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CONDITIONS FOR THE HIGH-TECH SECTOR DEVELOPMENT – THE CASE OF ISRAEL

Key words

Innovation, technology transfer, technology transfer offices, innovation funding.

Abstract

The paper analyses the factors which contribute to the effective development of the high-tech sector. The case of Israel was chosen for the basis of the analysis due to the country's considerable achievements in the realm of high technology industry. The paper argues that consistently implemented government policies and programmes are crucial stimuli to the innovativeness of the economy. The role of technology transfer offices, as the intermediaries between the academia and industry in technology transfer process is discussed. An overview of the main areas and means of their operations, as well as commercialisation strategies are presented.

Introduction

In the last 20 years Israel has recorded spectacular development of the high technology sectors, becoming one of the world's leaders in this respect. Since the early 1990s we have seen a dynamic emergence of the Israeli high-tech, mainly ICT industry, which today constitutes a significant share in the country's GDP in business sector and exports.

Israel created a vibrant venture capital (VC) market, which between 1992 and 2009 raised about \$13.3b invested in Israeli start-up high-tech companies. Seventy percent of this amount was raised between 2000 and 2009 [11]. In terms of venture capital investment as a percentage of GDP Israel ranked second with 0.3%, outdistanced only by the United Kingdom [19]. The recent global economic crisis brought steep decrease in VC's fundraising which in 2009 was by 72% lower than a year before. Nevertheless, overall results of the Israel's VC activity is outstanding. The country is in the forefront in terms of the number of start-up companies and it is on the fourth place, following USA, China and Canada, in the number of companies listed on NASDAQ [17].

Israel's expenditure on civilian R&D stands out among all OECD countries, as it reached 4.9% of the GDP in 2009, over double the OECD average. Israelis are the best-educated nation in the world – as of 2003 about 45% of the population aged 25–64 held university degree [7].

In 2010 the World Competitiveness Yearbook, compiled by the Swiss Institute for Management Development, ranked Israel 17th most competitive economy in the world, 7 positions up from the previous year. The same source ranks Israel high on entrepreneurship.

Such outstanding performance can be traced to a number of factors which relate to internal and external conditions within which the country operates, or stem from deliberate courses of actions undertaken by the government.

This paper provides a review of the above-stated conditions with the main focus on the government policies, which played a considerable role in boosting country's innovativeness. The overview leads to the issue of university-industry technology transfer, which is fundamental for the innovation of the economy. The paper particularly discusses the role of technology transfer intermediaries, i.e. university technology transfer offices (TTOs). The concluding part recapitulates the general question of the factors critical for the economy advancement with reference to country-specific conditions. It also outlines the challenges Israel's high-tech sector faces to maintain its growth and competitiveness.

1. Government actions stimulating development of the high-tech sector

Israel is a country whose specific characteristics, resulting from its immigrant nature, political and geographical conditions played part in creating its outstanding innovation potential. Just to name a few: location among mostly hostile countries entailed the development of strong military R&D which leaked to the civil sector [25]; small domestic market and limited export opportunities to neighboring countries contributed to the global orientation and competitiveness of Israeli companies and products [1]; the scarcity of natural

resources and the persistent problem of water shortage triggered world-class solutions in clean technologies and alternative energy sectors.

Nevertheless, even when combined with the exceptional manpower accumulation, these factors would not have sufficed for the growth of the dynamic high-tech industry. Implementation of government policies and instruments was vital to discharge the potential existing in the society and transform it into the economic advantage.

The construction of the national defense system was the first step on the Israel's way to expand innovative industries. However, it was not until the early 1990s, when the high technology sector's formation noticeably accelerated. By that time government had primarily focused on the employment creation and any private or public investment in industry, including government horizontal grants, was expected to attain this objective [21]. The Law for the Encouragement of Industrial R&D enacted in 1984 has become a tool for the government support of the high-tech sector. The main goal of the law has been development of the local knowledge-based industry, improvement of the country's trade balance and employment. Beginning in mid-1980s, and especially 1990s, emergence of high-tech companies speeded up. A growing number of start-ups sought well-developed capital market which Israel was lacking at that time. So did it lack abilities of financial management [8].

