

The Achilles Heel of a Strong Private Knowledge Sector: Evidence from Israel

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Abstract

Scientific research in universities is a critical and powerful component of knowledge creation for any society. However, for a country like Israel, one with no resources but its human capital – and that faces constant regional instability - scientific research is crucial for its existence. Historically, there was a fundamental understanding that in such a small country only universities can ensure viable, profound and high-calibre research, by critical mass of human capital and by optimising its resources. In this study, we look at the role of Israeli research universities in the National R&D System, why Israel is unique in its R&D structure, and how that structure is related to the universities' roles. We found that, despite Israel's outstanding ranking, in comparison to other OECD countries, for its R&D inputs and outputs, the Israeli universities' R&D output – measured in patents – is highly volatile and mostly affected by the country's strong business sector. This finding has implications regarding the strengthening of specific fields of research and the discussion about the role of universities in conducting applied vs basic research.

1. Introduction

Unlike many OECD countries, in recent years there were significant cuts in the Israeli Higher Education Research and Development (HERD) that had affected its performance in terms of infrastructure investment, lack of human resources and its inability to step into new important fields of research, due to a lack of qualified researchers, partially caused by 'brain drain'. During the 70's the Israeli HERD was around 60% of the national civilian R&D. However, over the years HERD has dropped down to 13% of the national gross R&D (IBS, 2010) [1]. Despite the HERD decline, the Israeli academic outputs are among top OECD countries, as it reflects in academic publications and their impact (measured in citations relative to the world citation average per field), and in patents, where academic patents applications as a percentage of private sector patent was 13% in 2011.¹ A partial reasoning for the decline in the Israeli HERD was an expanding private knowledge sector that pushed the whole national R&D intensity upwards, to be the highest among OECD countries². In Israel, around 80% of the national R&D is executed by the private sector. This private sector is actively supported by the government in various programs, by a relatively large presence of foreign investments and a developed Venture Capital (CV) local market.

One may falsely conclude that knowledge is being transferred to the private sector, where the private sector stepped in to filling the gap of the declining HERD. However, this unbalanced situation in the Israel's national R&D - a too small university sector that needs to address large private sector that might even have a different composition of research or effective R&D composition – should be carefully examined in a long term view of benefits the country would have from its national R&D investments.

In order to understand the university's changing role we provide a review of the Israeli universities' funding and conduct some analysis of one type of universities' output – patents, that although are limited in their ability to provide a comprehensive picture of universities outputs, are still a valid proxy, in particular when analysing research fields and output and trends in outputs. Such trends suggest future challenges for the Israeli National R&D System, i.e. is there any effect to the declining government funding of universities, and whether today's research seeds would pull the private sector to join the public fields of research in the future?

¹ Patents application to the United States Patent and Trademark Office (USPTO), data from 2011.

² R&D Intensity i.e. R&D as a percentage of GDP.

2. Literature review

Global economic changes in recent decades caused many countries to examine the universities' role in their national research system, such as the Bologna process, which aimed to promote the university and to adopt the American model in order to encourage excellence in research. However, The US itself deals with the same questions, which led The US Congress to assign the National Academy of Science (NAS) to conduct a comprehensive review of how the U.S. research universities should face the growing competition, losing its advantage it had enjoyed since World War II.

The research university definition is a general and somehow an abstract term around the world. Carnegie Institution for Science defines Research University by criteria that include the financial scope of the university's studies, scope of the research funded by the US federal government and the number of eligible doctoral students. NAS uses a "soft" definition stating that a Research University links values such as freedom of research, creativity, excellence and openness, with aspects of organizational characteristics like the size of the institution, the breadth of issues that they are dealing with, and level of education for both undergraduates and postgraduates, highlighting the promotion of research faculty and enlightened leadership. Altbach , 2011 ; Salmi , 2011 [2,3] also talk about the "spirit" research University, based on achievement both in terms of academic staff and students, thus making the Research University an institutionally elitist body (and creating tension with egalitarian democracy).

A leading principle for a Research University is academic freedom that may allow teaching and research without any restrictions. Academic freedom was a key point in Wilhelm von Humboldt Research University definition in the early 19th century. Von Humboldt's reform changed the university institution from an academic teaching institution to a research institution. However, the purpose of a Research University was to serve the state and, accordingly, to encompass not only basic research but also (or even primarily) applied research, which led to the development of science department in disciplines such as chemistry and physics, and also social sciences.

In general this approach is still valid today. In the US, the universities created the infrastructure for economic growth, starting as early as in 1862, but accelerated greatly during World War II and following the war. This infrastructure included the well-known major inventions such as radar, penicillin, the computer, the jet engine and the nuclear bomb, all of which came out of federal government research findings.

