or franchising"[2]; or 2."the process of skill transferring, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services."[3] All definitions refer to the process of transforming intellectual properties into products, and, in the scope of this report, transferring research results from public research organizations (PROs) to the industrial sector. Technology transfer is a collective term for the mechanisms and processes that enable the development of a product or a technology used to manufacture products from the knowledge formed in PROs. In the following, we mainly refer the academia, where novel and basic knowledge is generated in, for its own sake. Industry, on the other hand, develops and manufactures products, and markets them. Academia and industry are two cultures that differ from one another and exist side by side. *The process that bridges between them, and that enables the marketing of goods based on academic research, is defined as the transfer of technology.* While technology transfer is of great importance to the knowledge-based economy and to modern society; it should be examined in all its aspects against the backdrop of the traditional roles of both academia and industry to quantify its usefulness and estimate where and to whom the profits are directed.

Starting at the second half of the twentieth century, structured technology transfer is a deliberate and established activity in developed countries – which is generally viewed as desirable by society. However, due to the classic roles of both academia and industry, technology transfer may also have undesirable aspects to it.

[1] See, for example: Bozeman, B., *Technology transfer and public policy: a review of research and theory*, Research Policy 29_2000.627–655

[2] http://www.businessdictionary.com/

[3] http://en.wikipedia.org/wiki/Technology_transfer

There is a cultural gap between academia and industry, a gulf that is sometimes called "the death valley", because they are essentially different from one another. The challenge of technological transfer is the challenge of bridging between these cultures, of building a bridge across "the death valley", the valley that divides between them. Since their foundation, the ultimate objective of the universities has been the **creation of knowledge, its preservation and dissemination for the benefit of the public for generations to come.** According to classical interpretation, "the creation of knowledge" is research for its own sake, in all the fields; "preservation of knowledge" is expressed in writing books, papers and articles and publishing them, as every academician is obliged to do; and "the dissemination of knowledge" is teaching and the publications of research results. The openness, the spreading of knowledge – both in publications and in conferences, lectures and the like – and the obligation to make it accessible to all, the public and the researchers' community, ensure that it will serve the public in the broadest aspect. Academia functions in all fields of knowledge according to the principle of total **academic freedom**. That is to say, there is no preferment of one academic field or another and the significance of the knowledge is determined by its novelty and innovativeness and not according to its field. The definition of academic culture may be reduced to its two key characteristics: Academic freedom and openness. Both these characteristics are imperative for a creative and innovative academia to flourish.

Contrary, the goal of industry is very much differently defined. The ultimate objective of industry is to create wealth. Success in industry is measured in terms of profits for the shareholders. Prosperous industry does indeed benefit society; creating jobs, and wealth that promotes the economy, thus raising the standard of living. Both academia and industry serve the public interest, but while industry serves its shareholders and public benefit is a by-product of it, academia's goal is to benefit the public directly. An understanding of the differences between the sectors will assist the understanding of the problems involved in the transfer of technology from academia to industry.

In the 18th and 19th Centuries there was a clear distinction between academia and industry. The universities were entrenched and ensconced in an ivory tower. They were small and isolated bodies and not an important and essential component of society. Most professors were occupied with teaching, research, writing and forming associations within their community and with other similar communities. Their contact with society was minimal. As opposed to it, the business sector – commerce, industry and also government – was based on pragmatism. Any interface between the practical side of life and its academic side was almost non-existent.

Alongside the tools that were developed in the business world, the subject of registering patents for the protection of inventions also arose. The inventions of that time were principally based on ploys, "tricks", and not on theoretical research. A classic example is the invention of the tea bag. The inventor did not invent it following extensive research into types of materials, but rather on the basis of a brilliant ad-hoc idea and a linking between need and material. It was only towards the end of the 19th Century that a certain link began to take shape between academic research and patents, when knowledge was created in academia and registered as a patent by its inventors. A great and important motivation for the academia's departure from the seclusion of the ivory tower and the strengthening of the connection between science and industry was, in fact, war. In wartime, scientists were enlisted to transfer academic technologies to the armed forces as a contribution to the war effort. Much of the great technological progress that was generated in the 20th Century is closely connected to the two world wars and the cold war that followed them. World War II heralded the development of nuclear technologies that, indeed, were used for destructive purposes in the development and manufacturing of the atomic bomb, however their importance nowadays is greatly embedded in the production of energy and medical instruments. Other technologies like radar technology, coding and encoding, and even computers, originate in technologies that were developed during World War II and all of them are connected to initiatives in which scientists from the universities "were called to the flag". In other words, the military requirements brought about the breakdown of the walls of the ivory tower and the integration of its inhabitants with the general society.

In the second half of the 20th Century, a broad and methodical phenomenon took shape that shattered further the ivory tower, and higher education became accessible to a broad stratum of the population. Academia ceased to be perceived as God's little acre of a few isolated scientists and researchers, who sit with their students and occupy themselves with their own interests, but as a place providing "a commodity", i.e., education, for all. "Accessibility" became the keyword for it. In the 1960's, a system model of higher education, called "the California Model", became entrenched into law in the State of California in the U.S. According to this model, the public system of higher education is composed of three levels. The upper level is the University of California, a multi-campus research university. The middle level is called the State University of California, and it is structured on a network of colleges that award academic degrees. The third level is that of the Community Colleges that is composed of regional bi-annual colleges. According to the California model, higher education is accessible to all who want it – not only people of means and not just the few – since funding of these institutions is public. At this level or another, everyone can acquire higher education. In various countries in the world a policy of encouraging accessibility to education was announced and various models of implementation were developed and, at the same time, an academic degree became a conditional requirement for acceptance in a broad variety of professions. In practice, these processes led the universities to become an important and key factor in society and in the economy, and reinforced society's expectations from academia. Alongside the accessibility to higher education, another trend of increased accessibility to research, science and its products was also developed. In the second half of the 20th Century, organized systems of trading knowledge created in academia began to develop. One of the key systems that promoted the protection of the products of academic research was that of registering patents, which was already widely used by the industry. The procedure starts when a scientist in academia, a member of the academic staff, develops an invention in the framework of his research. The research institute (the university) secures its right in the ownership of the invention by registering a patent that covers the invention, and later on licenses the industry to make use of the patented invention and pay royalties to the research institution and the researcher himself. This mechanism, which was developed in universities in Israel as early as the end of the 1950s and was improved in the 1960s and 1970s, was adopted by the American Administration, by means of legislation, in the 1980s in order to encourage the American universities to trade the knowledge they produce from research that is federally funded. This law, named the Bayh-Dole Act after its initiators.

At face value, the transfer of technology is a process that is profitable to everyone. Industry benefits from the accessibility to the forefront of knowledge and technology, thereby increasing its competitiveness in today's knowledge-based economy. Nowadays, it is not sufficient to invent a tea bag with an aluminum tab in order to have an economic advantage. Today we are discussing industries like biotechnology, nano-technology and hi-tech for information and communication industries in which more advanced and in-depth knowledge is required, and it is already impossible to make do with pragmatic thinking and life experience. In other words, industry requires knowledge that is produced in the universities in order to ensure economic success while decreasing the inherent risk involves in any R&D activity, and a greater ability to compete, which makes the transfer of technology vital. On the other side of the barrier stand the public universities and research institutes, for which research in general, and scientific research in particular, are the foundation stones of their existence. Today's research demands ever-increasing resources: laboratory equipment is expensive, materials are highly priced, and the high quality research person-power requires lengthy training and is costly. Most of the universities in the world are heavily supported by public funding but, many countries do not regard the necessity of supporting them as a high priority, therefore, research financing is insufficient. However, technology transfer enables the universities to increase their budgets with income from royalties, to finance more research and, in the end – produce additional knowledge. Therefore, universities all over the world regard the transfer of technology as an important source of financing. The use of technology transfer is not considered as an obstacle towards achieving the academia's goals, but rather as an important contribution, hence universities make an effort to develop it. The researchers – the inventors – also benefit from the process of technology transfer. Researchers, who developed technologies in the framework of their research that were later successfully commercialized, usually benefit from additional income, sometimes very high, that compensates them for their modest salaries. In some fields in academia a university professor earns much less than he or she could expect to earn in the business sector, and it seems that income from commercializing knowledge could fill that gap. Last but not least, it seems that the broad public benefits from the transfer of technology as well: it is exposed to new and innovative products based on advanced knowledge, to economic prosperity, and is eventually generously remunerated for the investment in research made with the taxpayers' money. Thus, we have a process that everyone benefits from: Industry, the universities, the researchers and the public.

However, this is a mixed blessing. There are cracks in the idyll and that there is a price to be paid for the success stories of commercializing academic knowledge. The attempt to build a bridge across "the death valley", that same ravine that exists between academia and industry, by means of procedures of technology transfer, involves the infiltration of commercial thinking into Academia.

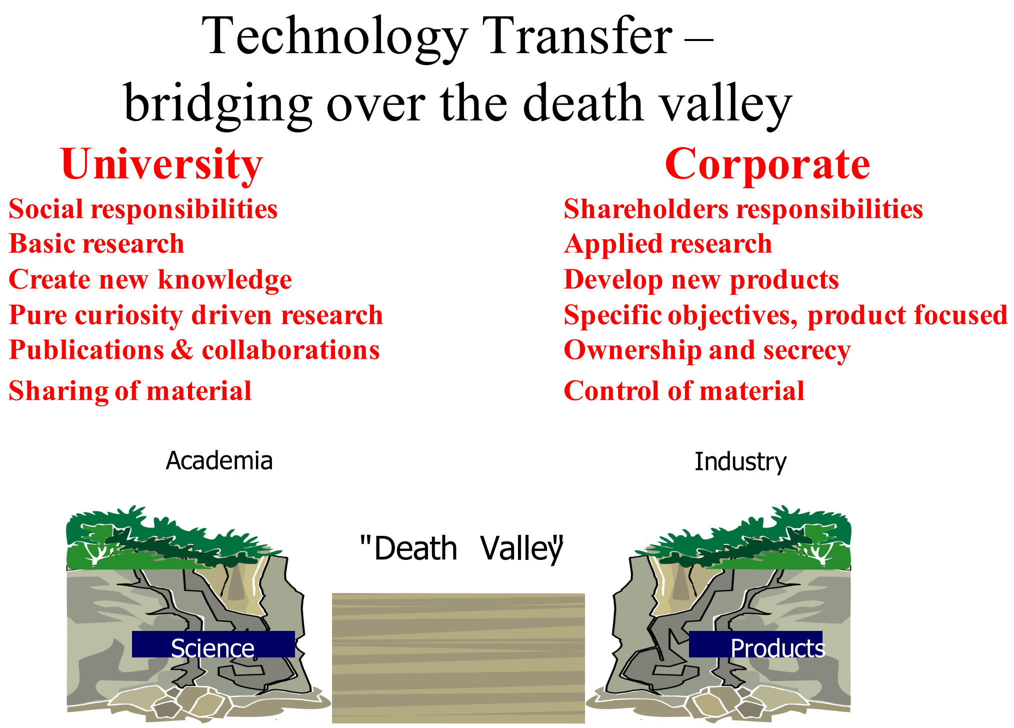

Figure 1 - The "death valley" and the challenge of technology transfer.

Commercial considerations are likely to cause changes in several of the unique characteristics of the university as a public servant and, thus, damage to these characteristics is likely to cause long range damage to the public's interest. Academia – as we know it today and as it was for many years in the past – brought achievements that were scientific, social and more. Damage to its unique character is likely to be expressed, inter alia, in the disappearance or the degeneration of certain fields of study that, perhaps, do not have any foreseeable economic usefulness. It is also likely to cause damage to values, like the value of knowledge for the sake of knowledge, that is not profit driven and doesn't answer the question "What for?" but rather the question "How?" It also causes damage to the status of academia as the guide of humanity's culture and spirit. The academia, by its very nature, is a key institution in human culture and of enormous importance in the development of the human spirit, and commercial consideration is likely to damage this. Moreover, in the long run, changes formed in the academia character are likely to exert an economic toll, both because of the disappearance or weakening of specific areas of knowledge and also because of the limited access to scientific knowledge that will no longer be in the public domain.

Therefore, the challenge that technology transfer from academia to industry poses is to find mechanisms that will create a balance between the broad public interest and the interests of those who participate in the process – industry, the research university and the researcher, both in the short term and in the long term.

1.2 Metamorphosis of an invention – from scientific research to a product.

In spite of the inherent difference and the division between academia and industry, products have always been produced as a result of academic research. In this section we will focus on the mechanisms that have made this possible, meaning the methods and structures that bridge the cultural gap and transfer technologies from academia to industry.

There is an essential difference between transfer of technologies in the past and at present due to the changes in society's perception of the role of academia and the universities. In the past "the death valley," which divided between academia and industry, was not considered a problem since society did not have expectations of a connection between the two sectors. Each of them was managed separately, according to its own organizational culture and its method of activity. Nevertheless, there were links between academia and industry and they were maintained in two principal ways. The first link, the classic one, was formed by university graduates. Some of them studied at university in order to acquire education and were later on absorbed into industry, bringing academic knowledge and relevant skills to it. This link mainly enabled the transfer of "Know How," of abilities, and is less relevant to the implementation of the specific results of research by the industry since the students are less occupied and exposed to research. The second link between academia and industry catered indeed to the transfer of specific concrete knowledge with certain inventions. We are mainly referring to initiatives by individuals. There have always been some people in academia who were interested in developing their inventions. There were also people in the business sector who took an interest in ideas and techniques that were developed in academia and came into public domain via publication, especially publications that passed from academic literature to more popular literature as *Popular Science*, or *Scientific American*, and demonstrated their potential for implementation. Those same entrepreneurs bridged between academia and industry by contacting the university or the scientists directly in order to advance their ventures. The entrepreneurs of the time, on both sides of the fence, can be called "Super-Marios" because, as in the famous game, they skipped over "the death valley," from academia to industry and back. They were few in number, with the personal characteristics of entrepreneurs, and the establishment was not organized to assist them. Nowadays, initiatives by individuals and "Super-Marios" are no longer relied on for two main reasons: First, this method doesn't ensure that the relevant knowledge will reach the wide public; and secondly, the wide public, or the government that represents it and invests public funds in the universities, want to ensure the efficient transfer of technology so that the process will, indeed, serve the public interest. Accordingly, mainly "institutional" methods and built-in mechanisms of transferring technology from academia to industry are used nowadays.

In addition to the bridging across "the death valley", the development gap must also be bridged in order to bring a product to the market. The invention made during academic research is only the beginning of a long and bumpy road. Even if it is proven not to cause damage and to be implementable, further development work is required: to engineer it for manufacturability, usability and cost, prepare a user-friendly interface and suitable packaging and calculate a price for the product the market will be prepared to pay. In the case of drugs, the regulated approval procedure of the invention for medical use includes many lengthy and expensive clinical studies before introducing it into the market. If a research indicates on a potential drug, the scientist at the university can isolate the active ingredient, identify its components and, if it is new, the university will be able to register it as a patent. However, from here, the road to introducing the new drug which begins with academic research and ends up on the drugstore shelf is long and paved with pitfalls constituting the development gap. The more advanced the development, the less the risk and uncertainty of reaching the end of the road. Who finances this development process? In general, the private sector is not happy to take risks, hence it will not invest money except towards the end of the process, when it approaches completion and the risk is small.

While academic research is open, free, and driven only by curiosity, the next stage on the way to producing the product, after identifying a potential direction, requires research directed towards implementation. This kind of research is built-in and involves a series of definite steps and milestones. For example, there is a definite protocol for the development of drugs with regard to isolating the active ingredient and synthesizing it under controlled conditions (e.g., GMP, Good Manufacture Practice), testing its action on animals and, only then, conducting a set of controlled tests on human beings aimed at verifying the safety and efficacy of the drug, also, comparing it to other drugs on the market in case there are any. Contrary to basic research, which has plenty of room for improvisation and creativity, implemental research involves rigid and regulated procedures with definite goals, objectives and milestones. As stated, the developmental road begins in academia and continues to industry but the question of where the border line between them is drawn, is open and dynamic. The answer depends on the field, the financial backing, the researcher and the time period. The road to implementation begins in research that is different in its nature from the basic academic research described in the previous chapters, but not only from the standpoint of industrial research and development. It can be defined as the "optimization" of academic ideas, as a feasibility research. This type of research may possibly be financed by a business corporation (industry) that is interested in the potential product, within the framework of an agreement between it and the university, according to which the first stage of the development will be carried out by the inventor himself within the framework of the university. The advantage of this route to industry is the fact that the inventor is familiar with the technology and can therefore perform the task efficiently and relatively cheaply. Sometimes, public bodies (foundations and governments) will undertake the financing of the initial "nascent" stage of development - implementation-oriented research – in academia, with the aim of reducing the business risk and advancing development to the stage where industrial entities will be interested in the product. However, even when a source of finance is found for implementation-oriented research, the researchers are not always trained for or interested in this type of research, but prefer to focus on academic/basic research. In a system based on academic freedom, the choice of whether to agree to take part in the implementation-oriented research or not is exclusively that of the researcher.