Government's response to this situation was the implementation of the mechanisms targeted at creation of the local VC industry. VC-supporting programmes were launched – Inbal, in 1992, which failed, and Yozma, in 1993, which proved remarkably successful. Yozma aimed to attract foreign capital investment to Israeli high-tech companies. The programme established ten funds of \$20 million each. Government provided initial funds (of 40–50%) which had to be matched with private investment. Besides the initial government contribution, another significant incentive for private investors was a 5-year option to purchase government's share. Yozma did not aim to generate upside for the government. It was fully designed to build an independent VC market. The success of the programme also depended on the ability to attract talented managers, mainly from the US, who Israel was short of. Acquiring foreign investors additionally strengthened global orientation of the high-tech companies, and thus, their competitive advantage [2, 23].

Emergence of the VC industry was accompanied by the inflow of leading multinational corporations, which were attracted by specifically designed benefits, such as tax breaks, grants, loans and new multinational joint development funds. As of 2007 there were over 40 international companies in Israel, which predominantly in the course of mergers and acquisitions established there their R&D centres. Multinational firms channel 60% of the Israel's exports. Since their presence is related mainly to the development activity (as opposed to production), and hence, their operations are more

connected to fixed than to variable costs, they are more resistant to economic shocks than multinationals' production subsidiaries. This is particularly crucial in the times of economic instability, as witnessed in the past two years [3].

Israel's government plays an important role in encouraging industrial R&D. However, it should be emphasised that government funding of R&D, including university R&D, constitutes only about 16% of the overall R&D funding, whereas the greatest proportion of the research financing - 81%, comes from the business sector. The remaining three percent of the country's R&D financing comes from the private nonprofit sector. The structure of government civilian R&D expenditures shows that a vast majority of the funding (following the general university funds), i.e. 36%, is assigned to the advancement of the industrial technology. It exceeds almost five times agriculture R&D financing, and eight times social services research funding. Israel's BIRD intensity as a percentage of GDP is the highest in the world [5, 6, 19].

Government funding of industrial R&D is channeled through the Office of Chief Scientist (OCS) at the Ministry of Industry, Trade and Labor (MOITL) which operates grant programmes. Although Chief Scientists are also appointed at many other ministries, Chief Scientist of MOITL wields the most power and has the largest budget at their disposal. The R&D support programmes executed by the Chief Scientist Office at MOITL are designed to stimulate starting entrepreneurs, generic and competitive R&D.

Pre-seed programmes include the following instruments: Tnufa, Technological Incubators and Heznek. Tnufa aims to support setting up start-up companies. The programme enables entrepreneurs to conduct preliminary studies, support filing patents, develop business plans and build prototypes. This course of action is expected to increase the attractiveness of a preliminary business idea in order to draw private investment. Grants are up to 85% of the approved budget for a maximum of \$50,000 [16].

Technological Incubators programme was conceived at the time of Yozma implementation. The programme's main task is to minimise the risk of early stage ventures, when acquisition of private funding is the most difficult. The Technological Incubator programme went through a considerable transformation in 2003 when the Incubators were privatised. Government cut direct funding of the Incubators allowing VC funds to take over. Instead, government funding is provided to companies selected for the *incubation*. The total public contribution to a start-up company for the period of two years ranges between \$350,000 and \$600,000. The VC's matching funds account for a minimum of \$100,000, though typically they reach \$300,000–\$400,000. A very important aspect of the incubator's functioning is the option for the VCs to purchase the government share in the company and raise their ownership. To be accepted into the Incubator novice companies have to prove high export potential of their products which have to be in a high-tech field. In addition, the

product must be manufactured in Israel. Start-ups aspiring for the incubator's financing undergo a very tight, VC-oriented selection criteria. There are currently 24 technological incubators in Israel which jointly manage about 240 companies [8, 23].

Heznek seed-fund's goal is to raise the number of new start-ups. The programme's main idea entails matching government and investor's funds and the option for the company to purchase government shares at their initial price. Grants amount to a maximum of 50% of the project.