In other countries the situation is similar, there is growing number of universities that are forced to improve their services and allocate resources for teaching and research. Research itself has become more expensive, which made universities carefully allocate their resources; while the public is expecting that the universities' research would be beneficial to society and not only yield 'just' inventions. Serving the public is a key element in the research university role, as perceived by the

general public. In some countries senior academic staff are appointed by ministers, while in other countries research guidance is wearing a different form, such in the US where the government is funding selected research streams; in Korea the government has its own research institutions that allows it to address its changing needs to achieve national goals. The growing understanding regarding the link between innovation and economic growth led many countries to create research collaborations and knowledge transfer mechanisms. The long list of global government programs indicates the tension between the need to conduct 'free' research – that is motivated by interest - and research for public interests. This tension also exists in Israel, and will be discussed in the following section.

3. The Universities in Israel

The Israeli Research universities includes 7 institutions: (in their establishment order) The Technion , Hebrew University, Weizmann Institute of Science , Bar-Ilan University, Tel Aviv, Ben-Gurion and University of Haifa. For many years (even before the Israeli state was established) there were only two research universities, that didn't even compete in their research field. In the last 60 years, Israeli universities enjoyed their 'monopolistic' position, and it was only in the 1990s, when new colleges started to emerge, that the universities faced some competition in terms of funding resources and graduates enrolment. This change created a funding distinction between Research Universities and Academic Colleges. The goal was to reduce the teaching load of Research Universities and divert it to the colleges, while keeping the Research in the Research Universities. For many years the Israeli universities also enjoyed some 'immunity' from public criticism. Apart from military collaboration, which was expected to occur, universities were funded by the government without any research guidance or academic grants to promote specific field. Staff were expected to conduct basic research with no requirement for any applied research. This picture changed in the last two decades due to globalization processes and the rapid growth of the Israeli Hi-Tech sector. In respect of university graduates, industry expected that academia would provide sufficient scientists and engineers in required fields, and in terms of research, the industry was 'fighting' academia to take the best human capital by offering high monetary benefits and other future commercialization potential benefits. These processes in Israel, like in many other places in the world, pushed some of the universities research from basic research into a more applied research, in that new models have been established to allow public-private collaborations which made a significant different in research universities systems. In order to understand the universities' role in the national R&D system we provide in the following section some Israeli macroeconomic and R&D indicators, benchmarked with a selected list of reference countries.

Table 1.1 Characterization of key indicators for R&D and innovation, Israel and reference countries

Variable	Description	Israel	Korea	Germany	UK	Netherlands	Switzerland	Sweden	OECD Average
The Achilles heel of a Strong Private Knowledge Sector: Evidence from Israel <i>Tzameret Rubin, Dan Peled, Benny Bental</i>									
General Macro Variables									
Population	Population (millions, 2010)	7.6	49.4	81.8	61.3	16.6	7.8	9.4	
GDP per capita	US dollars, current prices and PPPs, 2010	26,531	28,797	37,430	35,687	42,196	48,657	39,346	33,971
International trade in goods and services	as % of GDP, 2010: imports	34.9	49.7	41.4	32.7	70.1	40.5	43.5	27.9
	as % of GDP, 2010: exports	36.9	52.3	47	30.5	78.2	51.7	49.7	27.2
National R&D Indicators									
GERD per capita	Gross expenditures on R&D, US dollars, current prices and PPP, 2010 84	1,167	1,077	1,056	628	781	1,455	1,338	806
GERD	(% of GDP)	4.40	3.74	2.82	1.76	1.85	2.99	3.40	2.37

Variable	Description	Israel	Korea	Germany	UK	Netherlands	Switzerland	Sweden	OECD Average
BERD	Business expenditures on R&D (% of GDP) <small>The Achilles heel of a Strong Private Knowledge Sector. Evidence from Israel Talbot Rubin, Dan Peled, Barry Berjal</small>	3.44	2.80	1.88	1.10	0.89	2.11	2.33	1.58
HERD	Higher education expenditures on R&D (% of GDP)	0.58	0.40	0.51	0.49	0.75	0.77	0.89	0.44
GOVERD	Government expenditures on R&D (% of GDP)	0.17	0.47	0.41	0.17	0.22	0.02	0.17	0.29
National R&D Performance Indicators									
Quality of Universities	Number of universities in ARWU Top-500 world universities, 2013, (aka Shanghai ranking)	7	11	38	37	12	7	11	
Quality of research	Publications in the top-quartile journals, per 1m \$US GDP, (rank among 40 countries) 85	4	25	20	9	8	1	2	
Tertiary attainment rate	% of population ages 25-64 with a tertiary education (both types A and B)	46	40	28	39	32	35	35	32