There are three main key mechanisms or models of technology transfer from public research organizations to industry:

A. **Sponsored research - Agreements to order research:** This refers to application-oriented research, which is ordered and funded by the relevant industry under conditions that will assure it of a license to use the product of the research as stated in the agreement. The order may be placed by and at the expense of an existing industrial company that is interested in the technology, or by another party that is interested in the promotion of the study and its industrial development. From the university's standpoint, the sponsored research is a source of research funding. But, unlike academic research, driven by curiosity, the sponsored research has goals, assignments and schedules that by their nature are actually suited to the industrial "side" of "the death valley." The mechanism of the ordered research constitutes a directional bridge that allows for the channeling of characteristics from the industrial sector to the academic sector.

B. **Commercialization of Intellectual Property Rights through License agreements:** Filing of a patent application and the following formal grant of the patent is a legal registration of ownership of the intellectual property in inventions. The patent owner has the legal right to prevent and stop any unpermitted make, use or sale of a product or service that infringes the patent. A license agreement grants a person or an entity, usually an industrial organization, a license to use the patent. The university seeks to enter into a license agreement with an existing industrial company, to use a patent which is based on the invention of a faculty member and has potential in the field of operation of the company's business. The agreement sets the conditions of the license, beginning with the obligations that the industry takes upon itself (like the obligation to diligently develop and market the product), the obligations that the academia takes upon itself (the most significant obligation is the exclusivity right) and ending with the financial terms. The financial terms are aimed at sharing the profits generated by sale of products based on the invention between the owner and the user of the invention. It may be determined that a one-time fee shall be paid immediately upon signing the agreement, or the company may wish to reduce the financial risk by paying a smaller up-front fee to be accompanied with milestone payments and royalties on product sales. According to this model, the university transfers its intellectual property rights to industry in a manner similar to renting out halls to external entities for conventions, which ends the university's involvement in the process. This model is quite common in the industrial arena, for example in the drug industry where the university's patent is for a substance found during a research to have the potential to treat a specific disease. In many cases, the industry is interested in having the beginning of the development process done at the university. In such a case this further research work is integrated into the license agreement, and a research and license agreement (***R&L***) is signed.

C. **Creating a new company:** The third mechanism is the model of new companies established on the basis of university technologies, also known as "spin offs". This refers to start-up companies, when a seasoned entrepreneur backed by an external body decides to develop certain research results into a product. In many cases, the university takes a certain share of the ownership of such a company in lieu of the up-front fee, as part of the consideration for the license to use the patent. In most cases the inventor, the faculty member, becomes an active partner in the new company. According to this model, the university is likely to benefit from the future sale of its shares in the company, and once the product comes on the market, it will also benefit from royalties on its sales.

If we analyze these three models according to the metaphor of "the death valley" that divides between the academic culture and the business culture, then, as was pointed out, it will become clear that the first model – ordering the research from the university - bridges "the death valley" from industry to academia. In other words, the academia takes upon itself certain characteristics originating in the industry's culture - schedules, obligation to the client - that don't usually exist in the academic culture. However, by virtue of the fact that an agreement has been signed involving the flow of money from industry to academia, or from a body that represents the industry's interests, this culture permeates the academia. Of course, this process serves a desirable goal of product development, but it may have undesirable damaging implications that have not been taken into account. Firstly, the introduction of business thinking into academia may damage one of its fundamental characteristics – its openness: the industry will request certain confidentiality treatment of the research result. Some compare science to a parachute: both work only when they are open. Like the parachute, science that isn't open may crash and lose the creativity and innovation that characterize it. Furthermore, the ordering and financing of research by industry may place the researcher in a conflict of interests between his obligation to the company funding the research and his obligation to the university, to science and research.

Figure 2 - The 3 main mechanisms to bridge over the Death Valley in structured technology transfer.

For example, if a researcher is assisted in her studies by a research student and the research achievement is of commercial importance to the company funding the research, the question is asked: can that same research achievement serve the student in the continuation of his research work, or will it be entrusted solely to the commercial company? A potential conflict of interests almost never exists when the work environment is open and cooperative and the common goal is to contribute to universal knowledge. The additional risk that derives from the ordered research is the limitation placed on publishing academic knowledge. Often, the body that orders the research demands the right to prevent or delay publication in order to assure itself of an advantage over the competitors. A demand like this opposes the basic character of academic research, which is the obligation to publish all the research findings in their entirety as soon as possible. Moreover and perhaps even worse, is the fact that it has already been proven that aside from delaying publication, the involvement of a business corporation in research may lead to sifting the results, and even the concealing of part of the relevant information that may not serve the goals of the company. What happens, for example, when university research suggests that some drug or another, in existence or in development, causes damage? If the company owning the drug is the one that funded the research, there is a danger that it will try to prevent the publication of this information. But even if the company did not fund this particular research project but another project of the same researcher; he may be under heavy pressure because his project is dependent on funding.

The second mechanism of the license agreements of patents registered for the products of university research bridges "the death valley" from the opposite direction - from the university to industry. Here, the business factor does not permeate the university; rather, it is the university that transfers the fruits of the "trees of research" to industry, and industry takes responsibility for continuing the development. Seemingly, this model is less "hazardous" to academia, but also involves undesirable implications. One of the dangers is blocking the access to research methods and tools. When a patent is registered for a research method or a research tool, this method or tool become less accessible for use by all scientific and academic agents, since it requires a license in order to make or use such method or tool, or one has to pay the licensee. Another danger is the price increase of tools that are required for scientific research. Moreover the licensing system might limit the spread of scientific knowledge. Sometimes, publication may be delayed until the patent is registered. Another danger is the change in the directions of the research. As stated, academic research is conducted according to the principles of academic freedom and openness and every faculty member decides what area of research he will be involved in. Registration of patents on research products that can reward the researcher with personal royalties and funding for future research may deflect the directions of research of some of the researchers according to the potential inventions worthy of registration as patents.

The third mechanism, which focuses on the establishment of start-up companies where academia and industry are partners, has advantages, like the other two models, as well as negative implications that were not taken into account. Here, too, a conflict of interests is likely to be created both for the individual, the researcher (as in the previous case) and for the research institution itself. The university, which is obliged to the public that finances a large part of its activities, may find itself as the owner of a company with a business interest that conflicts with that of the public at large. Here, too, there is danger of deflecting the directions of research conducted by faculty members in favor of business advantages, and areas of research that do not have a business potential will disappear. A statistical study conducted in 2003 found that indeed, as a result of commercialization and orientation to technology transfer, there were reports of concealment of knowledge that would otherwise have been published to an extent of 48%. The study also found that in about 46 % of the cases, the researchers postponed the scientific publication by about four months due to patent registration procedures.

The statistical study also revealed that when the research was funded by an industrial corporation or some other external body, there was a delay of five months in 72% of the publications. In other words, the undesirable influence of technology transfer on the characteristics of academic research was proven empirically.

Chapter 2: Best Practice Examples: Technology Transfer in Israel

2.1 National and institutional policy

National knowledge-based economy is commonly measured the expenditure on civilian R&D as a percentage of the gross domestic product (GDP). In most countries this level is less than 3%[4]. The average expenditure on a civilian R&D as percentage of the GDP in all OECD countries in 2008 was 1.9%. In 2000, the Lisbon treaty of the European Union set up a strategic decision to raise the average expenditure on R&D in Europe from 2.4% of the GDP to 3% towards 2010. The Lisbon target was retained other aspects of the treaty were lost) because a higher rate of R&D expenditure was seen as essential for Europe to build a thriving and competitive knowledge economy. Figure 3 indicates on the fact that in 2008 Europe has still be far from the Lisbon target, while Israel was leading the world with a record rate of 4.7% of the GDP expended on R&D.

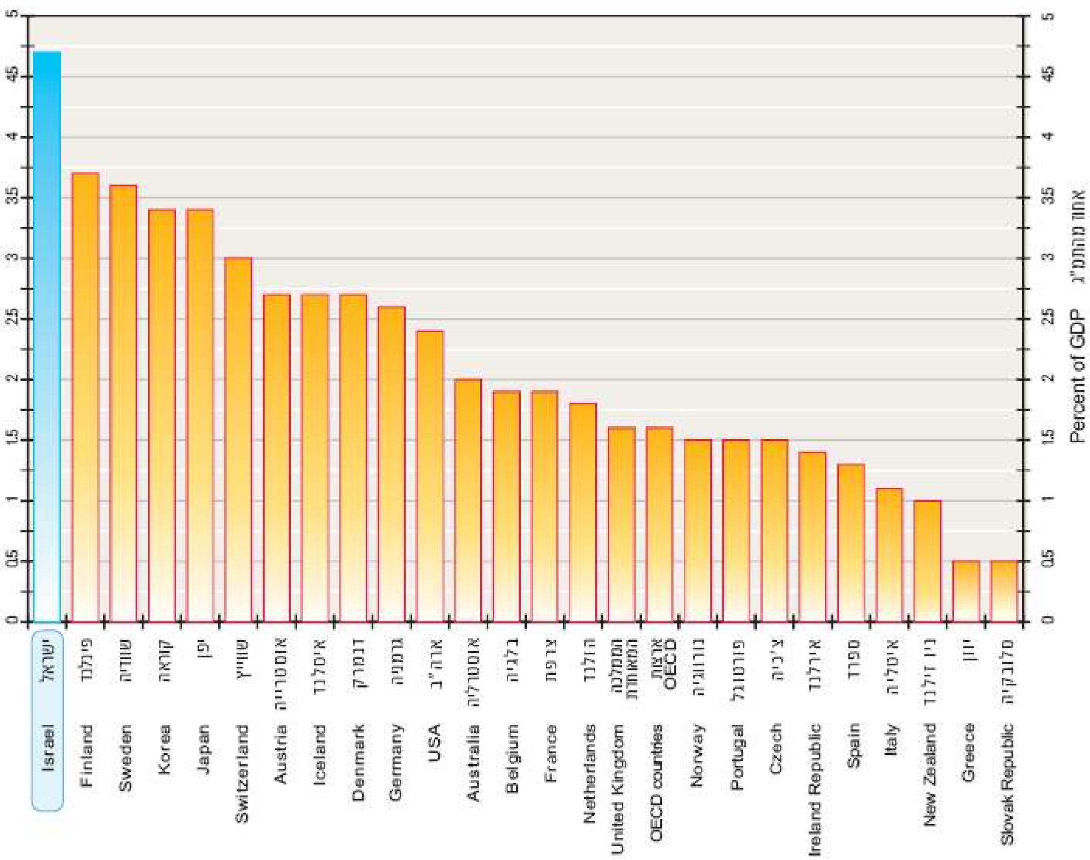

Figure 3 - Expenditure on civilian R&D as a percentage of the gross domestic product (GDP) in 2008 (source OECD)

[4] http://www.nationsencyclopedia.com/WorldStats/WDI-tech-research-expenditure.html

Israel has more companies listed on NASDAQ than any country outside North America. Since the 1980s almost 200 Israeli companies had an initial public offering on the NASDAQ. Currently, approximately 125 companies are listed (through the years, many have been acquired, merged with other companies or gone out of business). In a recently published book[5], *Start-Up Nation*, Dan Senor and Saul Singer describe Israel's remarkable success in technology innovation. They suggest that the creation of an innovative culture is the key to success on commercializing technology. Where is this R&D investment directed into? Also, it is important to note that technology transfer from universities to the Industry in Israel started already in the 60, and – by all measures – it is very successful. As such, Israel can be considered as a best practice example.

Like many other countries, Israel has three R&D sectors: Industrial, academic and governmental. ***The industrial sector*** is defined as market-oriented. Its objective is to introduce new and innovative products into the market which will sell and benefit the shareholders. Industrial R&D is conducted entirely by the business sector or in few cases by other sectors, according to the industry's instructions. Most of the industrial R&D is funded privately by the industrial companies themselves, by investors and venture capital funds, etc. About 80% of the total investment in civil R&D in Israel comes from the private sector, which directs it towards industrial R&D. The rest of the investment in R&D comes mostly from public funds, where approximately 40% of these *public* funds being channeled through the Office of the Chief Scientist of the Ministry of Industry and Commerce to support industrial R&D. ***The academic sector*** is characterized by research that is intended to enrich the pool of common knowledge, and is not directed towards a specific application, otherwise known as "basic research." Academic research based on the principle of academic freedom, meaning the researcher – and only the researcher - determines the research topic, the methods and the research plan. Academic research in Israel is performed in research universities, which are independent legal entities. Such research requires funding, mostly public, which is directly transferred to the university via the Planning and Budgeting Committee of the Council for Higher Education, and via research funding agencies such as the Israeli Science Foundation. About 50% of the Israeli

[5] Senor, Dan, and Saul Singer. 2009. Start-up nation: *The story of Israel's economic miracle.* New York: Hachette Book Group.

governmental investment in R&D (which is about 10% of the national R&D investment) is directed towards academic research. The third sector, ***the governmental R&D sector***, and pertains to necessity-oriented applied research for the public's good. "Necessity" refers to, inter alia, the areas of agriculture, public health, quality of the environment or education, which the government must provide its citizens with, and which often require R&D, even if the products do not have a potential market for sale. In Israel, the governmental R&D is mainly performed in governmental research institutes or by civil servants, or by other sectors following successful proposals made for tenders issued by the relevant governmental offices. The funding for governmental R&D is entirely public. The governmental R&D budget is fairly small compared to the other sectors, and it constitutes approximately 10% of the public investment in R&D. In short, the civil R&D investment in Israel is mostly directed towards the industrial sector. This sector receives the entire private investment as well as approximately 40% of the public investment. The academic research sector and the governmental R&D sector share the remaining public funding, while the academic research sector receives about a half of the public funding and the governmental R&D sector receives only about one tenth.

Historically, each of the 3 R&D sectors in Israel operated independently with respect to technology transfer, according to its goals and means. The ***academic sector*** in Israel includes seven research universities: The Hebrew University of Jerusalem, Tel Aviv University, Bar Ilan University, Ben Gurion University, Haifa University, the Technion and The Weizmann Institute of Science. All of them have been involved in technology transfer for decades. Each of the universities, which are non-for-profit independent legal entities, founded a subsidiary – a technology transfer company - that handles the commercialization of academic research results on behalf of the university. This activity started as early as 1959, with the foundation of Yeda Research and Development Company Ltd., the commercializing company of the Weizmann Institute of Science, to be followed in 1966 by the foundation of Yissum, the technology transfer company of the Hebrew University in Jerusalem and in 1974 by Ramot at Tel Aviv University Ltd., the commercializing subsidiary of Tel Aviv University. All the universities have internal statues that regulate their researchers' rights and obligations on the issue of technology transfer, as well as agreements with their subsidiaries, the commercializing companies. Universities in Israel worked and are working towards transferring technology to the best of their understanding, and according to the existing national and international legal infrastructure regarding taxes, intellectual property etc. In U.S. universities, for example, the body in charge of academic technology transfer is a Technology Transfer Office (TTO) – a sub-unit of the university and not a *subsidiary*, a Technology Transfer **Company** (TTC). The decision taken in Israel to establish technology transfer units as Companies instead of being university offices derives from the existing regulatory infrastructure in Israel, and mainly for tax purposes. Until about the end of the second millennium, the government was not involved or even interested in the issue of technology transfer from academia to industry. Despite (or perhaps due to) this non-involvement, two of the seven universities – The Weizmann Institute of Science and The Hebrew University of Jerusalem have proven highly successful in technology transfer on an international level. These two universities commercialized academic technologies for an incredible financial scope, and are among the top dozen universities in the world today in terms of income from commercialization of academic inventions. Other Israeli universities are also registering patents and trying to commercialize them, but have been less financially successful so far. It is interesting to note that the leading institutions in Israel have managed to maintain high quality scientific output alongside successful technology transfer activity. In the beginning of the third millennium, Israeli scientists won 5 Nobel Prizes in science[6], a great achievement by any international standard, and in 2005, The Weizmann Institute of Science was named the top research institute in the world for scientific study by readers of *The Scientist* magazine.