Generic R&D programme, MAGNET, is carried out in four main tracks: Consortium, Association, Magneton and Nofar. MAGNET has been designed to enhance technological lead of the country. The programme requires collaboration between companies and academic research groups within consortia. Funds granted to an industrial partner are up to 66%, whereas academy is able to receive 66%, 80%, or 90% [8].

Consortia involve academy-industry cooperation on development of next generation innovation of their products. Magneton entails dual collaboration of an academic group and a company with the goal of technology transfer and raising feasibility of the academic research outcomes before their commercial implementation. Association track does not assume technology development, but it mainly focuses on the implementation of existing know-how to the particular activities of the programme participants. Unlike the so-far-listed programmes which do not determine specific sector of support (as long as it is high-tech-oriented), Nofar addresses biotechnology and nanotechnology academic basic and applied research with the objective to facilitate technology transfer to the industry. Grants amount to 90% of the approved budget of up to \$100,000 [8].

The above short characteristic does not exhaust the whole array of government funding channels designated to augment the country's R&D and innovativeness. Israel also operates a number of bi-national and bi-lateral R&D programmes and agreements, and it participates in European Union R&D programmes which add to the pool of public funds supporting industrial research.

2. The role of intermediaries in technology transfer process

Effective technology transfer which translates into virtual economic advantage cannot be performed single-handedly, as it is a function of numerous interrelated factors, such as policies, legal mechanisms, society disposition, as well as the performance of the main technology transfer actors, i.e. universities, industrial companies, and intermediaries. This section depicts the latter group of technology transfer agents – university technology transfer offices (TTO) and the major modes of their operation.

Growing interest and importance of technology transfer have derived from an ongoing process of universities reorganisation which began in Europe about 30 years ago. It resulted from the rise of the knowledge-based economy in which knowledge gained recognition as an asset of its own, a vehicle for innovation and economic development. This involved growing expectations as to the role that universities should play in society and economy. Shrinking public funding and increasing pressure put on universities to fund research through their cooperation with industry strengthened the process. In consequence, changes also embraced university-industry relationships which become more institutionalised, *inter alia* through the emergence of the university technology transfer offices [4, 21].

In the United States noticeable interest in technology transfer appeared with the enactment of the Bayh-Dole Act in 1980, which granted universities property rights to patents resulting from federally funded research.

TTOs act as intermediaries between academia/researchers and companies – they assess market value of the inventions, protect intellectual property and search for potential investors interested in commercial gains new technology may generate. Hoppe and Ozdenoren [10] argue that the main reasons for the existence of technology transfer agents lie in the shortage of companies' capability to precisely estimate the value of new technology developed by research institutions. Thus, they might be reluctant to invest in innovation. At the same time, even though technology transfer intermediaries' estimations of the invention's commercial value may also lack precision, the use of success-based payment, which may take the form of royalties or equity, raises chances that the investor will obtain the most profitable invention. Still the condition is that the TTO's pool of inventions is large enough.

The issue of the asymmetric information between the university and company was also raised by Macho-Stadler et al. [13] who developed a reputation model which shows that larger TTOs are prone to shelve some of the inventions in order to create a reputation of high quality of their projects among potential buyers. In this model, similarly to Hoppe and Ozdenoren's conclusions, a critical mass of technologies, and hence, the size of a TTO appears to play important part in commercialisation success. Although TTOs are believed to underpin the effectiveness of technology transfer, in practice only larger universities can afford to conceive such entities.

University-industry technology transfer in most cases entails many challenges for the TTOs. This is also true in the case of Israel. Firstly, it involves three main actors who represent different interests, cultural backgrounds and objectives related to the research outcomes commercialisation. For instance, scientists are mostly interested in publishing which may impede their willingness to disclose the inventions, which stands in opposition to the TTO's goals. Appropriate incentive schemes for researchers, such as a share in

royalty payments, appear to be critical in motivating scientists to disclose their research results.