Variable	Description	Israel	Korea	Germany	UK	Netherlands	Switzerland	Sweden	OECD Average
The Achilles heel of a Strong Private Knowledge Sector: Evidence from Israel Tzameret Rubinfeld, Dan Peled, Benny Benita S&T tertiary rate	% of tertiary new entrants in sciences and engineering fields (2011)	32	32	29	23	16	25	30	25
Triadic patent families	Triadic patent families (per billion USD GDP)	1.68	1.49	1.88	0.74	1.27	2.38	2.49	0.42
Triadic patents	triadic patents in 2000	221	742	5,535	1,036	1,710	1,018	671	
	triadic patents in 2010	425	1,260	8,331	1,123	2,350	2,350	1,554	
universities patents	Patents filed by universities and public labs 2005-09, (per billion USD GDP), rank among 36 countries	1	3	16	8	13	9	33	

Source: STI Outlook ISBN: 978-92-64-17039-1, Published: September 2012 (online)

4. Comparing Israel to Other National R&D Systems.

In order to appreciate the scale of R&D indicators in Israel, we provide in the table above some macroeconomic and R&D indicators with a few comparable countries. Those countries are Germany, UK, The Netherlands, Sweden, Switzerland and Korea: two large and developed countries, three developed European countries with similar relatively size and a developed Asian country of a medium size. The selected macroeconomic and R&D indicators delineate a general picture of Israel:

Macro variables - The size of the economy and income per capita, and the degree of openness to international trade (studies show a positive relationship between R&D Expenditure and the volume of international trade). **In Israel, GDP per capita is the lowest among the comparison group.** Its openness to international trade exceeds the United Kingdom and the mean OECD countries, but it is lower than in the other countries of comparison.

R&D expenditure in various sectors: Israel expenditure on civilian R&D as a portion of GDP is the largest in comparison to the selected countries (and to any OECD country). It has the highest business R&D, which is among the highest in the world. Conversely, government expenditure is relatively low in the world.

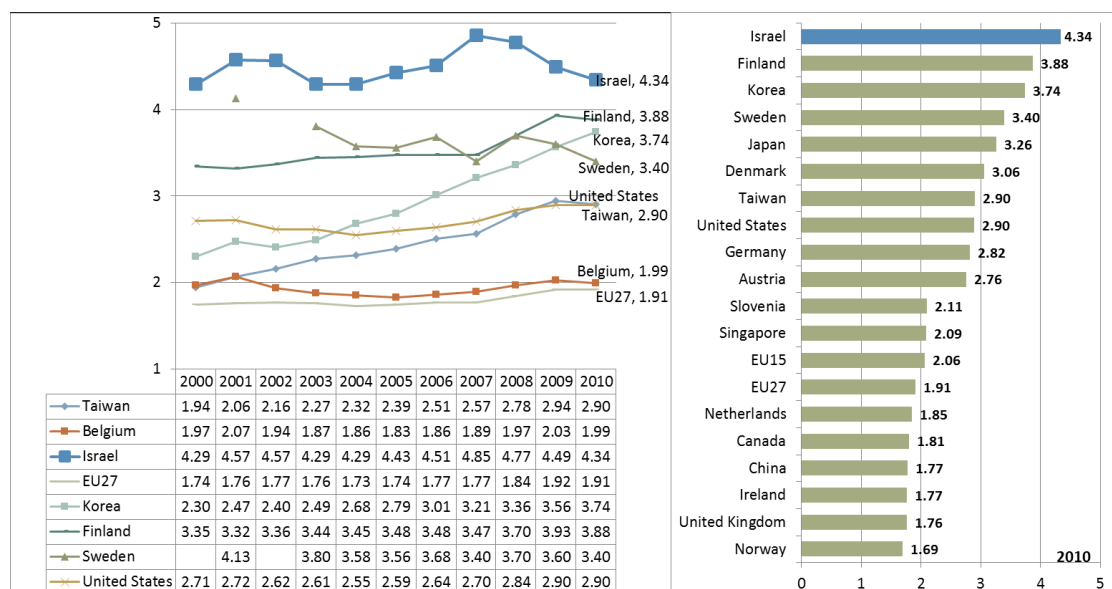
4.1 Performance/ output measurement of R&D:

- The quality of the educational system - the number of universities in the countries ranking ARWU 2013 included the 500 best universities in the world. **In Israel, all seven research universities are included in the top 500 .**
- The quality of academic research – ranking among the 40 OECD countries, top 25% article cited, normalized by the country's GDP, **Israel is ranked fourth among the 40 developed countries** , after Switzerland, Sweden and Iceland .
- Rate of Higher Education in the economy - rate of citizens age 25-64 having an academic degree type A (research university). **Israel has the highest rate in comparison to the seven countries (46 %).** Although the high rate was mostly affected by significant immigration cohorts from the Soviet Union in the 1990s.
- Science and technology studies - the rate of new students in higher education who are studying science and engineering. A high rate in **Israel relative to the comparison** countries.
- R&D applied outputs - the number of triadic patents per GDP, and the increase in the number of triadic patents between 2000 and 2010. Though patent numbers are an accepted measure of the output of R&D, its measurement is affected by field of research expertise and other economic considerations of the inventors. **Israel is positioned much higher than the OECD average.** The university patents number relative to the country's GDP - representing the degree of applicability and relevance of academic research. **Israel has the highest universities patents per GDP among the comparison group.**