What is the secret in technology transfer and scientific success? We shall examine the policy of the most successful institute of all - The Weizmann Institute of Science. The Weizmann Institute has a clearly stated policy on technology transfer, which includes four principles. The first principle states that the industrial funding of academic research must be limited in scope and time. That is, research conducted by the institute's researcher will not be based on private funding only; it is authorized to receive a research budget from the industry for a limited time only, so as to ensure other activities based on budgetary resources that allow for complete academic

[6] Ada E. Yonath, Chemistry, 2009 ; Robert Aumann, Economics, 2005 ; Aaron Ciechanover, Chemistry, 2004 ; Avram Hershko, Chemistry, 2004 ; Daniel Kahneman, Economics, 2002

freedom. The institute itself also makes sure that only a limited portion of its research funding comes from the business sector. In doing so, the institute maintains the characteristics of academic research and a favorable gap between academia and industry. The second principle pertains to the right of publication. In any engagement whatsoever, the Weizmann Institute ensures that the researcher maintains his/her right to publish articles and papers with no limitations. The funder cannot limit the right to publish, and if he insists on it, the institute turns down the funding. The third principle states that when signing agreements with an industrial firm, the firm will undertake to develop the product diligently in order to introduce it to the market. That is, The Weizmann Institute does not allow a firm to acquire the rights to material or technology in order to gain advantage over competitors just by preventing access to it. If the industrial firm fails to develop the product, its license is terminated. The fourth principle states that The Weizmann Institute reserves the right to commercialize other technologies, even if they may compete with a technology that has already been commercialized to a certain firm. The four basic principles of the Weizmann Institute of Science, together with the fundamental rule to keep the ownership of intellectual properties at the institute, and license it under conditions which guarantee the public interests, are in essence ethical principles set forth out of concern for the public interest and not only for its immediate financial benefit. In 2007, twelve research institutions in the U.S. got together and published a document with a similar approach to that of the Weizmann Institute, detailing nine proposed principles for responsible commercialization of academic knowledge entitled, "In the Public Interest"[7]. The Weizmann Institute's success as a leader both scientifically and commercially proves that protecting the public interest does not conflict with successful technology transfer, and perhaps even goes hand in hand with it. The Weizmann Institute, via its technology transfer arm, the Yeda Research and Development Company Ltd., was rated first in the world in technology transfer revenues in 2006. In 2003 it has been reported[8] yearly royalties income of $93,000,000, monotony increasing over the years. So far, dozens of products based on Yeda's patents have made it to the market. In 2003, more than three billion dollars worth of products licensed by Yeda were sold world-wide, and at least twenty new companies were established in connection with technologies transferred from the

[7] http://www.fptt-pftt.gc.ca/eng/news/2007/docs/mar07_white_paper.pdf
[8] http://www.ishitech.co.il/0904ar5.htm

Weizmann Institute. The Weizmann Institute is possibly the only academic institute today that could claim to have invented concurrent three "block-buster" drugs in the market: The COPAXONE®, a drug for treating Multiple Sclerosis, which was licensed to Teva Pharmaceutical Industries Ltd.; REBIF®, a competing drug also used to treat Multiple Sclerosis, which was licensed to Inter-Lab Ltd. a Serono S.A. company; and ERBITUX® for the treatment of colorectal cancer and head and neck cancer which was licensed to ImClone Systems Inc.. The Weizmann Institute success is not limited to pharmaceutical products, and another technological invention bringing in high revenues for The Weizmann Institute is an encryption algorithm which is widely used as the basis for television set-top box smart cards, and was exclusively licensed to NDS Ltd. The Weizmann Institute received royalties on the sales of these products and others, and part of the revenues is distributed to the inventors.

How technology transfer from universities is handled from the point of view of the Industry? Most of the R&D leaders in the industry are university graduates, who know and appreciate professors, and view the academic faculty as a source of knowledge and skill. In addition, it is very common in Israel that faculty members serve as consultants to the private sector, and the universities allow for it (within the time frame of one day a week). Until recently, industry, and mainly in hi-tech fields, was not aware of the consultants' obligation to their home institutes, and the faculty members serving as consultants saw their once a week pre-approved consultation to the industry as legitimacy for transferring knowledge and technology from academia to industry. Moreover, The Chief Scientist at the Ministry of Industry and Commerce, who is in charge of industrial R&D on behalf of the government, encouraged technology transfer from academia to industry by way of transferring the practical knowledge, the skill, the Know How of the faculty members. This encouragement was manifested in a few ways. One way is intervention plans aimed at facilitating and encouraging industry-academia relation, such as MAGNET, Magneton and Nofar, which the government initiated and funded via The Chief Scientist's office[9]. However, the industry-academia relations in these programs are not symmetric, giving advantage to the industry and its needs. Another way to encourage technology transfer from faculty members to industry is via tax reliefs. Clause 34 of The

[9] http://www.xml.ecomtrade.co.il/article.aspx?id=847

Encouragement of Industrial Research and Development Law, 5744-1984, which states that a faculty member working in the industry on an R&D project during his or her sabbatical year, will pay tax up to 35%, when the marginal tax is higher (55%). This means that unlike the academic sector, in which technology transfer was done autonomously by the research institute itself according to its policy and understanding, without the government's "guiding hand", the regulator of the industrial sector encourages technology transfer from academia to industry.

From the point of view of the governmental R&D sector the situation is fundamentally different. Basically, the rule in this sector is that the intellectual property rights to the products of knowledge created by governments' employees or via outsourcing to research institutes belong to the state. This means that all the research and development results conducted in governmental institutions, government controlled hospitals or universities under direct funding of the ministerial offices – belong to the state. This situation is similar to that of the US before the Bayh-Dole act, with one major difference – the scale. The governmental R&D sector is Israel, as defined above, covers less than 5% of the university research. Till 2004, only when explicitly requested, the intellectual property rights are transferred to the universities' ownership. If such an explicit request is not accepted then, like any governmental property, the intellectual property is handled by the Accountant General at the Ministry of Finance. Since no mechanisms were formed to handle intellectual property, few patent applications were applied for. Generally, no patents owned by the state were commercialized, and therefore the relevant research results were not developed into products. In 2004, the policy in the governmental R&D sector has been modified in line with the Bayh-Dole act and since then much is being done to facilitate technology transfer from the governmental R&D sector to the industry, in lines similar to that of the successful academic sector.

To sum up: There are three R&D sectors in Israel, each operating independently and creating its own policy for technology transfer from public research institutes to the industry according to its perception and understanding of the situation. The academic sector formed successful technology transfer mechanisms that served the universities and the public, without the regulator's intervention and seemingly. The industrial sector worked in favor of industry, sponsored and encouraged by its regulator – the Chief Scientist office at the Ministry of Commerce. In the third, small sector of governmental R&D, practically no technology transfer was executed. Until the beginning of the third millennium, technology transfer in Israel was not investigated nor analyzed on a national level, and no infrastructure, such as specific tax laws and patent laws to support such activities, was created or even discussed. The changes in the last decade are mostly aimed at the governmental R&D sector, leaving the academia-industry successful direct channels in place.

2.2 Bridging the "Development Gap" – providing proof of principle

It is quite well-known among technology transfer organizations serving academic institutions around the world, that the Achilles' heel of transforming academic invention into useful product is the so-called Development Gap that lies between the state of immaturity of the academic discovery and the proven feasibility requirements of the industry. Special care is been given in Israel to bridging the development gap.

From the standpoint of the universities in Israel, a successful transfer of technology is part of the circular research route, as shown in Figure 4. The process originates in ***basic*** academic research, curiosity-driven research initiated by the researcher, in research directions of his/her choice, and according to the criteria of academic freedom and the aspiration to excel. From time to time, research of this kind may produce inventions. There are innumerable examples of research that began for curiosity's sake and gave rise to an idea for an invention leading to products. The story of Prof. Ada Yonath, who studied the activity of the ribosome, a component in every cell that is responsible for manufacturing its protein, for 20 years, a work for which she received the Nobel Prize for Chemistry in 2009, is one example. Her study was a typical basic research. Its ramifications stretched from the depths of the Dead Sea, where she found forms of life that were resilient to difficult conditions, to outer space, where the absence of gravity served as a laboratory for her experiments. Only after it became known that Yonath had deciphered the structure of the ribosome, her study aroused great interest in the drug companies, which saw in these findings the possibility of developing new antibiotic drugs. Without aiming to a product, her basic, excellent research results could be transferred to the industry, leading to new products. As in this example, and due to the decentralized pattern of work in academia, the researcher is completely independent, both organizationally and cognitively, and therefore the researcher and only he/she can recognize the implementable potential of the research either on his/her initiative or as a result of reactions to his research from the community. Hence, the entire technology transfer process begins with the researcher and relies on his/her initiative. When a researcher reaches the conclusion that he/she has an invention or a potential invention, he/she can report it to the commercialization arm of the university – the TTC - and the professional handling of transferring the institutional technology begins. This is point A at Figure 4. Please note that the researcher can publish the results without consulting the TTC. In that case, it actually follows the traditional route of technology transfer – from the public domain to the industry, via Super Marios.

Once a researcher reports on an invention or discovery by filing an Invention Disclosure Form (IDF), the experts at the TTC examine the latent possibilities of the invention both for patent registration and for commercialization. If the results of the examination are positive, the TTC sets about registering a patent for the invention and begins building a marketing strategy, that is, business development. The TTC tries to identify an industrial body that is interested in the invention so it can produce a product based on it, and if successful the university will grant the industry a license to use the patent under an agreement that safeguards the industry's obligations, including payment for the license. The money received for the commercialization of the invention will be divided between the inventors and the university[10] and will be used to finance other basic curiosity-driven academic research that might allow for new inventions. Following is the "life cycle" of a university invention, which besides making it possible to self finance further academic research; it also contributes towards economic growth and the welfare of the inventors.

In many cases, however, the reported invention is premature for commercialization. In these cases, a bridge over the development gap is needed. The TTC experts identify the "missing information", which will be subsequently requested by potential licensees. A proof of the principle of operation of the technology, or a proof of feasibility will be required. The business development officers of the TTC will advise the researcher regarding the performance of such further research that will fill the gap, and point him/her towards possible funding instruments for performing these activities. This specific point needs further elaboration:

[10] In most universities sin Israel, the inventors receive 40% of the commercialization income. Out of the 60% left, some goes back to finance research (typically 20%) and the rest to cover the TTC expanses and to the university needs.

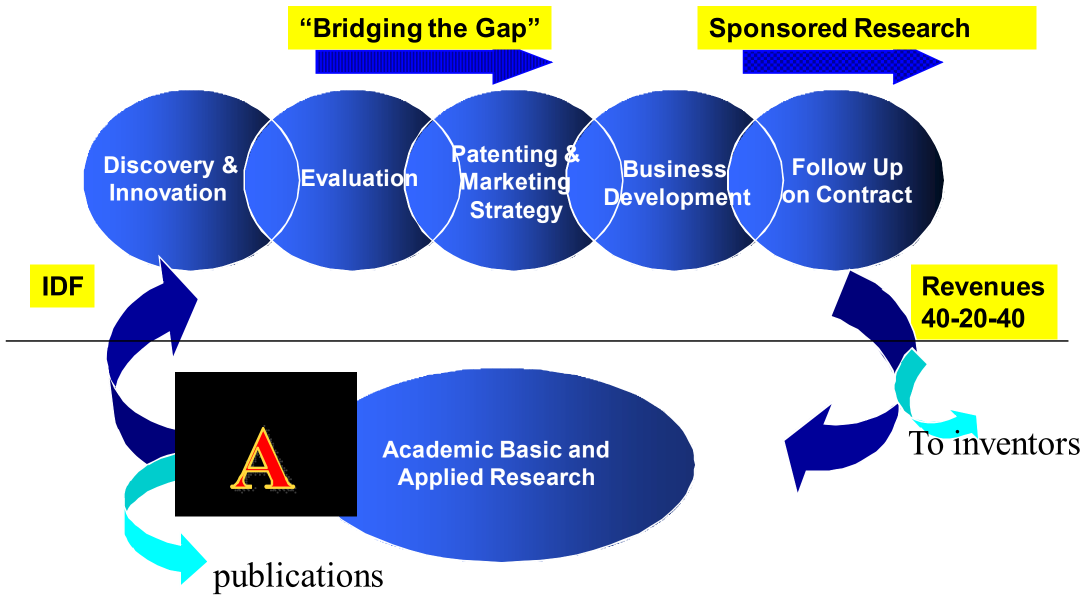

Figure 4 - Technology Transfer process in a research university in Israel. The horizontal line represents the border between the university (below) and its commercialization arm – the Technology Transfer Company (above).

As universities in Israel, and their TTCs, are independent legal entities, and as the technology transfer process was a bottom-up one, they found their own solutions for dealing with the need to bridge the development gap. In 2003, Ramot, the TTC of Tel Aviv University, founded the Tel Aviv University Fund for Applied Research, with contributions solicited from the Yeshaya Horowitz Foundation, a non-profit philanthropic organization. Ramot recruited an advisory board made up of scientists from TAU and other academic institutions, industrialists and venture capital officers, and this board is convened twice a year for selecting the research projects that will be funded. Project selection is based on scientific merit, IP protection, ability to attain a proof of operating principle within a limited period (usually one year) and limited funding (about $100,000), and clear and present market need. Apparently, at about the same time frame, two such funds were founded in the US, with similar targets: The MIT's Deshpande Center and the University of California, San Diego's von Liebig Center[11]. In 2007, a second similar fund was established by the TAU's Colton Family Next Generation Technologies Institute, to be matched with equal financing by Johnson & Johnson Services Inc. As of 2008, about 50 research projects at TAU have been financed by these funds, of which 18 were still ongoing. Six of the funded

[11] Gulbranson, C.A. & Audretsch, D.B. (2008) 'Proof of Concept Centers: Accelerating the Commercialization of University Innovation'. Ewing Marion Kauffman Foundation Report, http://www.kauffman.org/pdf/POC_Centers_01242008.pdf

technologies have already been commercialized under an option or license agreements with Ramot, and 27 technologies were being actively negotiated for commercialization. This performance rate is in the same ballpark figure of that of the MIT's Deshpande Center and the UCSD's von Liebig Center. Based on the proven success of this fund, the state of Israel has recently adopted this mechanism and initiated a governmental support system called KAMIN, to finance proof of concept of academic inventions.

Another type of support for bridging the Development Gap was provided by the TAUTECH Partnership fund, which was founded by Ramot in 2002 with capital raised from private investors. This unique fund was used to finance eight applied research projects selected in the fields of biotechnology, medical devices and energy. Each project received funding of approximately $1,000,000 for a period of three years, with the goal of providing a demonstration prototype, or certain efficacy and toxicity results in animal models at the end of the period. Each research project was accompanied with a dedicated managing advisor, while a steering committee comprising industry and technology experts supervised the overall development progress. The investors of the TAUTECH Partnership are expected to earn a share of the income that is generated from commercializing the sponsored technologies. Of the eight research projects, two were already out-licensed by Ramot. In 2008, one was at the final stage of negotiations, one was still on-going and one project was terminated in mid-term for not meeting its projected milestones. A third type of bridging the Development Gap fund was initiated by Tel Aviv University and Ramot in cooperation with industrial organizations interested in certain technology fields. The funding organizations participate in the selection of the research projects to be funded, and they have certain rights of first review of intellectual properties generated in the sponsored projects.

Many other university technology transfer organizations became aware of the need and the ability to jump-start internally academic innovations in order to boost commercialization, and various combinations of internal and external funding were invoked in order to bridge the Development Gap. The example of Ramot's strategy shows that the money for this process can come from: 1) philanthropy or governmental resources; 2) investors; 3) industry, mostly in emerging technological fields.

2.3 **Technology entrepreneurship in a research university**[12]

EnStorage inc. was founded in 2007 by two veteran business entrepreneurs, Mr. Eran Yarkoni and Mr. Nachman Shelef, in cooperation with Prof. Emanuel Peled of the Faculty of Exact Sciences at Tel Aviv University (TAU), Israel. The young startup acquired from the TTC of Tel Aviv University, Ramot, a license to develop, manufacture and sell innovative secondary fuel cells (energy storage fuel cells) under an innovative technology developed by Prof. Peled. Prior to the license acquisition, the fuel cell technology was developed at TAU with generous funding provided by the TAUTECH Partnership, followed by secondary funding provided by the Tel Aviv University Fund for Applied Research, two internal mechanism for bridging the development gap. The funding obtained from these two sources enabled Prof. Peled and his team to demonstrate feasibility and proof of principle of operation of the novel technology at TAU laboratories. The two enthusiastic business entrepreneurs succeeded in raising the interest of leading US and strategic venture capital organizations that invested in the new startup company. Initial technology and product development is being performed at Prof. Peled's laboratory at TAU under a sponsored research agreement made between Ramot and EnStorage Inc.