Secondly, TTO's responsibility is to select the most promising inventions from technological, economic and personal points of view. The assessment of new ideas is followed by the decision on which inventions should be legally protected, in which geographical areas, and next, which commercialisation paths and strategies will be most effective. This process is both difficult and ought to be carried out carefully, as patent protection is usually very costly. The evaluation of the invention's market potential becomes easier in the events when a company has already articulated its interest in the technology [24]. However, such occurrence appears to be rare; thus, risk is inherent to the invention selection process. To minimise the uncertainty, the evaluation of new technologies' potential should involve a group of market and scientific experts, which on the other hand, generates significant cost. Therefore, in practice the assessment of inventions is, in many cases, done by the TTO's staff only, based on their experience [12, 18].

Legally protected inventions are subject to the commercialisation strategy which TTO has to outline. The first step involves the decision on the commercialisation track which usually comes down to the selection between licensing and spin-off. Though spin-offs seem to generate more value for the country's/region's economy, licensing is a prevailing path of technology transfer, as the time perspective for the university to obtain income is much shorter than in the case of a spin-off. Additionally, creation of a spin-off requires a number of additional factors vital to the venture's success, such as personal dispositions of researchers involved in the company, management skills, entrepreneurial and strategic orientation, and market knowledge [9, 15, 22].

Another challenge TTOs face is the stage of contract formulation between the TTO and the company/investor which involves the agreement on the type of payment the university will receive. It may take form of either royalties, fixed payments or university shares or equity in the firm. Macho-Stadler and Perez-Castrillo [14] argue that royalties have certain advantage over the fixed payment as they signal the high quality of the technology and facilitate technology transfer process due to higher motivation of the innovator at the development stage. In comparison to licensing contracts, university spin-off agreements are much more complex, as they involve the TTO, the scientist(s) and the financing party. The spin-off agreements must define issues related *inter alia* to control rights, cash flow, exit strategies.

3. Israeli Technology Transfer Offices

Israel's government has undertaken a number of actions to boost the country's competitiveness which resulted in the creation of a vibrant high-tech

sector, backed with a strong capital market. Substantial emphasis has been put on the enhancement of academia-industry relationships seen as the main means of technology transfer.

There are currently seven public research universities in Israel. Israeli universities rank high in international comparisons. For instance, in the Academic Ranking of World Universities Israel has one university in the first hundred (Hebrew University of Jerusalem ranks 64th), and three universities in the second hundred; the THE-QS World University Ranking places one Israeli university in the first hundred and two other in the second hundred.

All of the universities are both education and research institutions, however, Weizman Institute is primarily research oriented. Most of them established their own technology transfer companies/offices which specialise in commercialisation of research outcomes. The table below delineates the universities which have TTOs in place.

Table 1. Israeli research universities and their technology transfer offices, 2010

University	General characteristic	TTO
Tel Aviv University	embraces the most diverse group of academic disciplines	Ramot
Technion	main technical university	T ³ -Technion Technology Transfer
The Hebrew University of Jerusalem	encompasses most of the academic disciplines with a strong position of medical sciences	Yissum Technology Transfer
Ben Gurion University	focuses mainly on desert studies, though its curriculum involves also a wide range of other disciplines	BGN Technologies
Weizman Institute	provides only post-graduate studies; Institute's research embraces life and exact sciences	Yeda Research and Development
Bar Ilan University	Jewish studies	Bar Ilan – R&D

Source: Author.

The first technology transfer office in Israel, and also one of the first in the world was Yeda R&D at Weizman Institute established in 1959. Other Israeli TTOs also have a long-standing tradition, e.g. Yissum was set up over 40 years ago, Ramot in 1973. They are separate entities but entirely owned by the universities within which they operate.

An important factor which constitutes one of the background conditions for the TTOs' functioning are incentive policies employed by the Israeli universities, which entitle researchers to participate in royalty payments. They range between 30% and 60% depending on the university (e.g. Bar Ilan university awards researchers with 60% of the benefits, Technion – 50%, Hebrew University – 33%-35%, Ramot – 40%) [8, 12]. Another crucial facet refers to the ownership of the intellectual property (IP) developed within the

university, which in Israel belongs to the universities. Therefore, technology transfer to the industry is exclusively performed through the TTOs and Israeli universities are very strict about any attempts to *independently* commercialise the know-how built up in their laboratories.