4.2 R&D intensity

National expenditure on R&D as a percentage of GDP is the country's R&D intensity. It represents the use of economic resources for research and development needs. As can be seen in the figure below, for many years, Israel was a leading country in its R&D intensity. Although it still sustains its leadership, it has a declining trend while other countries, in particular Korea, increase their effort to improve their R&D intensity. Another striking phenomenon that is shown in this figure is the volatility that characterizes the Israeli data (and to some extent those of Sweden). This volatility is mainly due to the dominant role of the R&D in the business sector, which tends to follow a business cycle.

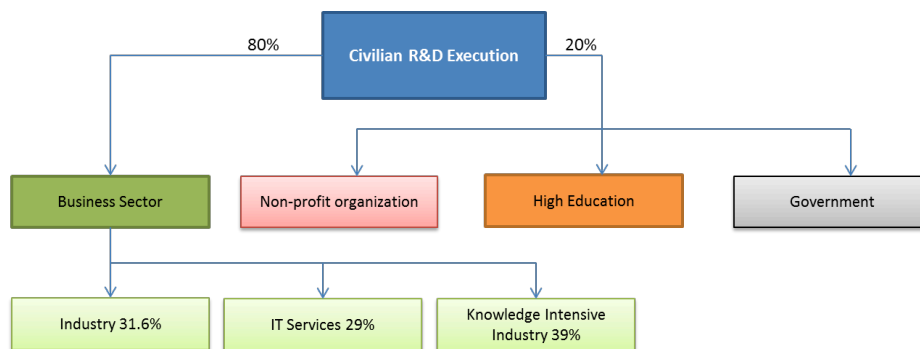
Figure 1.1: GERD as Percentage of GDP, 2000–2010^a



Sources: Samuel Neaman Institute Analysis on Israel CBS and OECD data in 'Science and Technology Indicators in Israel, 2013.

Figure 1.2 demonstrates the split of R&D execution between the private and public sectors, and a very general split within the private sector. The total civil R&D expenditure amounted to 38.2 billion New Israeli Shekel (NIS), representing 4.34% of GDP in 2010.

Figure 1.2 Civilian R&D Expenditure Executions as a Percentage of GDP, 2011.



Sources: Samuel Neaman Institute Analysis on Israel CBS and OECD data in 'Science and Technology Indicators in Israel, 2013.

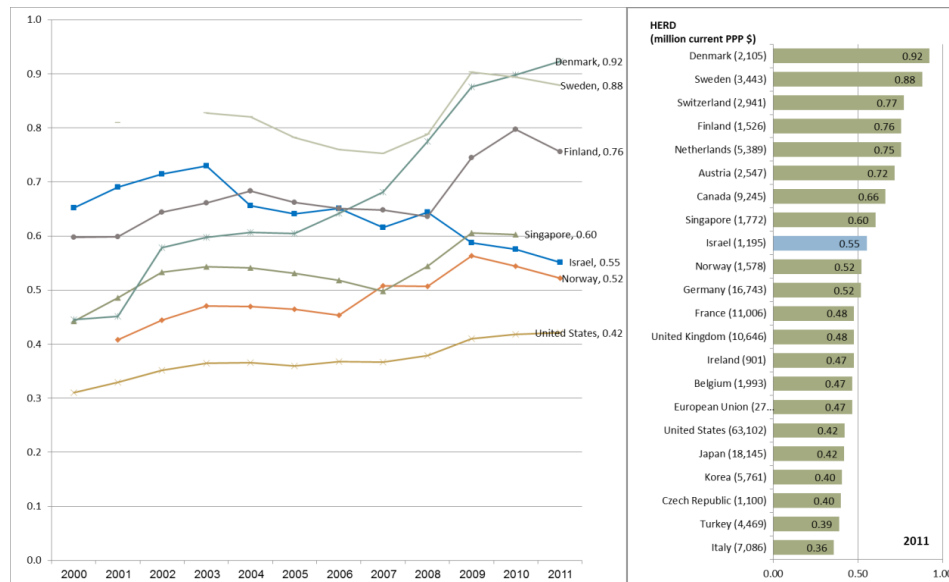
4.3 Academic Financial Resources

The Israeli research universities' are funded through the following four channels:

- General government universities budget for both teaching and research, as part of the budgeting model of the Planning and Budget Committee (PBC).
- Israeli and international competitive research funds, based on agreements between states.
- Knowledge transfer and research support (mostly funded by the Chief Scientist Office in the Ministry of Economy).
- The university's self-financing internal sources.