Defining "technology entrepreneurship" as the act of transforming innovation into marketable product[13], the story of EnStorage Inc. is an act of entrepreneurship, in which there are few partners: Prof. Peled of TAU is the technology entrepreneur, Yarkoni and Shelef are the business entrepreneurs, and Ramot is the facilitator of the process. The technology entrepreneurial process usually begins with a scientific discovery, which is translated into a useful application. Academic institutions, where scientific basic research is being conducted, are a primary source for such discoveries.

The technology entrepreneurial process which is based on academic discoveries, exercised around the world by various institutions, is implemented in many different ways. In the following we elaborate further into the technology entrepreneurial process at a research university in Israel – Tel Aviv University (TAU), how it is realized, and the different facets it might have under different conditions and with different types of entrepreneurs. In particular, we shall point out where the public

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[12] This section is taken from: Niv Y, H. Messer-Yaron, ***Technology entrepreneurship in a research university: transforming innovations into products at Tel Aviv University***, International Journal of Healthcare Technology and Management, Volume 11, Number 5 / 2010, pp 345 - 355

[13] Brown, T. E., & Ulijn, J. M. (2004) 'Innovation, entrepreneurship and culture : the interaction between technology, progress and economic growth'. Cheltenham, UK ; Northampton, Mass., USA: E. Elgar Pub.

interests guide the process and take preference over the private interests. We shall base our description on experience gained at Ramot[14], in the process of transforming ideas and inventions into useful technologies.

Following Figure 4, the technology entrepreneurial process is part of the marketing efforts. The experts of the TTC, with the interested researchers, identify and locate potential licensees for the technology intellectual properties. Once identified, Ramot will provide the potential licensee with an appropriate business proposal, together with a detailed description of the technology which is provided by the researcher.

In limited cases, the researcher-inventor decides to take a leave from his academic duties, and turns into the business entrepreneurship course of action. The researcher-inventor then joins the startup that is founded around the novel technology, in a high managerial position, in most cases as the leader of technology and product development, and a partner of the business management of the company.

The foundation of Civcom Ltd., a startup in the field of optical communication, by Prof. Mendelovic of the Faculty of Engineering of TAU in the year 2000, is an example of such a case. During its first years of operations Prof. Mendelovic, on leave from TAU, acted as Civcom's CEO.

The process in which the researcher-inventor leaves the academy fits a limited number of people, who, in most cases, will find themselves engulfed and swallowed by the business world. There are few examples in Israel, such as Prof. Haim Aviv of the Weizmann Institute of Science, the founder of Bio-Technology General Israel (now Savient Pharmaceuticals), Pharmos and Peptor; Prof. Max Herzberg of TAU, the founder of Orgenics, D-Pharm and Sepal Pharma; Prof. Shlomo Ben-Haim of the Technion, the founder of Biosense, Instent and Impulse Dynamics; and Prof. Ehud Weinstein of TAU, the founder of Libit.

In most cases, the realization of the technology entrepreneurship can be achieved without the total and complete involvement of the researcher-inventor. In these cases the company-licensee will take upon itself the lead of the technology and product development process. The researcher might accompany the process in a manner limited both in time and scope, while investing most of his/her time and effort in continued academic and scientific research. In order to support and facilitate a

[14] www.ramot.org

successful process, the researcher-inventor should either provide consultation and advice to the company, and will join the company's scientific advisory board, or will take upon himself/herself a further involvement by performing in his/her laboratory at the university certain research that is required by the company as a backup and support for the technology and product development activities. Although considered problematic by some PROs from the conflict of interest point of view, such activities by faculty members at TAU are encouraged, in order to increase the probability of successful transformation of the novel technology into a product, and introduction to the market. At least in the early stages of product development, the contribution of the researcher-inventor to the process is highly valuable, and since the conversion of ideas into useful product is in the public interests, such limited involvement is allowed and fostered.

These models of involvement of the researcher in the technology entrepreneurial process at this stage are more common, and are realized generally in one of the two following tracks: a) Out-licensing the novel technology to a company doing business in the relevant field; b) Out-licensing to a startup which is founded around the technology. In both tracks the researcher might have to provide further entrepreneurial support:

In track (a), the company generally has the required resources (money, personnel, equipped laboratories and well defined product development process), as well as the business knowledge and awareness required to advance the technology into product. The researcher could provide assistance as scientific advisor, or in certain cases perform certain complimentary research in his laboratory under a sponsored research agreement with the licensee. An example for such a case is the license provided by Ramot in 2007 to Merz Pharmaceuticals GmbH, a German pharmaceuticals company, for the development, manufacture and sale of a drug treatment for Alzheimer's disease. The technology was invented and developed by Prof. Ehud Gazit of the Faculty of Life Sciences at TAU, under funding provided by the TAUTECH Partnership. The license agreement calls for further research to be performed by Prof. Gazit at TAU, to complement the drug development process which is performed at the company facilities. Another example for track (a) is the license granted by Ramot in 2005 to M-systems Ltd., which was later acquired by SanDisk Inc., the largest US provider of flash memories. The license provides the licensee with access to and rights of exploitation of technology dedicated to the increase of memory capacity of flash memory devices by use of novel mathematical algorithms which were developed by Prof. Simon Litsyn of the Faculty of Engineering at TAU. Prof. Litsyn provided further consultation to the company, and actively participated in the product development process at the company. Although the two examples above relate to licenses provided to well-established large companies, there are other examples in which licenses were executed with small and young companies. An example is the license for drug platform technology directed towards treatment of Schizophrenia and other CNS disorders, executed with BioLineRx Ltd., an Israeli biotechnology company whose mission is drug development based on academic discoveries. The technology is a cooperative development of a team of TAU researchers, Prof. Avi Weizmann, Dr. Irit Gilad and Dr. Ada Rephaeli, together with Bar Ilan University's Prof. Abraham Nudelman. In this case the licensee sponsored further supportive research at the universities, while all drug development activities are performed by the company at its premises.

In track (b) Ramot grants a license of use of the academic technology to seasoned business entrepreneurs who show proven record and relevant experience, such as the EnStorage example which was detailed in the introduction above. The researcher is usually required to provide deeper support to the new-founded startup. The main assets of the startup at foundation are the license to the novel technology and the team of founders-entrepreneurs. The founders will then develop a viable business plan for the startup, and based on such plan, technology and team will raise investments that will turn the product development process into motion. In such a track, in many cases the initial technology development activities of the company are performed by the researcher under agreement and within the university's facilities. In this way the company can start its R&D operations while hiring experienced R&D staff and setting up an equipped R&D laboratory at a slower pace. Again, such activities are allowed at TAU in order to increase the probability of successful product development.

An interesting successful track (b) example is the foundation of the Israeli startup Bio-IT in 2000 by Prof. Haim Aviv and Dr. Silvia Noiman, both of whom were business entrepreneurs with technological background, together with the active support of Dr. Oren Becker of TAU. Bio-IT was granted a license by Ramot to certain drug discovery software technology that was developed by Dr. Becker and Prof. Zvi Naor of the Faculty of Life Sciences at TAU, and their students. Dr. Becker left TAU and joined Bio-IT as its Chief Technology Officer, while Prof. Naor stayed with TAU, and did not continue his involvement with the company. The company was merged later with Predix, and thereafter with EPIX Inc. The computer program that was developed as part of the Ph.D. thesis of Dr. Sharon Shacham at TAU becomes the cornerstone of the company's drug discovery and development process.

The Canadian company Allon Therapeutics, which was founded on the basis of neuroprotection technology developed by Prof. Ilana Gozes of the Faculty of Medicine at TAU, is another successful track (b) example. Since the incorporation of the company Prof. Gozes is acting as the company's Chief Scientific Officer, besides her continued scientific and academic activities at TAU. The company has an on-going agreement with Ramot for the performance of sponsored research at TAU that is complimenting the company's drug development activities in Canada. DiSP Distributed Solar Power Ltd. was founded as an incubator startup in the Israeli "Yozmot Ha'emek" incubator organization, based on technology that was invented by Prof. Avi Kribus of the Faculty of Engineering of TAU and was licensed by Ramot to the company. Prof. Kribus was joined by Dr. Kaftori, and together they acted to promote the technology and the business activities of the company. Following the two-year incubation program, Ramot joined the negotiations for the next round of investment in the company.

The examples above depict a general view of technology entrepreneurship activities which were performed at a research university in Israel in the recent years.

> ***To summarize***: technology transfer in Israel is a success story – it leads internationally in commercialization of academic research results, while maintaining high scientific level. However, when trying to adopt its best practice, one needs to bear in mind that the present situation in Israel is based on 50 years of experience, and the theory and practice has been built by leaders of public research universities, who consider technology transfer as part of their mission, for serving the public interests.

Chapter 3: In the Public Interest: Guidelines for Commercializing University Technology in Countries in Transition

3.1 Case study on technology transfer in countries in transition[15]

3.1.1 Introduction

In this section we analyze the answers received from 18 countries in transitions to the questionnaire given in Appendix 1. Questionnaires were received from the following countries: Republic of Moldova, Armenia, Romania, Georgia, Lithuania, Uzbekistan, Serbia, Hungary, The former Yugoslav Republic of Macedonia, Poland, The Czech Republic, Cyprus, Azerbaijan, Bulgaria, Russian Federation, Belarus, Slovakia and Malta. The average public expenditure on research and development (R&D) activity in these countries was 0.45% of GDP[16]. While in Slovakia, Romania, The former Yugoslav Republic of Macedonia and Malta this number was 0.24% on average, it was 0.65% on average in the Republic of Moldova, Lithuania, and Poland.
Note that the average expenditure on R&D activity from the private sector in these countries is over 20%, with a high dispersion ranging from almost zero in Republic of Moldova, Romania, and Bulgaria, up to 46-62% in the Czech Republic, Malta and Slovakia.

The goal of the questionnaire was to collect as much as possible information regarding the importance of the knowledge and technology transfer process at the national and institutional level and the existence of adequate legal and institutional infrastructure for the process while learning about the human factor that operates within this framework.
This data, we hope, will help us find the bottle neck, as far as it exists, in the process of knowledge transfer from academic institutions to the industry.
Some of the questions asked to the respondents were "Yes" or "No" questions while some of the questions had the option to choose "in process", meaning that the subject of the question did not currently exist but that there were attempts being made for its establishment in the corresponding country. Other questions were qualitative

[15] This chapter is co-authored with Sharon Bar-Ziv

[16] http://www.nationsencyclopedia.com/WorldStats/WDI-tech-research-expenditure.html

questions in which the respondents were asked to rate their answers on a scale from 1 to 5. Sometimes the respondents were asked to provide detail on their answers, and we have referred to this in the analysis as described henceforth. In some cases we did not receive answers from all the representatives, and this is the reason why sometimes the number of the answers is less than 17. Other questions were formulated in an open question format, and the respondents could mention any additional comments as long as they have found it necessary. We have referred to this in the analysis henceforth.

3.1.2 Comparative Analysis of the different factors related to the Knowledge Transfer Process

The questionnaire was created based on the essential conditions required for the creation of an effective knowledge transfer system. These conditions include the following:[17]

- National economic strategy
- Intellectual Property (IP) infrastructure (IP laws and regulations)
- National IP/innovation strategy
- Capital
- Scientific research
- Institutional infrastructure
- Human Resources with IP skills
- University-Industry collaboration
- Effective commercialization of IPR originated in academic research institutes.

Except for one country,[18] all the respondents were asked to answer some background questions. The goal of these questions was to verify the existence of the above mentioned conditions.

First, the respondents were asked whether technology transfer is part of the national economic strategy in their country[19]. Most of the respondents answered positively (16 out of 17).

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[17] Ali Jaziry's presentation, Budapest October 17th, 2010.

[18] Slovakia did not receive this part of the questionnaire by accident. Therefore, the number of the respondents in this part was 16.

[19] Question No. 1

It is interesting to note that although an encouraging national strategy regarding knowledge transfer may exist, the assessment of the coherency of governmental policy by the respondents was medium-low (2-3) in a scale of 1 to 5[20]. This assessment is consistent with the evaluation of the degree of awareness of decision makers and regulators about the importance of patenting research results in PROs[21], which was also medium-low (2-3) in a scale of 1 to 5.

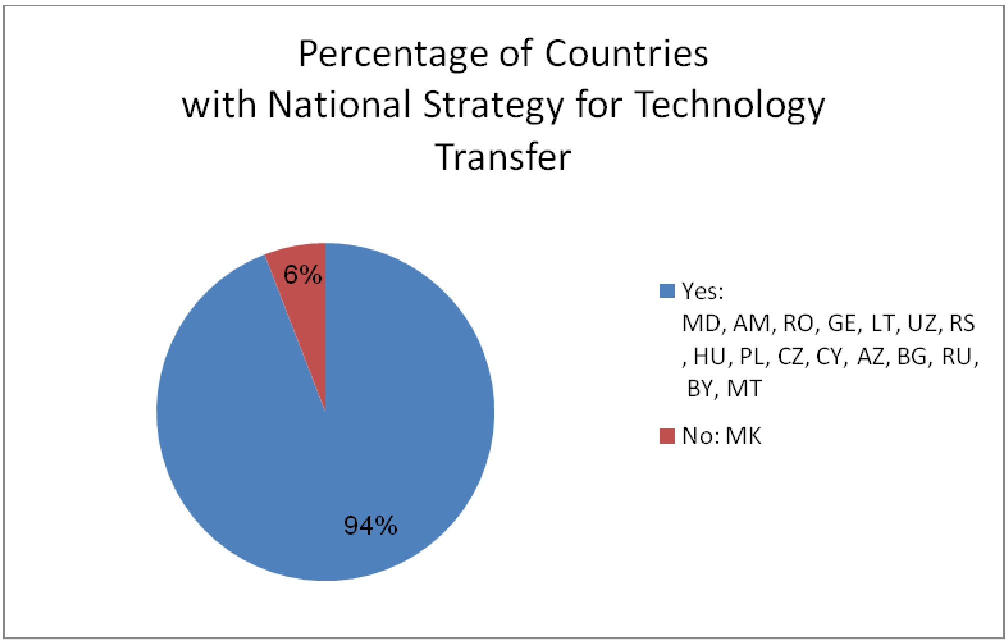

Figure 5 - Percentage of Countries with National Strategy for Technology Transfer (N=16)

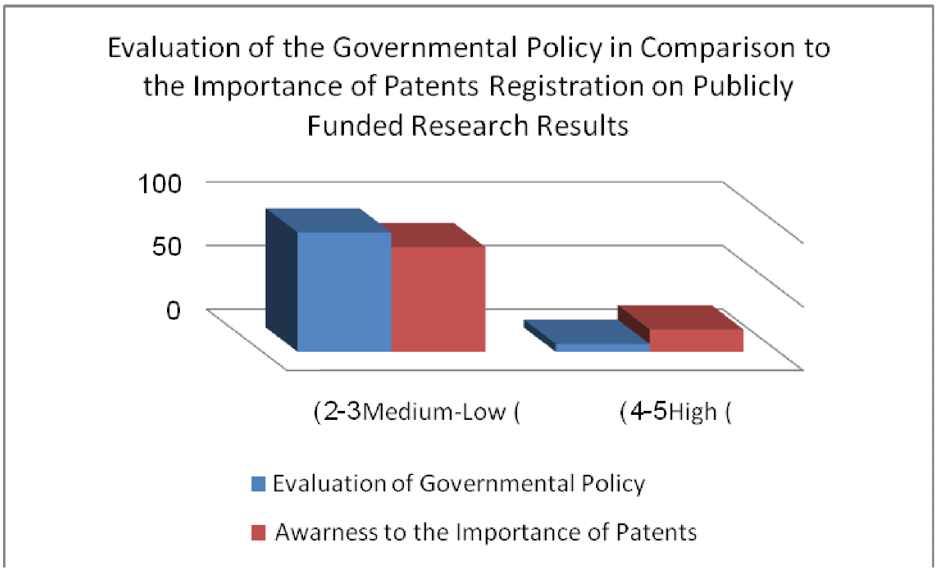

Figure 6 - Evalunmental Policy in Comparison to the Importance of Patents Registration on Publicly Funded Research Results

[20] Question No. 12
[21] Question No. 14

The respondents were asked whether there is an adequate IP infrastructure in their countries with updated IP laws and regulations[22]. 13 out of 17 answered positively and 4 responded that this issue is "in process". It is interesting to note that in comparison to the last report[23], in which Armenia and Romania had answered negatively, this time they answered positively.