The first area of the Israeli TTOs' operations is identification of promising inventions. Most of the TTOs claim close cooperation with university researchers, however, some admit that this cooperation could be more direct and intense. TTOs aim to encourage scientists to disclose their inventions before they become revealed in publications. Their role is also to alleviate the conflict between publishing and patenting which many researchers discern, and convince the researchers that patenting does not hinder their ability to publish, provided that the patent application has been filed prior to publication.

Once the invention has been disclosed, the TTOs take care of the patenting process. The decision on the geographical coverage of the IP protection is based on the assessment of the technology's commercial potential on the selected markets. The TTOs employ IP specialists and patent attorneys, who guide the researchers through the patenting process and file the patent applications. TTOs' activity in this realm provides unquestionable advantage to the researchers, as the complicated process of IPR protection is handled by a specialised unit. Usual patent protection area embraces the US and Europe; in justified cases – depending on the nature of the invention in relation to the probability of its profitability on a certain market, also other countries.

Commercialisation strategies employed by the Israeli TTOs represent all available tracks: licensing, establishing spin-off companies, joint ventures and collaborative research.

Yet a remark has to be made on the ground of terminology. The study of existing concepts of university spin-offs by Pirnay et al. [20] reveals variety of definitions of the discussed ventures. According to Pirnay et al. a spin-off is defined as a new company set up to commercially exploit new technology, knowledge or research results developed at the university. However, the interpretations of a spin-off differ as to the premises on which such company is built. For instance, more liberal definitions point to technology transfer, as the sufficient element of university spin-offs. Stricter ones underscore the role of the academics; thus, they perceive a spin-off as the company based not only on the technology developed at the university, but also founded by the university researchers. It should also be noted that depending on educational and research institutions models existing in each country, new ventures can also be spun off from research institutes, large national laboratories and other R&D entities.

Israeli spin-offs embody both models, though, some TTOs might qualify a company based solely on the technology transferred as their licensing activity, and not a spin-off. This is the case of Ramot at Tel Aviv University where despite the fact that the technology transfer is carried out through a start-up

company set up by external entrepreneur, the TTO classifies this model as licensing. The inventor is usually involved with the start-up as an employee, but the university does not have control over the company and it receives royalty payment for the licensed technology. In the situation where this model involves university shares in the company, Yissum Technology Transfer defines it as *a joint venture*.

The choice between licensing or setting up a university spin-off involving academician(s) is made in the course of the assessment of numerous factors such as the technology maturity, researcher's capability to embark on a new venture, probability to market the invention, fundraising ability. In fact, TTOs attempt to commercialise the invention at the most embryonic stage, in order for the development to take place out of the university. On very rare occasion is the university able to participate in the development of the final product/ process or is it capable to participate in funding a new startup company. Hence, in the vast majority of cases acquiring external funding is inevitable. Besides licensing and drawing an independent investor, Israeli university start-ups may apply for the government funding within technological incubators.

Even though in the view of the university benefits licensing to an existing company is the preferred commercialisation track, it is in fact a more difficult path. Licensing considerably lowers financial risk of the university and shortens the time to obtain benefits. Nevertheless, it is not easy to acquire a company willing to invest in a new technology. Furthermore, in this path a company executes a complete control over the IP. On the other hand, whereas it is easier to find an entrepreneur interested in setting up a start-up based on the university license, it usually takes several years for the technology to become profitable, which apparently delays university returns. It should also be noted that statistically only about one in twenty start-ups succeed [12].

At all commercialisation stages TTOs emphasise the role of researchers. A researcher has to provide required input to the patent preparation, and they are expected to actively participate in identification of potential licensees. Though TTO acts as the university gateway to the business sector, oftentimes inventors' contacts with the industry turn out critical in acquiring funding. Researchers are also expected to participate in the design of licensing strategy and assist in monitoring development and sales phases.