In the past decades, High Education R&D (HERD) budgets were reduced and reached a level that is the lowest among OECD countries. As can be seen in figure 1.3, when all OECD countries show growth in their HERD intensity (HERD/GDP), Israel shows a decrease from 2003, from 0.73% to 0.55% in 2011.

Figure 1.3 HERD Intensity (HERD as Pct. of GDP), 2000–2011



Sources: Samuel Neaman Institute Analysis on Israel CBS and OECD data in 'Science and Technology Indicators in Israel, 2013.

4.4 R&D in the Private Sector

Performing R&D in the business sector accounts for more than 50% of total R&D in most OECD countries; however Israel's rate is particularly high with over 78% of R&D occurring in the business sector. Israel differs from other OECD countries in two aspects: (1) the share of business sector R&D intensity, which reflects the different allocation of resources for business innovation. This business share is very high in Israel. (2) Financing sources for Business Expenditure on R&D (BERD). In Israel the business R&D financed by foreign investments is extremely high in comparison to other OECD countries. Table 1.2 provides some countries for comparison. The business sector in Israel is gaining in strength over the years and increases its shares in the country's GERD. This phenomenon raises some questions about Israel's R&D composition. One of them is the nature of R&D that is mostly performed by the business sector, is the applied research growing at the expense of basic research? Another question is when the R&D is concentrated in industries where outcomes are more rapid and do not require long-term investment, is the nation's GERD led by short time frames?

Table 1.2 Characterization Israel GERD and BERD

Country	Percentage of GERD* performed by business sector (2010)	Percentage of BERD foreign financing (last 5 years)
Germany	66.7	3.5
Israel	78.2	41.2
Korea	74.9	0.2
Netherlands	48.1	15.2
Sweden	68.5	12
Switzerland	73.5 ^a	7.1
UK	62.5	22.6

Source: Main Science and Technology Indicators, OECD Stat, 2008. * GERD is Gross expenditure on R&D.

4.5 R&D financed by foreign investments

Globalization processes are affecting the R&D mechanisms in two ways. First, firms transfer part of their R&D activities centres to other countries in order to utilize local areas' R&D competitive advantages, using local resources, such as specialized human capital qualities, low R&D costs or governments benefits, to support business local innovation. The second way is by outsourcing some of the business' R&D activities to foreign companies that are specialized in a particular type of R&D. In Israel the first option is more common, where large multinational companies have local R&D centres, For example, IBM, Intel, Motorola and Google established their development centres in Israel decades ago. According to the Israeli CBS data, in 2010 these companies employed more than 20,000 people.

It is important to note that, unlike many countries in the world that have a presence of R&D centres of multinational companies, in Israel the nature of these R&D centres is an integral part of the main R&D parent companies. In most states, these multinational companies' R&D centres are more local implementations, oriented to provide services as a means of reducing costs. Sometimes the existence of such centres is due to commercial reasons – marketing or tax benefits that are granted for their local R&D centres [4].

5. Universities Outputs

As reviewed above, due to the reduction in public R&D funding, the universities seek alternative financial sources. Alongside this, the Hi-Tech industry has grown and required more from the universities, in terms of both Science and Technology (S&T) graduates and products of research. These developments have created incentives for both institutions and individuals to 'trade with knowledge'. One proxy that might capture the trend is patent data. The section below provides some

evidence for the universities activity over time, and compares the areas in which university patents were applied relative to the business sector. The patent analysis might provide some insights into output trends from Israeli Research Universities. In this part we review one of the Israeli universities' outcome expressed in patent applications, with an international comparison. The Israeli data was benchmarked with the following selected reference countries: Switzerland, Belgium, the Netherlands and Korea, because of their relatively similar size. We also include US patent applications data as a high-end patent benchmark country. We use PATSTAT data looking at European Patent Office (EPO) patents in the years 1990-2010. We were in particular interested in identifying the applicants' nationality and institutional affiliation.

In the first part of this section we present universities patent data relative to the total patents granted in each of these countries in order to understand the significance of universities activity within its country. In the second part we examine the areas of universities patents in relation to the segments of the business sector in Israel and each of its benchmarked countries.

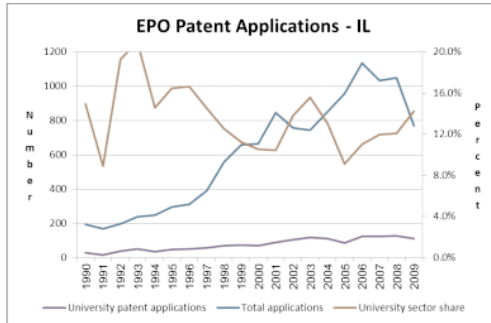
5.1 Universities' patents as a share of total national patents count

The figures below show a very low proportion of universities' sector share of patents in Switzerland, The Netherlands and Korea, reaching only 2-3%, while in Israel the average is about 12%, similar only to Belgium. But in contrast to Belgium, where universities' patents picked up only in the last decade, in Israel a high proportion of universities patents proportion was maintained throughout the examined period. This finding suggests that Israeli universities' outputs are dominant in the national R&D effort, despite the declining government funding. One possible reason for the high proportion of universities patent applications is that while in other countries government funding is more secured (and even on the rise) so academics have lesser need to protect their IP, since they are less involved with commercialization projects or even just expand their research through private sector funding. In Israel however, because the private sector funding is more crucial for academics, they are 'forced' to apply for patents more in order to start any collaboration with external bodies. The need to protect Intellectual Property (IP) from infringement and secure IP rights is crucial where a potential commercialization process might be apparent in the future.