Most of the respondents evaluated the legislative framework regarding IP ownership of publicly funded research results being medium-high (3-4), in a scale of 1 to 5[24].

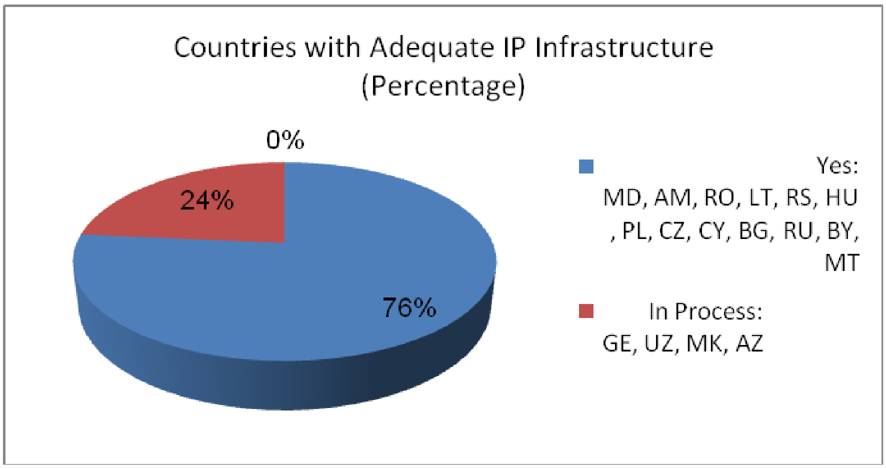

Figure 7 - Countries with adequate IP infrastructure

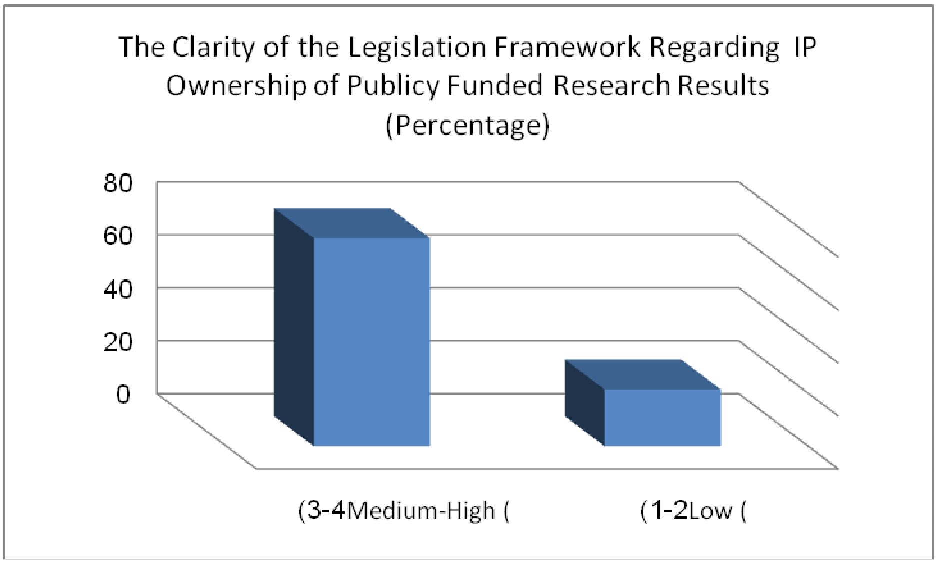

Figure 8 - The Clarity of the Legislation Framework Regarding IP Ownership of Publicy Funded Research Results

The respondents were asked whether there is a national legal framework regarding IP ownership of publicly funded research results and researchers' rights on inventions

[22] Question No. 2

[23] WIPO report: Management of academic intellectual property and early stage innovation in countries in transitions.

[24] Question No.16

that were developed in PROs. Most of the respondents answered positively (8 out of 17), a few answered that this is "in process" (5 out of 17), and 4 answered negatively. It is interesting to note that Azerbaijan, which had mentioned in the past that there was no such regulation in the country, said that this issue is "in process" today[25].

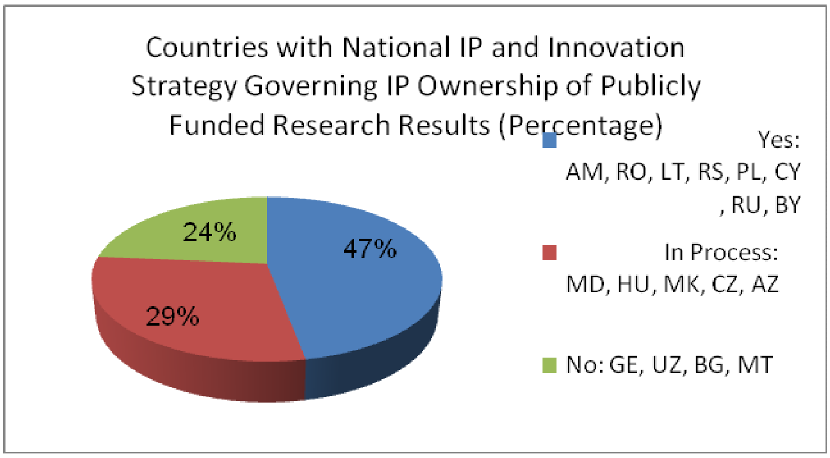

Figure 9 - Countries with National IP and Innovation Strategy Governing IP Ownership of Publicly Funded Research Results

Then, the respondents were asked whether there are sufficient sources of public and private funds to enable an effective technology transfer in their countries. Most of the respondents (16 out of 17) answered negatively[26].

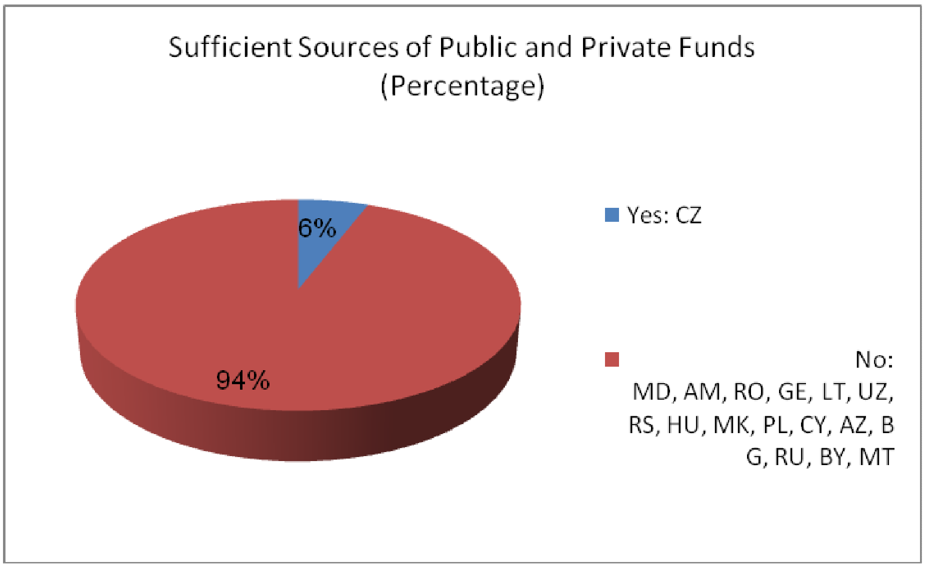

Figure 10 - Sufficient Sources of Public and Private Funds

Another question that the respondents were asked was whether there exist strong scientific research areas with potential technology applications that could generate a

[25] Question No.3
[26] Question No.4

competitive advantage for their countries[27]. Most of the respondents answered that there is strong research in their countries while a few answered negatively.

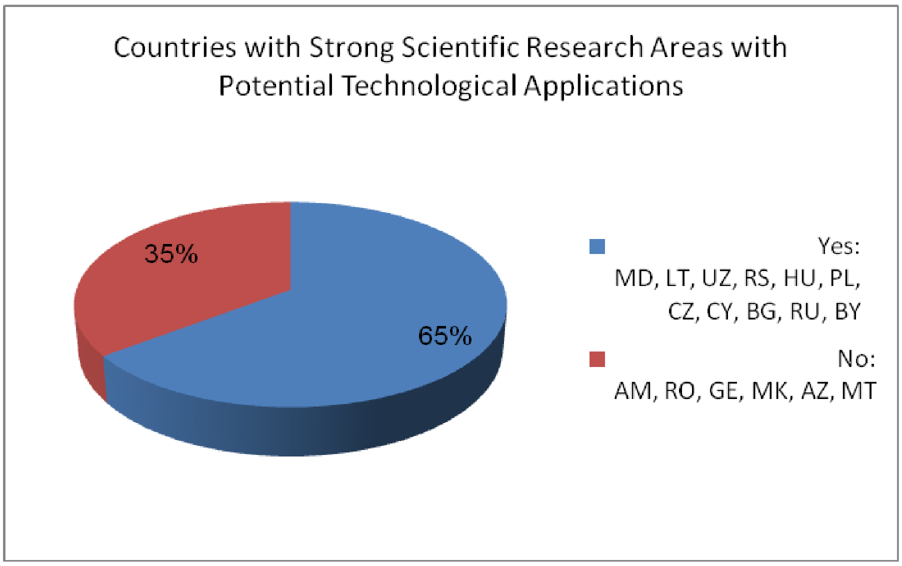

Figure 11 - Countries with Strong Scientific Research Areas with Potential Technological Applications

The respondents were asked whether technology transfer in public research organizations (PRO) is governed by an institutional IP policy in their countries[28]. Most of the respondents answered this issue is in process; some answered positively while a few answered negatively. The former Yugoslav Republic of Macedonia and Bulgaria, countries that had answered in the past that there was no official policy in their PROs, mentioned that this issue is currently in process.

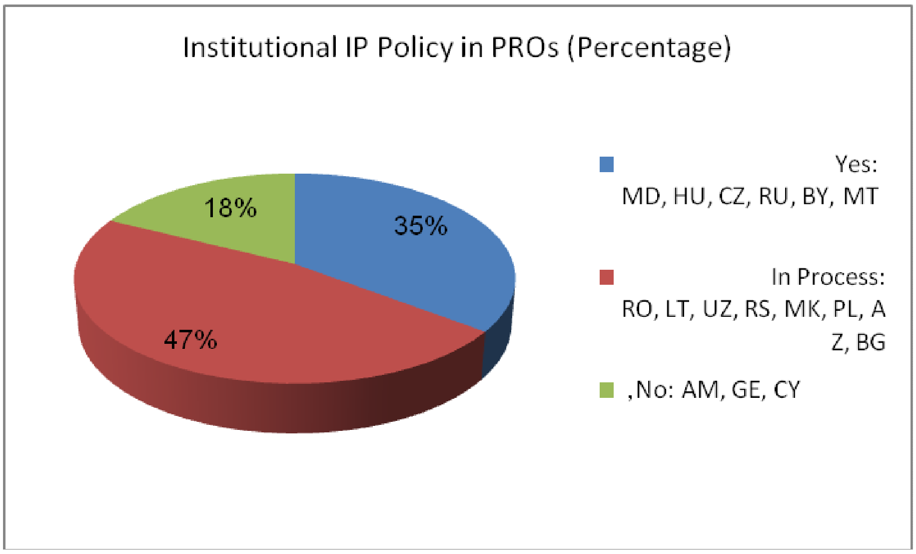

Figure 12 - Institutional IP Policy in PROs

[27] Question No.5
[28] Question No.6

The respondents were asked whether there is adequate university-industry collaboration for efficient technology transfer in their countries[29]. Only a few answered positively.

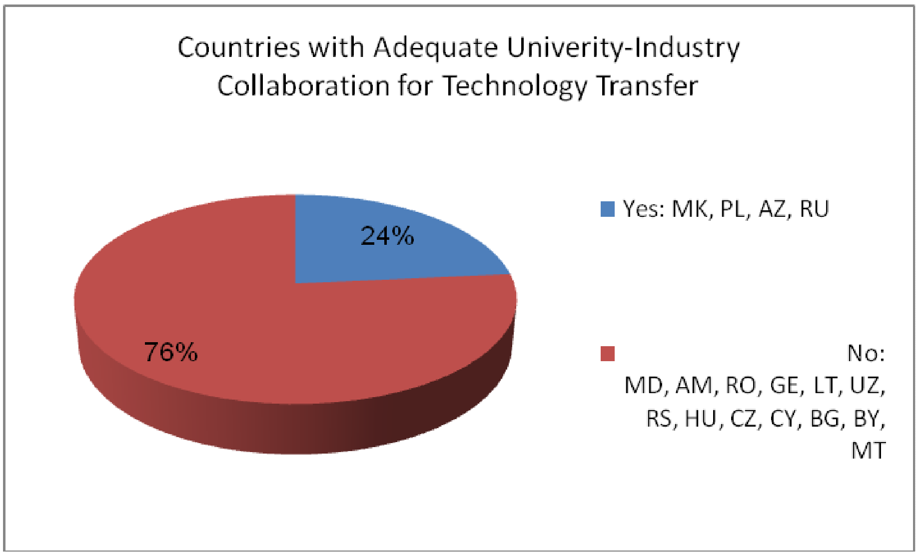

Figure 13 - Countries with Adequate Univerity-Industry Collaboration for Technology Transfer

The wide observation of the different conditions required for the existence of an effective knowledge and technology transfer process creates a picture where most countries either have an adequate legal infrastructure or are currently in the process of creating it and where there are adequate rules for the management of IPR that originated from publicly funded research.

In addition, in most countries, there is an encouraging technology transfer strategy and a strong scientific research with significant application potential that can generate a competitive advantage for the countries. Nevertheless, it seems *there is no adequate collaboration activity between the PROs and the industry, no effective commercialization of research results, not enough skilled human resources, and no funds to enable the existence of an effective knowledge and technology transfer system.*

The gap between the institutional conditions required for the existence of an effective knowledge transfer system (encouraging policies, regulation, and scientific research) and their interaction with skilled human resources and funds is reflected in the extent to which these factors are present in the different countries. At least 65% of the countries have the institutional conditions required for an effective knowledge and

[29] Question No.8

technology transfer system, while only 25% of the countries have skilled human resources and funds for the effective commercialization of research results.

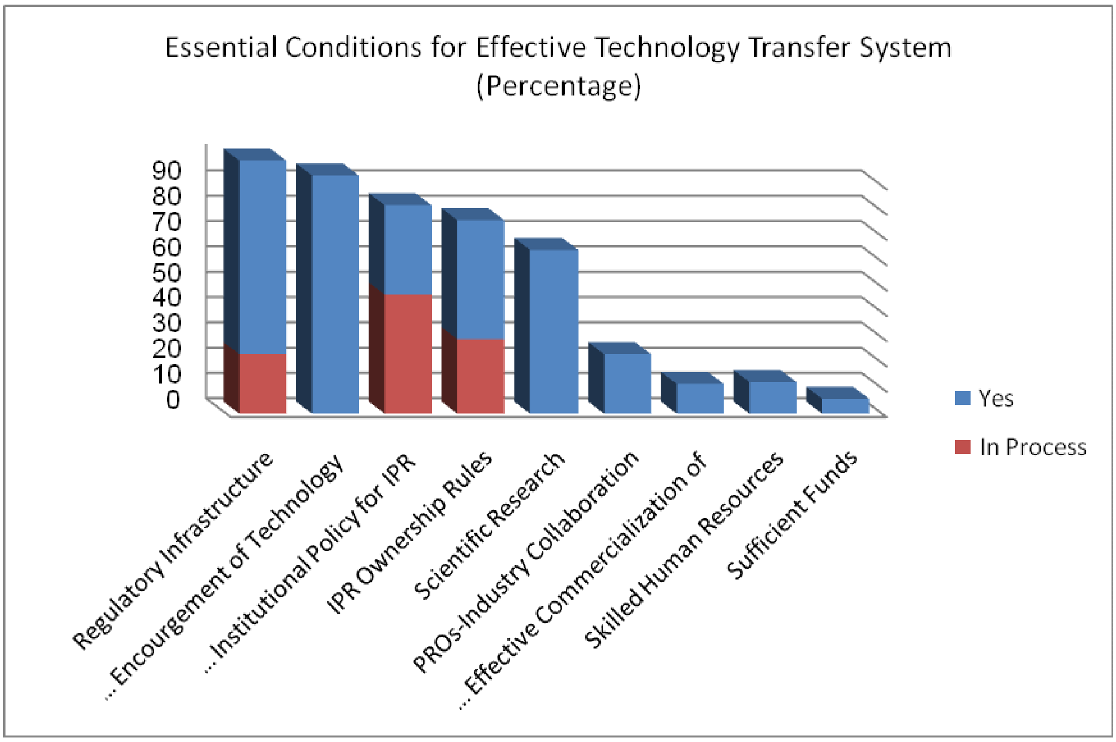

Figure 14 - Essential Conditions for Effective Technology Transfer System

3.1.3. Institutional Regulation

The respondents were asked to answer whether technology transfer in a PRO follows a specific institutional IP policy, code, or set of rules[30]. Most of the respondents (10) answered positively, with relatively highly comprehensible policies (3-4). 6 have answered that there is no such policy (Georgia, Uzbekistan, Serbia, The former Yugoslav Republic of Macedonia, Belarus and Slovakia). It is interesting to mention that Armenia, Hungary, Bulgaria, and Russian Federation had answered in the past that there was no technology transfer policy in the PROs of their countries, while today this exists and has been rated as being relatively highly comprehensible (3-4).