Conclusion

Not only is the Israel's high-tech sector a fascinating illustration of how an almost non-existent industry has been created from the scratch, but more importantly it is an example of outstandingly effective translation of the innovation into a country's economic advantage. Besides cultural and geopolitical conditions which constituted a stimulating, yet not sufficient

background for the emergence of a vibrant high-tech sector, Israel's government has embarked on a long-term course of action, which has been consequently implemented for at least the last 20 years. It has involved a number of instruments, including those aimed at capital market creation, such as Yozma, as well as R&D and innovation enhancing programmes, such as Technology Incubators, MAGNET, Tnufa, Hezkek. Additionally, the role of research universities in innovation generation has been widely recognized and embodied in the creation of technology transfer units at almost all public universities.

Government's participation in innovation funding appears critical for the increase of the country's economic competitiveness due to the market failure intrinsic to the knowledge transfer spillovers. Interestingly, Israel did not implement innovation policy *sensu stricte*. Innovation arose as a side-effect of the R&D support programmes. It should be stressed that government actions have been designed to trigger market mechanisms and thus, to enable further independent growth of the high-tech sector. Moreover, government programmes, including very successful Yozma, did not specify the sectors eligible to tap into public money, but rather they allowed a bottom-up development of industries. The only exception to this approach have been later established programmes to support biotechnology and nanotechnology sectors, as in their case it takes much longer to ripen.

Israeli TTOs constitute a good example of technology transfer intermediaries, however, TTO's effectiveness is not exclusively a function of organisational facets. Firstly, the university must provide the TTO with substantial funding to secure IP protection of numerous inventions which is pricey. Next, there must be market players in place ready to invest in new, oftentimes risky ventures based on the university inventions. However, it should be stated that despite Israeli TTOs' active role in linking the universities with the industry, neither their effectiveness nor impact on development of the country's high-tech sector have been subject of a comprehensive evaluation.

Though extremely successful, Israeli high-tech sector reveals certain deficiencies. First, highly developed ICT industry, which is acknowledged as one of the levers of the economy innovativeness, has not disseminated to other economic sectors. In addition, since over 40% of Israeli start-ups are financed by venture capital they tend to be sold at a very early stage to foreign companies. Prevailing foreign capital investment in the Israel's high-tech sector makes it also more prone to the economic crises, as foreign investors are likely to withdraw their money from risky endeavors during unstable times. Furthermore, a large portion of Israel's R&D performed by multinational companies adds to the flow of Israeli know-how abroad and in consequence decreases local economy benefits from the high-tech sector development. Additionally, significant fraction of business-funded R&D in Israel may pose a threat on basic research, especially in the face of shrinking government funding.

Israel stands in the face of significant challenges in order for the country to maintain its position in high-tech industry. The government has already taken steps to address the above-stated problems. Only recently has it announced a multiyear plan for a further support of the high-tech sector. The goal of the plan is to enhance the impact of the high-tech sector's achievements on the rest of economy and to prevent know-how outflow. A great emphasis will be put on the development of medium-sized and large national companies and counteracting early exits. To this end tax benefits will be employed to encourage growth of the companies, and state guarantees for local institutional investors.

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Analiza czynników kształtujących rozwój sektora wysokich technologii na przykładzie Izraela

Słowa kluczowe

Innowacyjność, transfer technologii, biura transferu technologii, finansowanie innowacji.

Streszczenie

Artykuł przedstawia czynniki wpływające na rozwój sektora wysokich technologii na przykładzie Izraela. Analizowany przypadek pokazuje, iż dominującą rolę w kształtowaniu warunków dla dynamicznego rozwoju sektora high-tech odgrywają systematycznie wdrażane strategie i programy rządowe, uwzględniające specyficzne uwarunkowania kraju. W artykule zaprezentowano rolę podmiotów pośredniczących w transferze technologii pomiędzy sferą nauki i przemysłu, tzw. biur transferu technologii funkcjonujących przy uniwersytetach. Wskazano główne obszary ich działania oraz strategie komercjalizacji wyników badań.