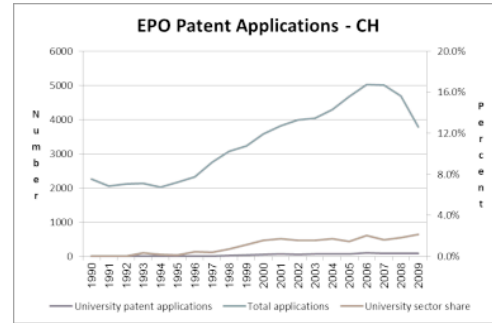
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Figure 1.4 Universities Patent Applications, and Patent Application Share

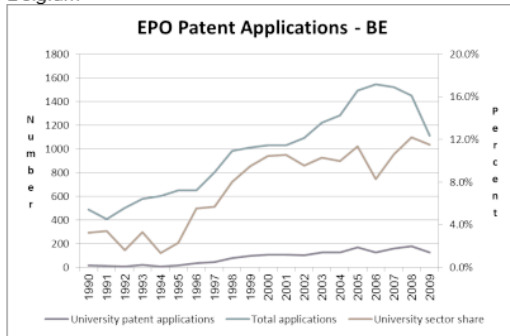
Israel



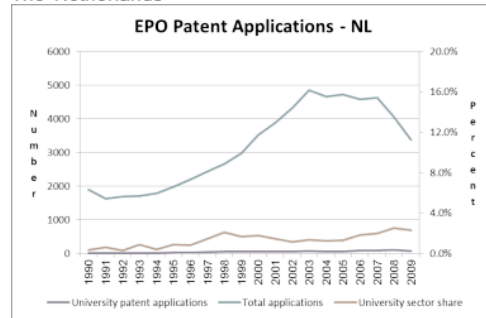
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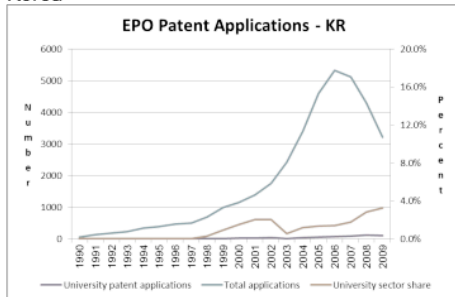
Belgium