The respondents were asked whether their institutional IP and technology transfer policies impose restrictions on publications and on the dissemination of research results[31]. Out of the 10 respondents, 6 (Republic of Moldova, Lithuania, Hungary, The Czech Republic, Malta and Bulgaria) answered “low restriction” (1-2) while 4

[30] Question No.17
[31] Question No.18

countries (Armenia, Romania, Azerbaijan, and Russian Federation) answered "medium-high" (3-4).

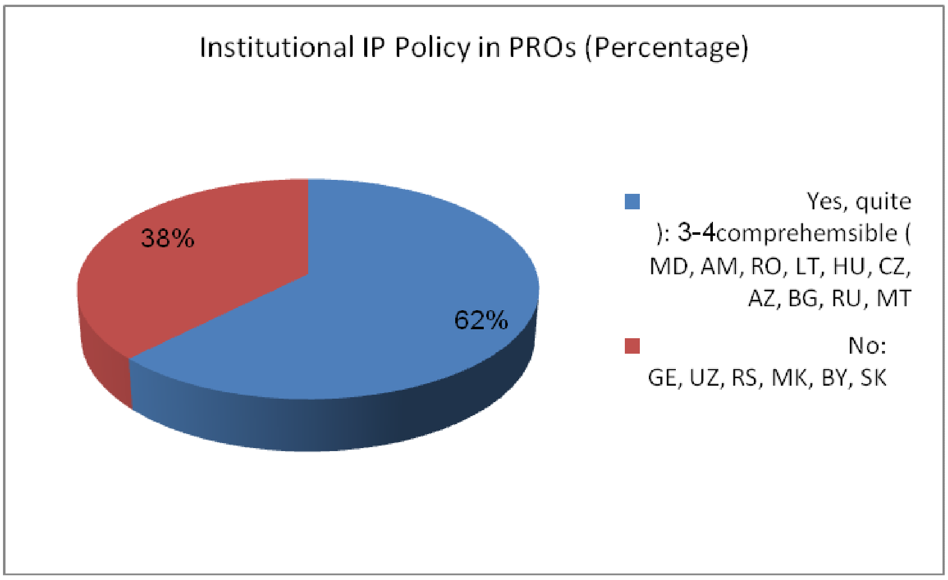

Figure 15 - Institutional IP Policy in PROs

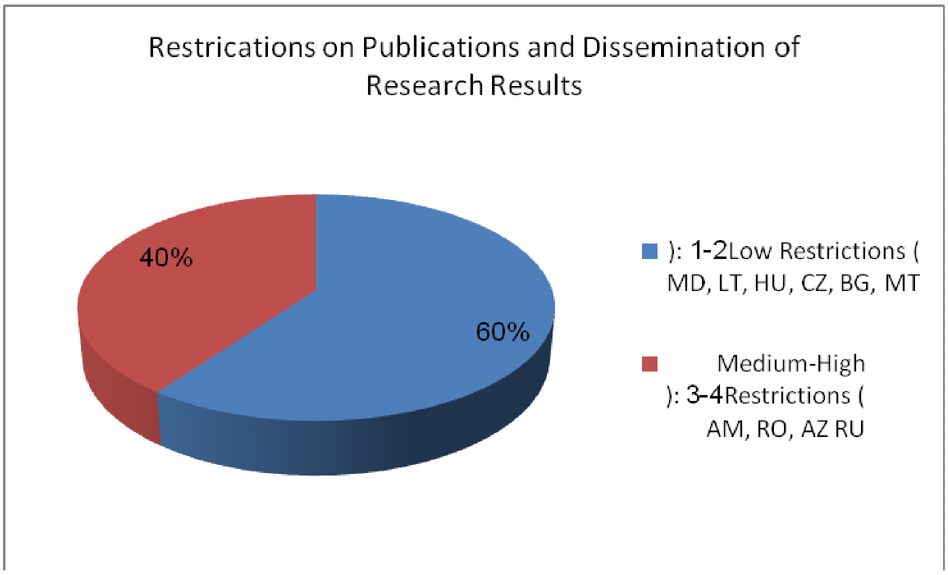

Figure 16 - Restrications on Publications and Dissemination of Research Results

The respondents were asked to state the countries in which the PROs patents are usually registered[32]. 7 respondents mentioned that their patents are registered in local patent offices. 4 respondents (Lithuania, Bulgaria, Malta and Russian Federation) mentioned PCT, and 3 of these (Lithuania, Malta and Russian Federation) said that they also registered their PRO patents in the US. Malta also mentioned EPO and Japan.

[32] Question No.19

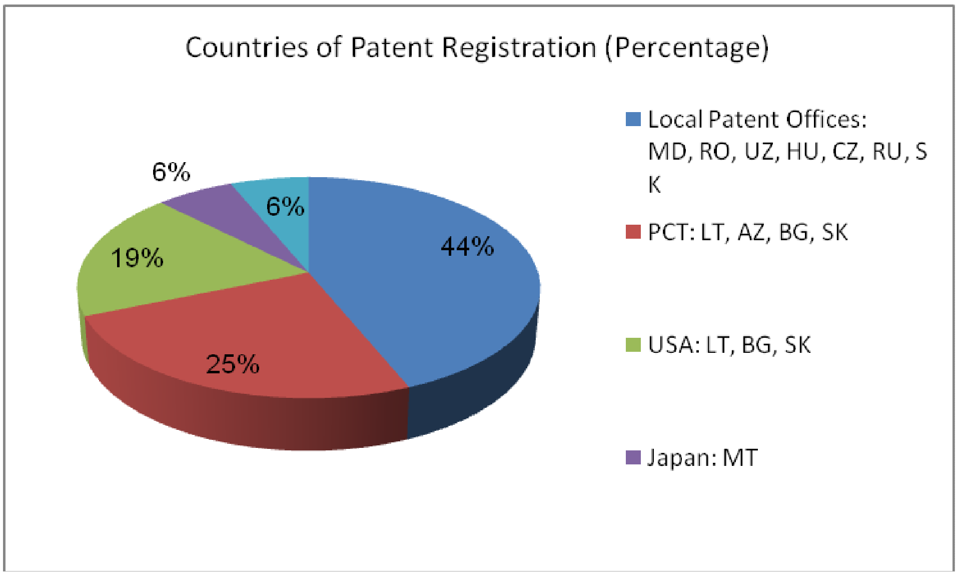

Figure 17 - Countries of Patent Registration

The respondents were asked who was responsible for the registration process and for the payment for the PROs patents[33]. 9 respondents out of 10 mentioned PROs as being responsible for these. In Uzbekistan, they are the researchers' responsibility. In the Czech Republic, the PROs and the researchers share the responsibility. In The former Yugoslav Republic of Macedonia, the PROs and the Technology Transfer Offices (TTOs) are responsible for these.

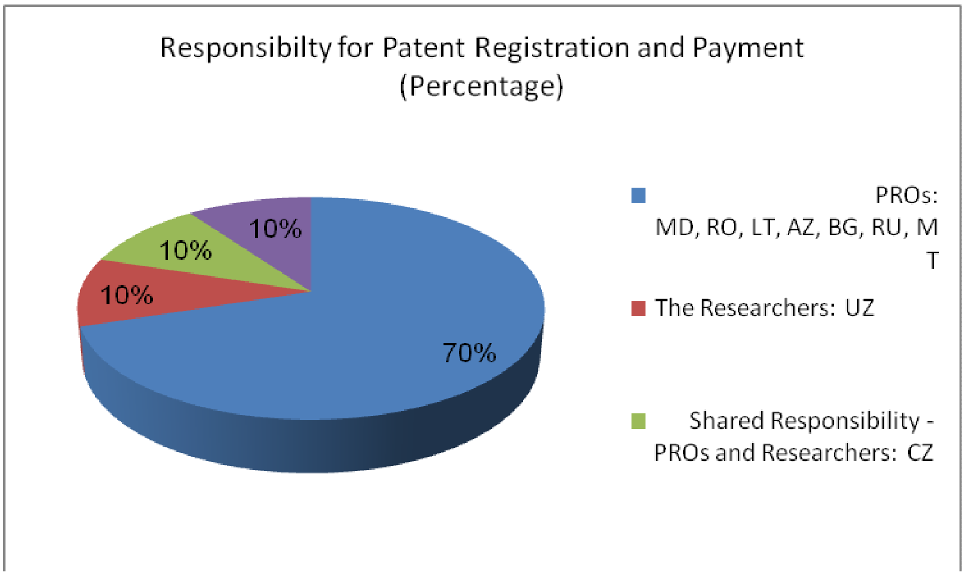

Figure 18 - Resposibilty for Patent Registration and Payment

[33] Question No.20

3.1.4 Technology Transfer Offices

The respondents were asked whether they have a specific body related to the PRO that is responsible for the technology transfer and the related IPR issues[34]. 8 respondents mentioned that they have institutional technology transfer offices in place, and 7 answered they have no such body (Armenia, Romania, The former Yugoslav Republic of Macedonia, Cyprus, Azerbaijan, Russian Federation, and Belarus). It is interesting to mention that Bulgaria, which in the past had answered that it had no such body, said that now it has it.

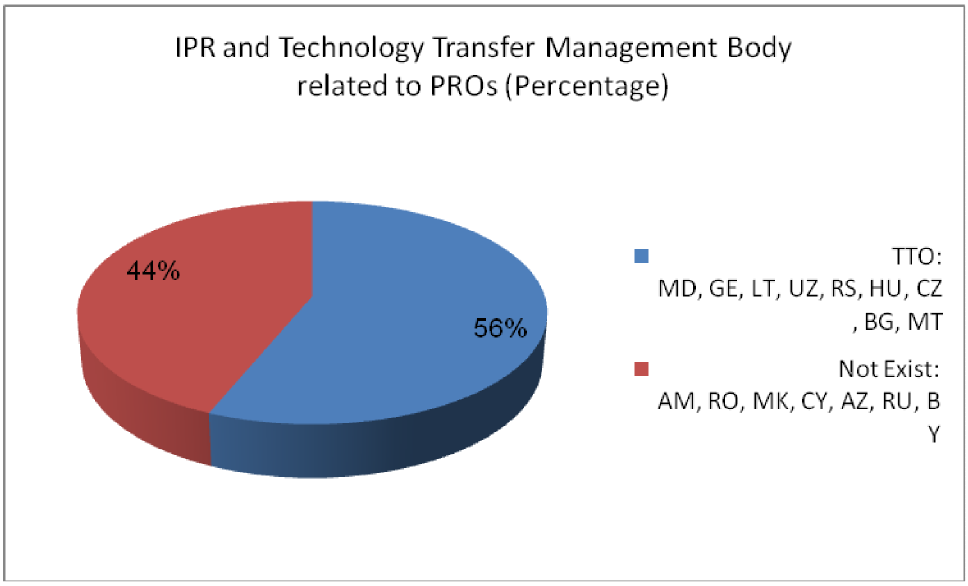

Figure 19 - IPR and Technology Transfer Management Body

The respondents were asked to describe in detail the function of the TTOs in the scientific, legal, and commercial areas[35].

Regarding the scientific area, the respondents mentioned functions such as applying of research results (Republic of Moldova, Lithuania and Bulgaria), coordinating between public research teams and the industry (The Czech Republic, Uzbekistan and Republic of Moldova), finding business partners for technology transfer (Republic of Moldova and Bulgaria), and providing consulting services (Republic of Moldova).

Regarding the legal area, the respondents mentioned functions such as facilitating the technology licensing process (Uzbekistan), editing legal agreements (Uzbekistan), managing IPRs (the Czech Republic), and submitting patent applications (Lithuania).

Regarding the commercial area, the respondents mentioned functions such as transferring technology to the private sector (SME) to support its competitiveness

[34] Question No.21
[35] Question No.22

(Bulgaria and Romania), finding investors (Uzbekistan), identifying the business potential of inventions (the Czech Republic), establishing spin-offs (the Czech Republic), licensing technology (the Czech Republic), communicating with entrepreneurs (the Czech Republic), finding business partners (Lithuania), organizing events in which new technologies are presented (Republic of Moldova), and choosing research projects and finding funds for them (Republic of Moldova).

The respondents also mentioned the need for legally skilled human resources (Uzbekistan) and the clarification of the TTOs functions (Uzbekistan and Georgia).

Following this, the respondents were asked to evaluate from 1-5 the scope of the TTO activity based on the following elements[36]:

- Number of patent applications
- Number of registered patents
- Number of material transfer agreements
- Number of licensing agreements
- Human resources skills in the body

The respondents were also asked to evaluate the TTOs based on the elements below[37]:

- Communication area (Availability of the TTO staff, user-friendly access to information, and transparency of the procedures)
- Scientific area (Assessment of the viability and potential development of the invention)
- Information area (Availability of adequate information tools and services related to patent information, search of prior art, and freedom of operation)
- Legal area (Assistance in IP protection, persecution, enforcement, agreement editing, etc)
- Funding area (Availability of IP protection and commercialization funds)
- Commercial area (Assessment of the commercial potential of the invention, marketing, search of suitable partnerships, business development, negotiation and administration of licensing contracts, etc).

Evaluating the percentage of the countries that responded to these questions with a high rating (3 and more), we discovered that high evaluations were given with a high frequency to the activity of the TTOs in the information and the legal areas (80% of

[36] Question No.23
[37] Question No.24

the countries for each category). The communication area was also given high ratings (80%). The human resources were given only 50%.Additionally, the number of patent application was high in 66% of the respondent countries. In contrast, the number of material transfer agreements was evaluated as being relatively high in only 40% of the respondent countries. 57% of the respondent countries evaluated the activity of the TTOs in the scientific area as being high, but only 37% gave a high evaluation to the commercial area. The number of the registered patents, the number of licensing agreements, and the funding area were evaluated as being high in only 16-33% of the countries.

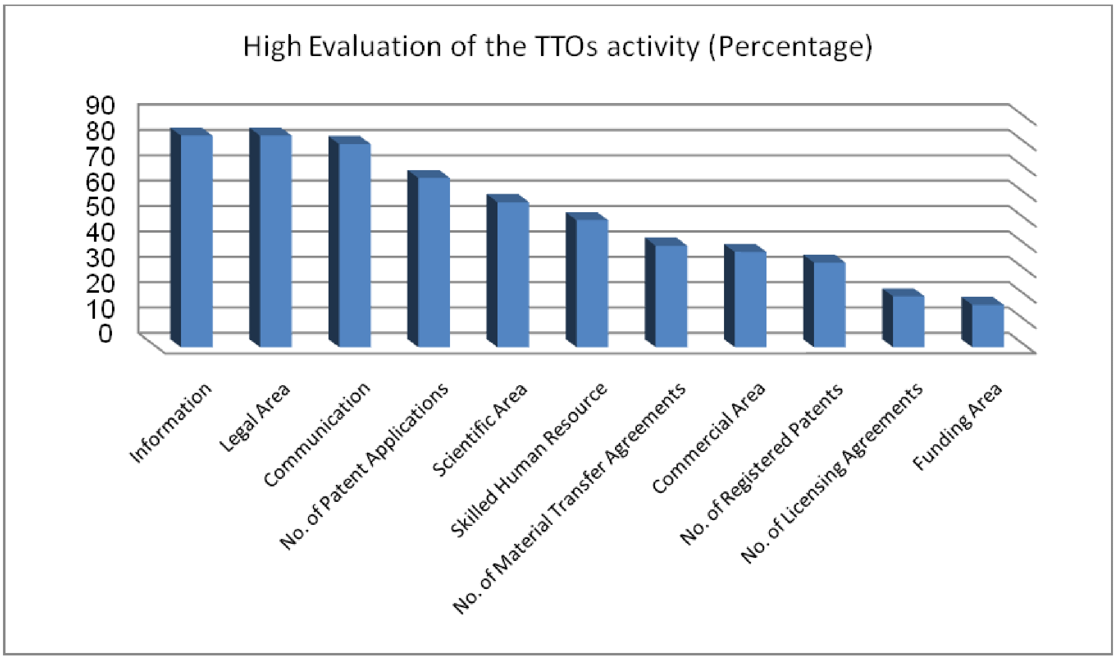

Figure 20 - High Evaluation of the TTOs activity

To summarize: only half of the respondents reported the existence of TTOs and referred to a quite low activity in terms of patent registration and the commercialization of IPR. In addition, the TTOs were given a low rating in the funding area and in their commercial activity. High ratings were given to the information area, the legal area, and the existence of skilled human resources.