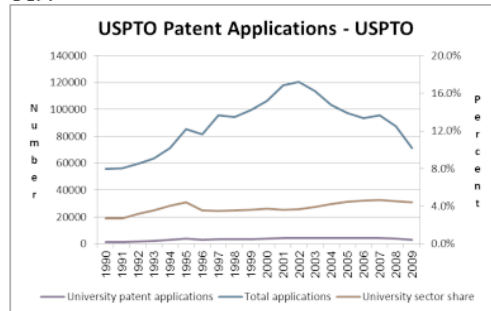
The Netherlands



Korea



USA



5.2 Linking Universities' Output (Patents) with Industrial Classification (ISIC)

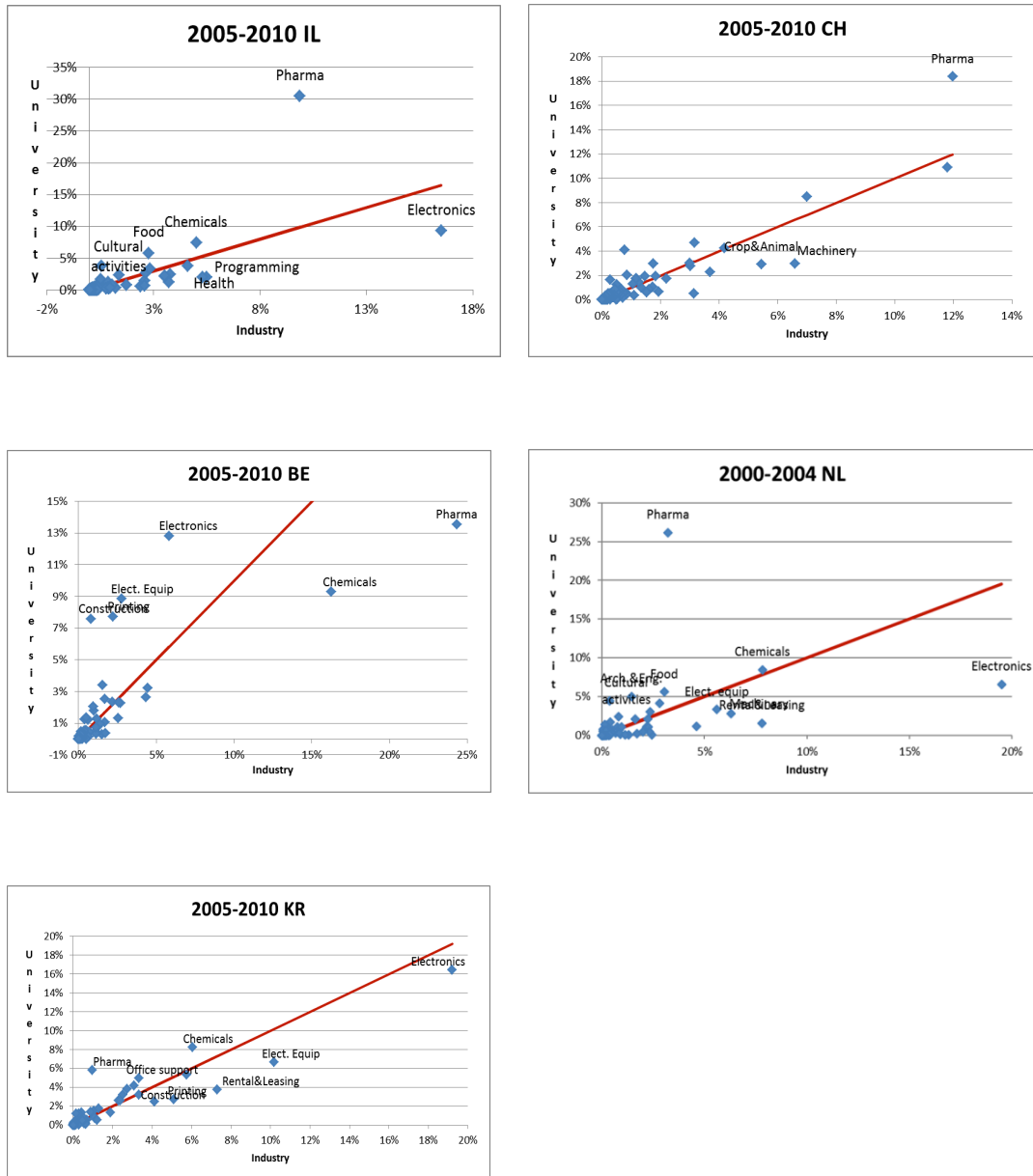
Finding the link between patents and industrial economic data is a known challenge in academic literature, as patents are classified according to technological codes (IPC - International Patent Classification) while industries economic data are categorized according to areas of economic activity (ISIC - International Standard Industrial Classification). Therefore, seeking to link research and technological innovations patent data with economic output activities such as exports, productivity and labour, must be assisted by a concordance.

In the literature there are several concordances. Typically concordances were created manually by experts, who were asked to indicate the most likely industry to use an invention accordingly the patent IPC classification was assigned to a specific industry. The original concordance was limited to industrial activities, mostly in manufacturing, missing important growing industries that tend to patent even more than the industrial sector. In 2012 Lybbert and Zolas (2012) published a new concordance [5]. where they developed a sophisticated textual algorithm that identifies keywords that describe patents on the one hand, and keywords that describe economic activity on the other hand. Keywords matching allows one to build a frequency table with the probability for a patent to be applied in a specific economic activity. While old concordances were mostly relevant to the manufacturing industry, now Lybbert and Zolas concordance can be applied to all industries.

The data that we use represent patents granted in accordance with their classification by using Lybbert and Zolas concordance. Industry level of detail is two digits, for example: Branch No. 20 is defined as: Manufacture of chemicals and chemical products, Sector No. 21 is Manufacture of basic pharmaceutical products and pharmaceutical preparations and the branch 72 is Scientific Research and Development. The data was divided accordingly into universities and the business sector, in order to allow us to examine to what extent patent activities in universities across industries corresponds to that of the business sector.

The data manipulation was conducted in two stages. First, we used the concordance to 'convert' IPC to ISIC. In the second stage, we compared between the existence of such patents in a specific industry in the business sector and universities. The same analysis was performed for a set of countries in order to benchmark the Israeli universities' outputs.