It is important to mention that there are respondents that mentioned that while there are no TTOs in their countries within the PROs, there exist central governmental bodies that function in a similar way, most of which were established only recently.

3.1.5 Researchers

The respondents were asked to assess the degree of awareness of the researchers in the PRO on the importance of patenting their research results[38] and to evaluate the level of cooperation between the researchers in the PROs and the technology transfer body scientifically (transferring all the needed information), legally (meeting legal requirements), and commercially.

We can see that while the degree of awareness on the importance of patents (12 respondents replied "3 and more") and the legal and scientific cooperation (10 respondents out of 14 rated "3 and more" in those 2 parameters) are high, the commercial cooperation was rated to be low and insufficient. As a result, the level of satisfaction with the outcomes of the commercialization of research results in PROs was low, and 10 out of 13 respondents provided low ratings (1-2).

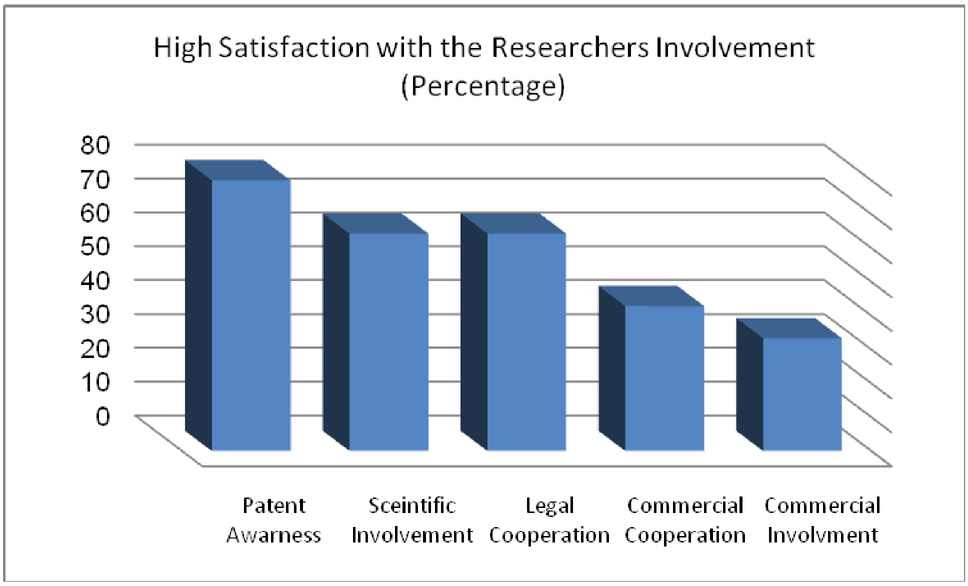

Figure 21 - High Satisfaction with the Researchers Involvement

Another issue the respondents were asked about is the extent of influence of the need to deal with legal issues such as material transfer agreements (MTAs) and licensing agreements[39]. Most of the respondents replied that there is no such influence at all, and about third of the respondents said that such influence exists.

[38] Question No.25
[39] Question No.27

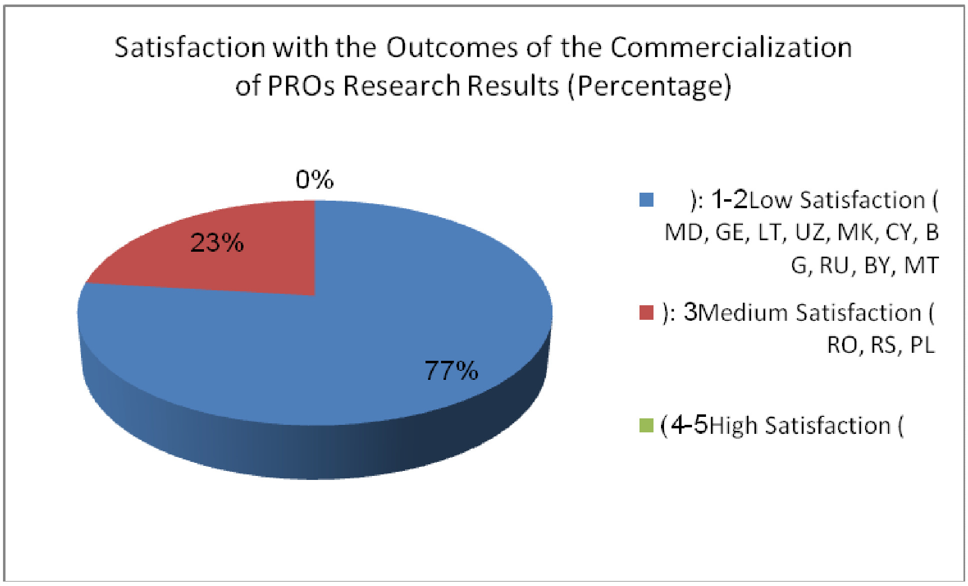

Figure 22 - Satisfaction with the Outcomes of the Commercialization of PROs Research Results

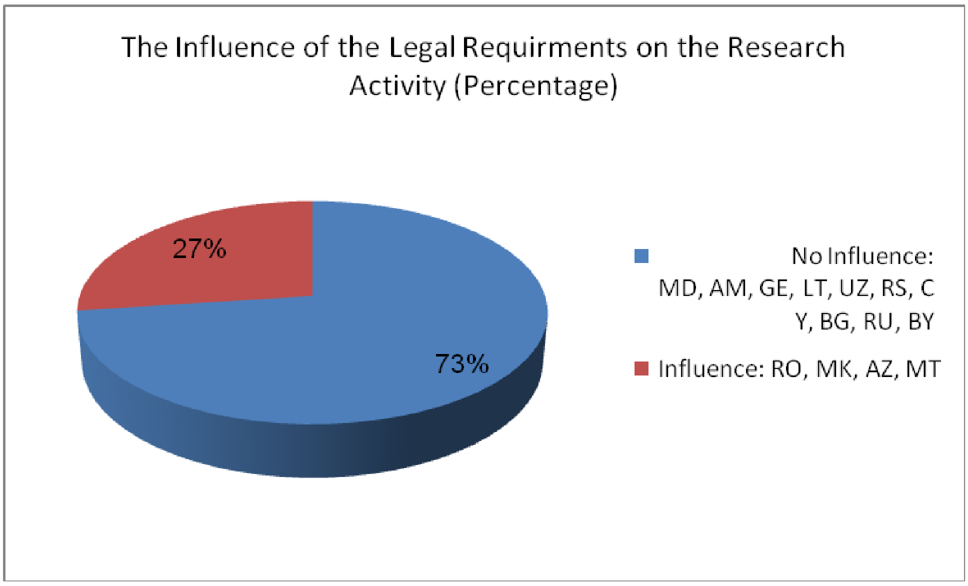

Figure 23 - The Influence of the Legal Requirments on the Research

3.1.6 Cooperation with the Industry

The respondents were asked to evaluate the technology transfer process from PROs to the industry based on the following elements[40]:

- Communication - Availability of the TTO staff, user-friendly access to information, and transparency of the procedures

[40] Question No.30

- Scientific - Assessment of the viability and the potential development of the invention
- Information - Availability of adequate information tools and services related to patent information, search of prior art, and freedom of operation
- Legal - Assistance in IP protection, persecution, enforcement, agreement editing etc
- Funding - Availability of IP protection and commercialization funds
- Commercial - Assessment of the commercial potential of the invention, marketing, and search of suitable partnerships, business development, negotiation and administration of licensing contracts, etc.

The number of respondents with medium-high satisfaction was relatively high in the legal area and the information area. The scientific area and the commercial area were also given medium-high satisfaction ratings. In contrast, the communication area and the funding area were given a relatively low degree of satisfaction rating.

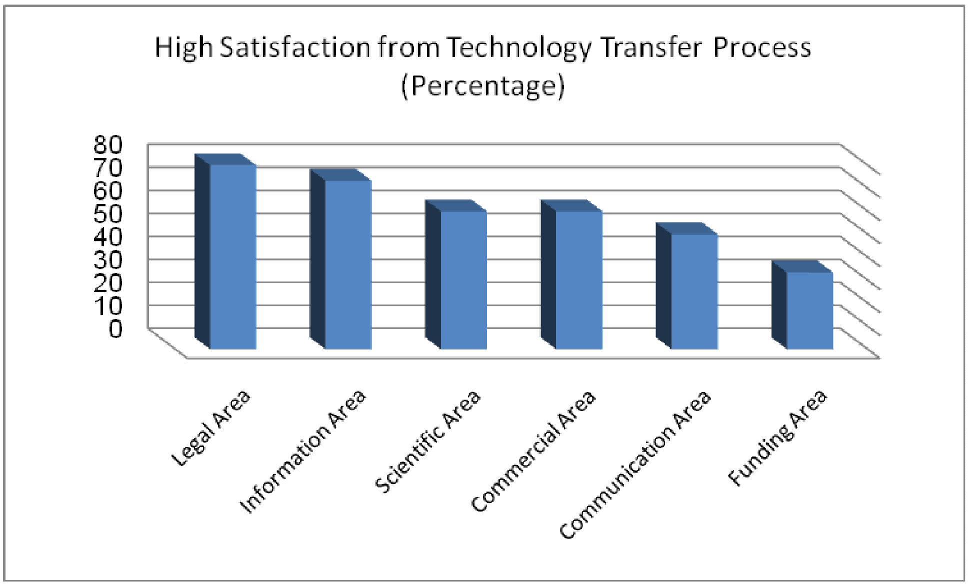

Figure 24 - High Satisfaction from Technology Transfer to the Industry

As a result, the degree of the satisfaction from the cooperation between the PROs and the industry [41] was relatively *low*, and most of the respondents answered "low degree" (1-2) of cooperation.

[41] Question No.31

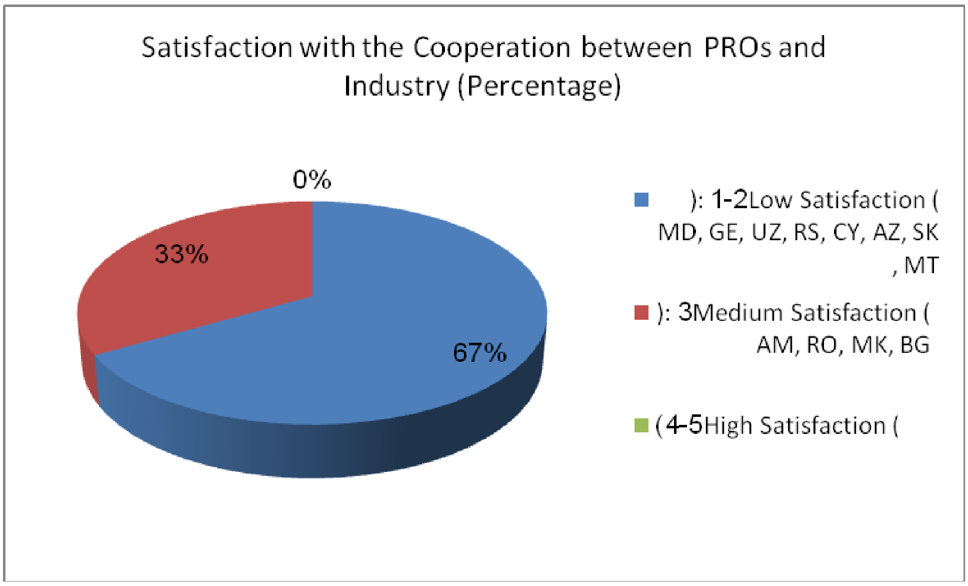

Figure 25 - Satisfaction with the Cooperation between PROs and Industry

The respondents were also asked to refer to the main obstacles that delay or prevent cooperation and direct relations between PROs and the industry, with special attention to bureaucracy, differences in organizational concept, disagreements regarding intellectual property rights and commercialization, and differences in research directions and conflict of interests[42]. The most significant obstacle, to which more than 65% of the countries gave high ratings, is the difference in organizational concept. In addition, disagreements regarding IPR commercialization and differences in research directions were mentioned as significant obstacles in high frequency (59% of the countries on average). Bureaucracy and conflict of interest were mentioned as significant obstacles in relatively low frequency (56% and 31% of the countries respectively).

The respondents evaluated the connection between PROs and the industry, based on the following mechanisms[43]:

- The industry usage of published research results
- Professional training based on industry needs
- Consolation to industry
- Science parks
- Cooperative research

[42] Question No.32
[43] Question No.33

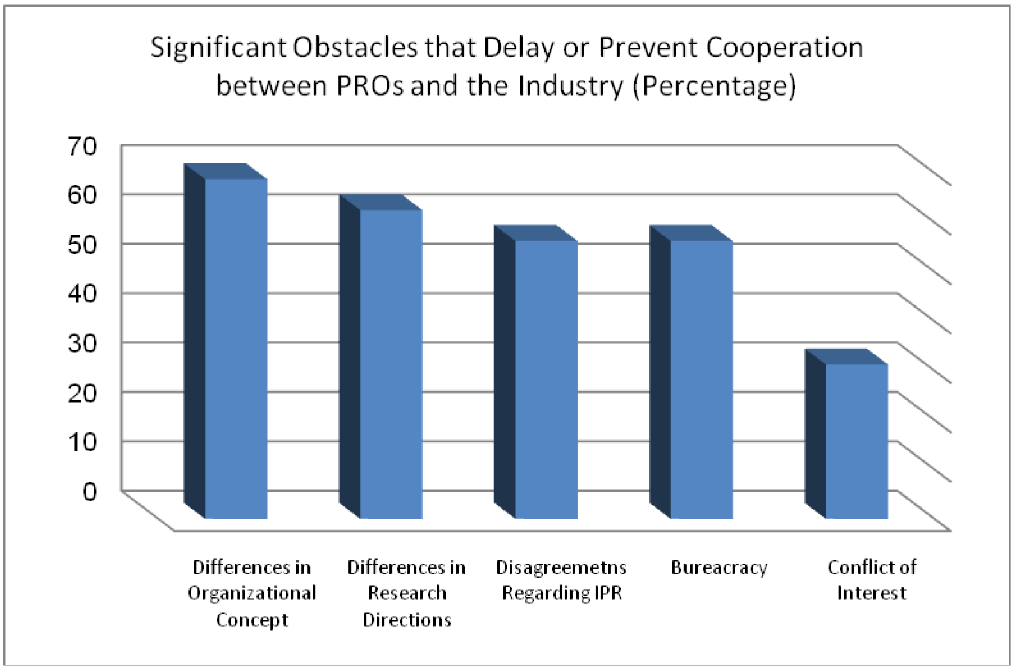

Figure 26 - Significant Obstacles that Delay or Prevent Cooperation between PROs and the Industry

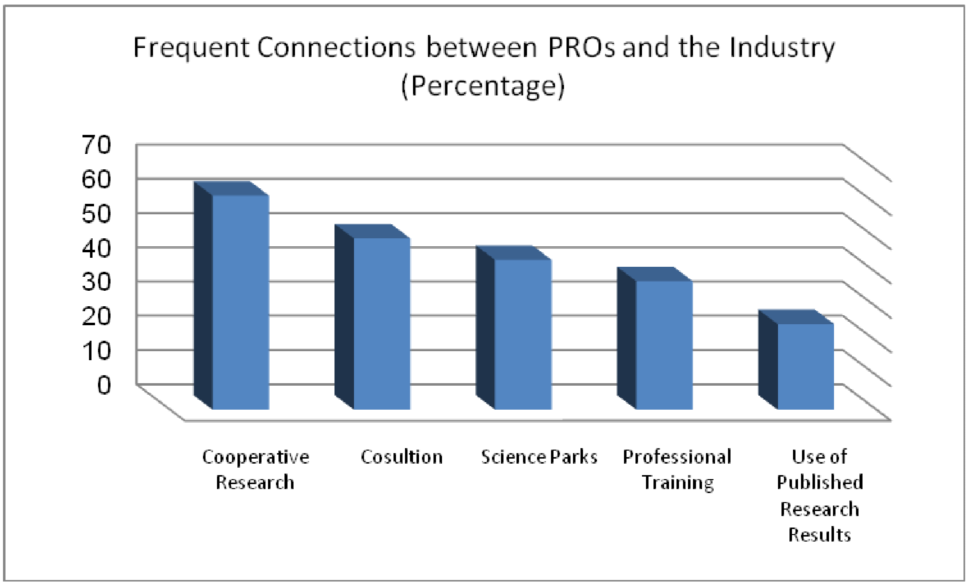

Figure 27 - Frequent Connections between PROs and the Industry

The most frequent connection in most of the countries was based on cooperative research (62% of the respondents rated the frequency of this kind of activity to be medium-high level), and also consultation (50%). Science parks, professional training, and the usage of published research results were relatively rare in most of the countries.