Figure 1.5 Patenting by industrial sectors classification



Each point in the figures above represents the percentage of patents attributable to an industry in the business sector (on the x axis) and the percentage of patents attributable to the universities (on the y axis). Along the red 45 degree line, universities and business sector tendency to patent in the specific industry is equal. If the university tends to patent more in a specific field, the point will be above the red line. Accordingly, each point below the red line reflects a stronger business sector share in that field. We marked the notable industries only in these graphs.³ It is notable from the above set of figures that in Israel the Pharmaceutical industry is an exception with respect to other industries. The rate of university patents in this area is three times larger than their proportion in the business sector. However, the business sector is more active in the Electronics industry. With a dominant private sector in R&D expenditure, if businesses are not aligned with universities fields of research, such a gap between knowledge and resources might cause a future problem in the national R&D system, both in terms of graduates and in terms of the ability to leverage the universities' knowledge. In other countries there are also a few gaps; in Belgium the business sector tends to patent more in the Chemicals industry than the university, while in the Netherlands the Electronics industry patents much more than twice as much as the universities.

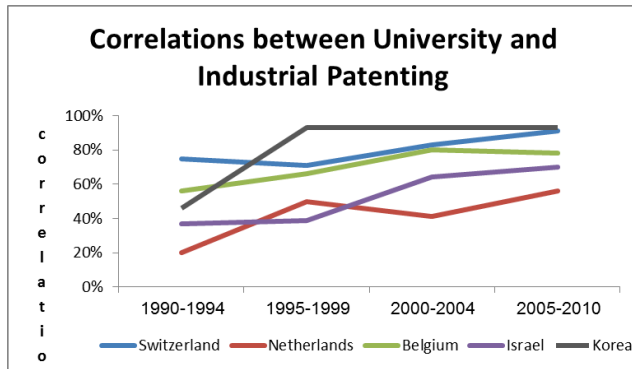
5.3 Dynamics

We ran a Pearson correlation coefficient test for universities' patents and the business sector's patents for the years 1990-2010 and found that the correlation between the fields of activity in the business sector and the universities is not fixed, and tends to rise over time in all countries. Figure 1.6 below indicates these changes over two decades (intervals of five years). Although through correlation we cannot know the cause and effect, we can say that both sectors – the universities and the business sector - are coming closer to each other in terms of technology fields. It might be that the knowledge is created in the universities and the business sector tends to follow their specializing fields, or the other way around - the universities are following interest coming from the business sector⁴. Therefore it might be that the universities tend to collaborate more in specific fields and that collaboration process requires more IP handling for further collaboration. If we compare the slopes between countries we can see that Korea - the country with the highest alignment between the sectors - closed the gap very rapidly in the late 1990s and maintained this close relationship between the sectors. While in Switzerland the sectors were drifting apart in the 1990s and since then they are becoming more aligned. The Israeli story correspond with The Netherlands, with a 'zigzag' path that has a positive cumulative slope, this might indicate a more independent and a strong business sector that does not continuously follow the universities' fields of research.

³ . Patent data for the business sector do not include those of foreign-owned research centers.

⁴ Hence patent data is a good proxy for a more applicable R&D stage rather than basic R&D.

Figure 1.6 Growing link between universities and the Business Sector patenting fields.



6. Summary

Our purpose in this paper was to examine the unique Israeli research and development system, in particular the role of research universities in this country. We provide some macroeconomic and R&D indicators in order to have a baseline of comparison between a few OECD countries, and in order to quantify the magnitude of each indicator. We found that Israel has a very high R&D intensity indicator; however, if one looks underneath the GERD an interesting picture may be found – a very strong knowledge business sector that is heavily reliant on overseas funding, with a declining government investment in R&D. This picture made us puzzled about the output of the research universities and whether they are affected by this anomaly – a strong tension between the private and public sector. Although we provided a list of output indicators that relates to the Israeli Research universities, we focused in patent applications data, as this proxy is a more adequate indicator for applied research, and therefore has a better ability to represent the link between the private and public sectors. Our findings suggest that the Israeli research universities' activity in patent applications is significantly higher than the other countries in the world. We also found evidence of growing correlation between the business sector activity and universities in Israel, that has become more evident in the last decade. This increase may be due to the growing economic pressure on universities' research directions for commercial implications and the declining government funding of R&D. However, it should be noted that the correlation obtained in Israel is slightly lower than in Switzerland and Korea, where these countries a high degree of involvement in directing university research for the benefit of the business sector. In Israel, some of the increase in correlation between the two sectors is a result of government programs encouraging cooperation between academia and industry. Our findings further indicate a significant role in innovation outputs in Israeli universities out of the total national innovation effort –reflected in patent data. We attributed this significant role of universities as due to the declining government funding of research that 'pushed' the universities to look for other research funding, where patents are used to secure any commercial process. Finally, when we converted patent codes to applying probable industry fields, in general we found a close grouping of patenting in specific fields for all countries, while Pharmaceutical patent applications stood out with a higher likelihood to belong to universities in Israel, The Netherlands, and Switzerland while in Belgium the business sector leads patenting in that industry. For the case of Israel, with a dominant private sector in R&D expenditure, if the business sector is not aligned with the universities' fields of research, such gap of knowledge and resources might cause a future problem in the national R&D system, in terms of graduates and in terms of the ability to leverage the universities' knowledge.

7. References

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