It might be that the medium level of the connection between the PROs and the industry influences the evaluation of the openness and readiness of the industry to comprehend innovative or advance technologies developed in PROs[44]:

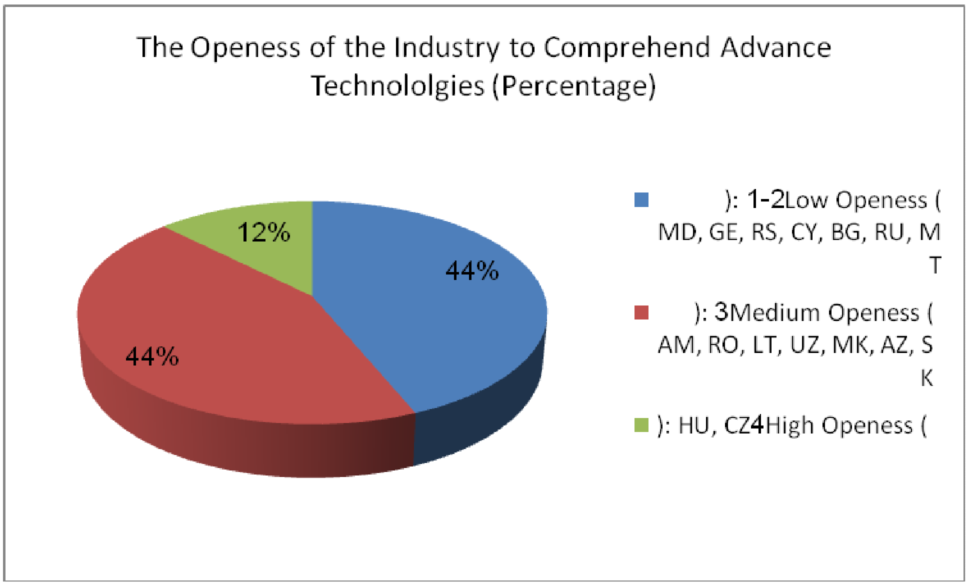

Figure 28 - The Openess of the Industry to Comprehend Advance Technololgies

To conclude: the relations between public research institutes and industry in countries in transitions were rated medium-low in most cases and most aspects.

3.1.7 Additional information

In addition to the questionnaire of Appendix 1, information were given by representative of countries in transitions in a regional seminar took place in Baku, 9-10th of June 2011, as follows:

Azerbaijan – The IPR as well as the R&D situation in the hosting country has been described in details by a local speaker.

Albania - The representative presented the national R&D system, focused on the need to increase the number of researchers, to strength the collaboration with the industry, to take part in the European research projects (i.e. FP7 etc) and to improve the PROs' autonomy.

Kirgizstan - The representative mentioned that his country does not have a strong scientific research that can create knowledge product that can be applied in the industry. Also the productivity of the industry is relatively weak.

[44] Question No.34

The former Yugoslav Republic of Macedonia - The representative mentioned there are few spin off companies, and some research results are being transferred to the industry, mainly by expertise governmental agencies.

Russian Federation - The representative raised the lack of adequate funds, and the lack of legal infrastructure. A request for the foundation of special technology transfer course was also raised by the representative.

3.2 Guidelines and recommendations

While the process of building up technology transfer mechanisms in countries in transition is almost completed, the results of the questionnaire presented in section 3.1 suggest there are 4 main obstacles left (see Figure 14):

1. Luck of skilled professionals in Technology Transfer.
2. Insufficient academia-industry interaction.
3. Luck of resources for basic academic research, IPR handling and professional commercialization.
4. Insufficient regulation of IPR commercialization.

In the following, we provide recommendations, based on Israel's experience, to deal with these obstacles.

3.2.1 Special training for technology transfer agents.

Technology transfer experts are hard to find all over the world. They should be with one lag at the science arena, and with the other well into business. They should be trusted and appreciated by researchers, as well as being able to swim in the deep water full of sharks of the business sector. They should be entrepreneurs while being responsible for the public good – all in all, it is a challenging, most difficult job. Moreover, at the end of the day, assuming that important research results are produced by the PROs (see Figure 11), and the success of the technology transfer is very much in their hand.

While some of the theory can be taught, it is most important to learn from experienced technology transfer experts, where everyday life and some specific examples can be discussed. Since the questionnaires indicated that on a national level, there is no more than handful of licensing agreements in most countries in transition, it is recommended to construct a special seminar for technology transfer officers in countries in transitions, given by experienced, international technology transfer experts.

The following are the recommended outlines for a 2 days seminar:

Part I: Introduction and background

1. Introduction to Technology Transfer: what is it, and why do we do it?
2. The Technology Transfer process – the different mechanisms to transform research results into commercial innovation.
3. Discoveries, Inventions, Know-how and Patents.
4. The players: the inventor, the research institute and the commercial organization and the public.
5. The ramifications of commercializing publicly funded knowledge.
6. Entrepreneurship within universities: the role of faculty members, students and administrators in the Technology Transfer process.

Part II: Day to day practice of the Technology Transfer process

7. Patents in a research institute: from invention to registered patent.
8. Bridging the "Development Gap" – providing proof of principle.
9. Business development and out-licensing.
10. Licensing revenues and their distribution: up-front and milestone payments, equity and royalties
11. Responsible licensing: points to consider.
12. Conflict of interest.
13. Measures of performance.

Part III: Case Studies

14. Analysis of actual local cases, to be presented by the participants.

This seminar should be given in each country separately, for a small group of active technology transfer officers.

3.2.2 Action plans for improving academia-industry relations.

Academia-industry relations are built on 3 levels. The first is the traditional channel: academic knowledge is traditionally distributed through academic publications, which are open to all, including the industry. The 2nd is the direct interaction between academic researchers and the local industry in joint R&D projects; and the 3rd is based on international licensing deals.

Academia should stick to its mission of creating knowledge and distributing it openly, and it can improve the reliance of the private sector on the public sector, and, as a result, to strengthen the scientific relations between these two sectors, while preserving the uniqueness of the academic research and the public interest.

When considering commercialization of academic research results via licensing deals, it is important to note that it should not be restricted to the local industry. Licensing to international companies has better chances to break into the global market which may lead also to significant income out of technology transfer. The contacts with such companies are usually done within international fairs. It is recommended to participate in such fairs and to explore possibilities for international commercialization of academia-originated IPR.

While these two indirect channels for academia-industry relations are important, the direct cooperation between the public research institutes and the local industry is ***most important*** from the point of view of governments, both as a channel for direct technology and know-how transfer, and as source of stimulus to the academic research. Indeed, most countries have evaluated the level of (local) academia-industry cooperation as insufficient (Figure 25).

The experience of Israel has shown that government initiated programs, where the financial support depends of academia-industry cooperation, have contributed to bridging the gap between PROs and local industry. The leading program in Israel is the Magnet program[45], with a budget of more than EURO 50M a year, handled by the

[45] http://www.tamas.gov.il/NR/exeres/111E3D45-56E4-4752-BD27-F544B171B19A.htm

office of the chief scientist in the ministry of industry, trade and labor. This program involves pre-competitive research and development (R&D) within a consortium that includes a number of commercial companies together with research personnel from PROs. The R&D focuses on new generic technologies that will lead to new generation advanced products. The industrial partners enjoy a grant amounting to 66% of approved R&D costs, whereas the academic partner will receive 80% of said costs. A foreign company may be included in the consortium if it can bring a unique contribution to the relationship. Improving the inter-personal interaction between PROs' researchers and industry R&D experts is a by-product of the program that is happening even in cases where the technical collaboration is less successful.

We recommend governments of countries in transition to consider adopting such programs.

3.2.3 Funding technology transfer.

Handling the protection of intellectual properties, especially internationally, can cost a lot. Indeed, almost all counties indicated that there are not enough resources for efficient technology transfer (Figure 10). Note, however, that in a successful technology transfer the industry cover the patent expanses.

It is therefore recommended to allocate a national fund dedicated for this purpose. The money will be given as a loan. Once a commercialization is performed, the loan is to be return (with a surplus), so in the steady state the fund can be financially balanced.

Appendix 1 - The Questionnaire

Basic Questions

1. Is technology transfer part of the national economic strategy in your country?

❑ Yes ❑ No

2. Is there an adequate intellectual property (IP) infrastructure in your country with updated IP laws and regulations?

❑ Yes ❑ No ❑ In process

3. Is there a national IP and innovation strategy governing IP ownership of publicly-funded research results and researcher's rights on inventions developed in public research organizations (PROs) in your country?

❑ Yes ❑ No ❑ In process

4. Are there sufficient sources of public and private funds that could enable an effective technology transfer system in your country?

❑ Yes ❑ No

5. Are there any strong scientific research areas with potential technological applications that could generate a competitive advantage for your country?

❑ Yes ❑ No

6. Is technology transfer in public research organizations (PROs) governed by an institutional IP policy in your country?

❑ Yes ❑ No ❑ In process

7. Are there sufficient human resources and professionals with IP and technology management skills in your country?

❑ Yes ❑ No

8. Is there adequate university-industry collaboration for efficient technology transfer in your country?

❑ Yes ❑ No

9. Is there effective and successful commercialization of research and development (R&D) results in your country?

    ❑ Yes ❑ No

National Strategy

10. What is the level of **public** expenditure on research and development (R&D) in your country? (Please specify % of gross domestic product (GDP))

11. What is the level of **private** expenditure on R&D in your country? (Please specify % in overall investment in R&D in your country)

12. How would you evaluate the government policy regarding commercialization of research results of public research organizations (PROs)? (Please select from 1 to 5, 1 being "ad-hoc or accidental" and 5 being "systematic and institutionalized")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

13. How would you evaluate the potential impact that commercializing publicly funded research products may have on the public image of PROs? (Please select from 1 to 5, 1 being "no impact at all," and 5 being "very high impact")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

    If you chose 3 or higher, please describe in detail the impact it may have:

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14. How would you evaluate the degree of awareness of decision-makers and/or regulators about the importance patenting research results in PROs? (Please select from 1 to 5, 1 being "completely unaware," and 5 being "highly aware")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

15. Is there a national legal framework (national innovation/intellectual property (IP) strategy) regarding IP ownership of publicly funded research results and researcher's rights on inventions that were developed in PROs? (if you chose "No", move to question number 17)

    - ❑ Yes
    - ❑ No
    - ❑ On process

16. How would you evaluate legislation framework regarding IP ownership of publicly funded research result? (Please select from 1 to 5, 1 being "completely unclear/incoherent," and 5 being "very clear")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Institutional Regulation

17. Does technology transfer in a PRO follow a specific institutional IP policy, code or set of rules? ((if you chose "No", move to question number 21)

    - ❑ Yes
    - ❑ No

    If yes, how comprehensible is it? (Please select from 1 to 5, 1 being "completely incomprehensible" and 5 being "very comprehensible")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

18. Do institutional IP, technology transfer policy or other specific rules impose restrictions on publications and dissemination of research results? (Please select from 1 to 5, 1 being "no restrictions at all", and being 5 "highly restricted")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

19. In which countries, to your best knowledge, the PROs patents are usually being registered?

    - ❑ Local patent office;
    - ❑ PCT - ________________
    - ❑ U.S.A
    - ❑ Japan
    - ❑ Other Countries: ___________________________

20. Who is responsible for the registration process and for the payment for the PROs patents?

- ❑ The researchers;
- ❑ The industry;
- ❑ Government offices;
- ❑ TTOs;
- ❑ PROs
- ❑ Other: _____________

Technology Transfer Offices (TTOs)

21. Is there a specific body related to the PRO responsible for technology transfer and the related Intellectual Property Rights (IPR) issues? (if you chose "No", move to question number 25)

❑ Yes ❑ No

If yes, please specify:

❑ Institutional Technology Transfer Office (TTO) ❑ National/regional Technology Transfer Center ❑ Other: __________________

22. Please describe in detail the function of the TTO in each of the following areas:

22.1. Scientific Area:

22.2. Legal Area:

22.3. Commercial Area:

22.4. Other:

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23. How would you evaluate the scope of the TTOs activity based on the elements below? (Please select from 1 to 5, 1 being "completely unsatisfying," and 5 being "very satisfying")

Number of patent applications Specify number/y: ___	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Number of registered patents Specify number/y: ___	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Number of material transfer agreements Specify number/y:	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Number of licensing agreements Specify number/y:	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Human Resources skill in your body	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

24. How would you evaluate the TTOs, based on the elements bellow? (Please select from 1 to 5, 1 being the lowest quality rate, and 5 being the highest)

24.1. Communication area – Availability of the TTO staff, user-friendly access to information and transparency of the procedures.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

24.2. Scientific area – Assessment of the viability and potential development of the invention.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

24.3. Information area – Availability of adequate information tools and services related to patent information, search of prior art, freedom of operation

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

24.4. Legal area – Assistance in IP protection, persecution, enforcement, agreement editing, etc.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

24.5. Funding area – Availability of IP protection and commercialization funds

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

24.6. Commercial area - Assessment of the commercial potential of the invention, marketing, search of suitable partnerships, business development, negotiation and administration of licensing contracts etc.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Researchers

25. How would you evaluate the awareness of the researchers in the PROs on the importance of patenting their research products? (Please select from 1 to 5, 1 being "completely unaware," and 5 being "highly aware")

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

26. How would you evaluate the level of cooperation between the researchers in the PROs and the technology transfer body? (Please select from 1 to 5, 1 being "no cooperation," and 5 being "high level of cooperation")

Scientifically (transferring all the needed information)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Legally (meeting legal requirements)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Commercially	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

27. Is the research activity influenced by the need to deal with legal issues as material transfer agreements (MTAs) and licensing agreements?

❑ Yes ❑ No

If yes, please describe:

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28. To what extent are you satisfied with the involvement of researchers in the commercialization of their research products? (Please select from 1 to 5, 1 being "not satisfied at all", and 5 being "very satisfied")

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

29. To what extent are you satisfied with the outcomes of the commercialization of research results in PROs? (Please select from 1 to 5, 1 being "not satisfied at all", and 5 being "very satisfied")

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Cooperation with industry

30. How would you evaluate the technology transfer process from PROs to the industry? (Please select from 1 to 5, 1 being the lowest quality rate, and 5 being the highest)

30.1. Communication area – Availability of the TTO staff, user-friendly access to information and transparency of the procedures.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

30.2. Scientific area – Assessment of the viability and potential development of the invention.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

30.3. Information area – Availability of adequate information tools and services related to patent information, search of prior art, freedom of operation

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

30.4. Legal area – Assistance in IP protection, persecution, enforcement, agreement editing, etc.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

30.5. Funding area – Availability of IP protection and commercialization funds

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

30.6. Commercial area - Assessment of the commercial potential of the invention, marketing, search of suitable partnerships, business development, negotiation and administration of licensing contracts etc.

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

31. To what extent are you satisfied with the cooperation between your research institute and the industry? (Please select from 1 to 5, 1 being "not satisfied at all", and 5 being "very satisfied")

❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

Please comment**:**

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32. In your opinion, what are the main obstacles that delay or prevent cooperation and direct relations between PROs and the industry? (Please evaluate the items below from 1 to 5, 1 being "not an obstacle," and 5 being "very big obstacle")

Bureaucracy	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Differences in organizational concept	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Disagreements regarding intellectual property rights and IPR commercialization	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Differences in research directions	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Conflict of interest	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

Other (please describe) ____

____

33. How would you evaluate the connection between PROs and the industry, based on the following mechanisms? (Please select from 1 to 5, 1 being "not relevant/rare", and 5 being "very frequent")

The industry use of published research results	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Professional Training	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

based on industry needs					
Consultation to industry	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Science Parks	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
Cooperative research	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

34. How would you evaluate the openness and readiness of the industry to comprehend innovative or advanced technologies, in particular, those developed in PROs? (Please select from 1 to 5, 1 being "completely closed and unready," and 5 being "very open and ready")

    ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5

35. If you have additional comments regarding this questionnaire and/or the technology transfer situation in your country, please fill them in here:
