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Department of Sociology and Anthropology

The Helix Model of Innovation in Israel:

The Institutional and Relational Landscape of Israel's Innovation Economy

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Prof. Henry Etzkowitz is a scholar of international reputation in innovation studies as the originator of the 'Entrepreneurial University' and 'Triple Helix' concepts that link university with industry and government at national and regional levels. Henry is Senior Researcher, Human Sciences and Technologies Advanced Research Institute (H-STAR) Stanford University and Visiting Professor, School of Management, University of London, Birkbeck. He is also President of the Triple Helix Association www.**triplehelixassociation**.org Henry came through the Mandelbaum Gate in Jerusalem on his first visit to Israel in 1963 when he was a U.S. Peace Corps Volunteer in Nigeria.

Avida Netivi, born 1981, is a MA student in the Department of Sociology and Anthropology. He is writing his MA thesis under the guidance of Prof. Gili Drori, focusing on the emergence of new organizational forms in innovation-oriented organizations.

Preface

This compilation is the outcome of an annual undergraduate seminar, titled “the sociology of innovation, entrepreneurship, and networks,” offered at the Department of Sociology and Anthropology at The Hebrew University of Jerusalem during the 2011-12 academic year. Captivated by the systemic and relational perspective encapsulated in the Triple Helix Model, which was outlined in the 1990s by Henry Etzkowitz, we decided to evaluate the applicability of this model to Israel’s innovation system. We quickly came to the conclusion that Israel’s celebrated innovation system is more complex than the model outlines: whereas the Triple Helix focuses on the triadic relations among industry, government and academia, in Israel additional “helices” are integral strands of innovation. Based this critique, we specified such additional helices that are most relevant for Israel’s innovation economy and we divided the research of these various helices among us. The outcome is offered here is, therefore, an exploratory study of the institutional components of Israel’s innovation system and of the integrative relations among these components. In this way, our joint work here is in conversation with several contemporary social science discussions: on national innovation systems, on Israel’s innovation economy, and on networks and organizational hybridity.

As much as the chapters are the outcome of individual research and writing, the project as a whole is very much a cooperative project. We read each other’s written drafts, commented on each other’s arguments in class discussions, and offered each other tips about data and information we found during our own “hunt” for relevant information. Therefore, each one of us extends her or his thanks to our peers, for the support and encouragement that they offered throughout the year. We also thank Prof. Henry Etzkowitz, whose work inspired us to venture into this project and who here engages with us in conversation about Israel. Etzkowitz’ commentary on our work and on Israel brings the Israeli story into the sphere of the international community of researchers who, like us, rely on the metaphor and model of the Triple Helix to understand the systemic foundations of innovation.

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Chapter 1

Helix Model of Innovation in Israel: The Global Scheme and its Local Application

Prof. Gili S. Drori

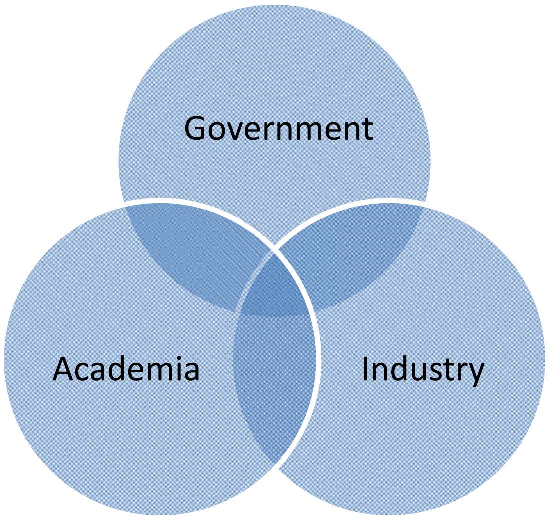
Senor and Singer's 2009 book, "*Start-Up Nation*," quickly hit the best-sellers list of the *Wall Street Journal* and the *New York Times* and was translated into some twenty languages. The book peaked the world's fascination with Israeli innovation by answering "the trillion dollar question": "How is it that Israel – a country of 7.1 million, only 60 years old, surrounded by enemies, in a constant state of war since its founding, with no natural resources – produces more start-up companies than large, peaceful, and stable nations?" And, "how is it that Israel has, per person, attracted over twice as much venture capital investment as the US and thirty times more than Europe?" The Israeli "miracle" stands as a code to be cracked, or as an exemplar for countries and regions worldwide that are seeking innovation-based development. The buzz around this book builds on the recognition of innovation as the critical component for success in the global knowledge economy: no longer can firms or nations grow solely off their natural- or human capital resources; rather, growth depends on innovativeness.

In seeking to decode the systemic foundations of innovation, previous studies analyzed the other so-called miracles of the global knowledge economy: Scandinavia, the Boston area and, of course, Silicon Valley. Many of these studies highlight particular causes for such innovation-based regional success – from immigration ties (e.g., Saxenian, 1994, 2006) to legal and financial institutions (e.g., Suchman, 2000, 2001) to network constellation (e.g., Whittington et al., 2009). But the question remains: What combination of such components and what "critical mass" of them would spark an innovation economy? Two conceptual tools, which were delineated in order to model the system components whose assemblage triggers a local innovation economy, dominate discussions throughout the past four decades: Christopher Freeman and Bengt-Åke Lundvall formulated the concept of "national innovation system" (NIS) and Henry Etzkowitz and Loet Leydesdorff outlined the Triple Helix Model. The work compiled in this volume takes the Triple Helix Model as a point of departure in mapping and analyzing Israel's innovation economy.

1.1 The Triple Helix Model

Seeking to explain the socio-structural conditions that encourage knowledge-based economic development, Etzkowitz and Leydesdorff proposed in 1995 the Triple Helix Model. The Model links among academia, industry and government and, building on the imagery of the double-helix structure of DNA, the Triple Helix model weaves these three helices into a spiral configuration which allows for multiple reciprocal links among the three institutions. Although Etzkowitz (2003) specifies as many as 10 propositions that express the Model's tenets, three principles stand at its core: (a) the three helices, or institutions critical for innovation, are academia, industry and government, (b) there exist multiple points of contact and exchange among these three institutions, and (c) each of the institutions is transformed through such intensifying interconnectedness. The outcome is not merely a joint project or a jointly developed product, but rather an integrated, often hybridized, form of knowledge-based development, of nations and regions (see. Meyer, Grant and Kuusisto, 2013). And, this systemic interlacing among the so-called helices maintains the dynamism and flexibility that are core features of any system of innovation.

Figure 1.1: Triple Helix Model



Source: adapted from Etzkowitz and Leydesdorff, 2000

(Figure 1, page 111)

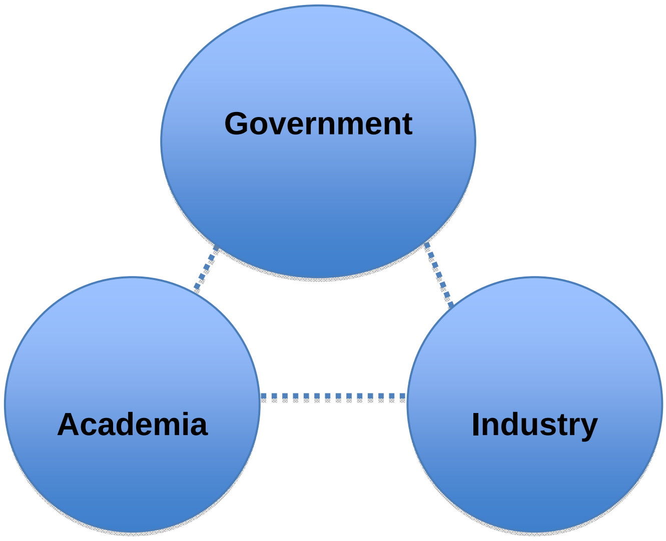
The three institutions laced into the Triple Helix model are described in Figure 1.1. These are:

University. The University has always been entrusted with knowledge creation, through learning and research. In today's knowledge-based economy, universities have been transformed into knowledge producers and market players. Etzkowitz describes this transformation as follows: "The university has traditionally been viewed as a support structure for innovation, providing trained persons, research results, and knowledge to industry. Recently the university has increasingly become involved in the formation of firms, often based on new technologies originating in academic research." (2003: 294). Such commercialization of academic knowledge also drives universities to guarantee legal protections of their intellectual property and, with that, defy the normative order of public science (see, Bok 2003, Willmott 2003, Ramirez 2006, Rhoten and Powell 2010). And while recent decline in university patenting has been taken to mean a re-trenching of academia to focus on ‘core business’ of basic research and teaching (see, Meyer, Grant and Kuusisto, 2013: 193), the overall intensification of commercialization and co-production of knowledge is the hallmark that defines the entrepreneurial university, or the “3G university” (see, Wissema 2009).

Industry. With knowledge and innovation becoming the new source of capitalization for firms, firms too are transformed into knowledge producers: firms replace their traditional model of in-house R&D and innovation, which drew solely upon internal capacity, with an open innovation model, which calls for cooperative models of innovation and on outsourcing of innovation functions. As a result, firms not only continue to build in-house labs and sponsor academic research, they now cooperate intensely with academic research and allow – even welcome – the mobility of researchers between academia and industry. This post-Fordist production is a form of open innovation.

Government. As the representative of the public and an advocate of public good, government serves as the third component in the driving of innovation. Whether national, state, or municipal, government serves as an enabler of innovation ties, mostly by sponsoring start-up initiatives or funding “big science” projects in hope of spillover effects. In addition, government guides innovation through its regulatory power, for example by formulating IP arrangements. Still, government’s supervisory role as regulator may also result in suffocating innovation through, for example, regulatory restrictions on types of research or on taxation of foreign investment.

Figure 1.2
The Triple Helix Model

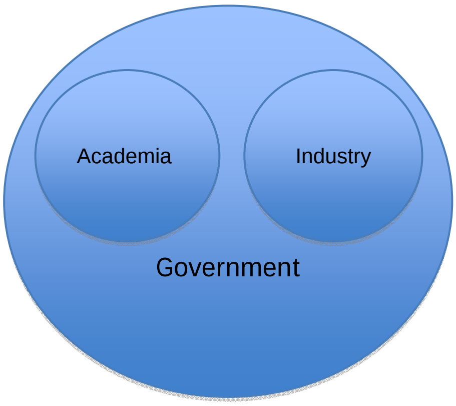


Source: adapted from Etzkowitz and Leydesdorff, 2000
(figure 2, page 111)

The important feature of the Model is that the 3 institutions, or helices, are intertwined and link in multiple points. Recalling DNA structure, the Triple Helix model of innovation laces the strands, or helices, and build multiple connects among them; this form is described as a “recursive overlay of interactions among the stakeholders” (Yang et al., 2012: 375). In its form, the Triple Helix Model distinguishes itself from two other possible format of relating academia, industry and government (Figure 1.2). The first alternative is the *Lesseiz Faire* Model, where a country has all three institutions, yet it is at their initiative and at their pace that any link is made between them. The second alternative is titled the *Etatic* Model. In this form of relations, government takes the responsibility to guide innovation and also to build innovation-related links between academia and industry. Like Goldylock’s choice of a bed at the bears’ home, Leydesdorff and

Etzkowitz regard these two alternative models for innovation as either too loose or too tight. The Triple Helix Model calls for a balance among the three helices, so to prevent a case of *tertius gaudens*, where one sector benefits from any stress between, or weakness of, the other two helices (see, Etzkowitz and Zhou 2006: 77). Unlike these *Lesseiz Faire* and *Etatic* formulations, the Triple Helix model is both flexible and self-reinforced, allowing for appropriate room for agency while offering a structural backbone for links to form and stabilize.

Figure 11.3:
Lessaiz Faire and Etatic models of relating academia, industry and government



Source: adapted from Etzkowitz and Leydesdorff, 2000
(figure 2, page 111)

1.2 Social Context

The backdrop for the Triple Helix Model is the discussions since the 1970s on the structural base of the transition into a knowledge economy. The Triple Helix model is, therefore, one of several eco-systemic outlines for innovation, all of which draft the environment, or social context, of innovation and entrepreneurship. Among such systemic maps of the innovation- and knowledge economy, and most clearly in comparison with the notion of NIS of Freeman and Lundvall (see, Nelson 1993), the Triple Helix model stands out due to several of its core features. First, it is a neo-evolutionary model, where the development of social institutions, herein the sectors of an innovation economy, is revealed as a co-evolutionary process. Second, it is a non-linear model of social action, herein of the interaction among the three sectors. In this sense, the development of an innovation economy, while path dependent to some degree upon historical circumstances, is sparked by the interactive and multilateral interactions among multiple stakeholders. Its neo-evolutionary tone makes the Triple Helix model most applicable for policy. Indeed, the model has been a basis for many policy reforms, of regions and nations seeking innovation-spurred development.

Epistemologically, from the perspective of organizational studies, the Triple Helix Model is a part of an overall move to regard organizations as open entities, which are embedded in a wider social context (see, Engwall 2007). For example, university governance is currently analyzed as involving relations with “external” and multiple stakeholders, such as accreditation agencies, international higher education associations, parents groups, and employers of their to-be graduates (see, Tuchman 2009). This understanding of the porous boundaries of each of the three core institutions in the Model does not weaken the positivist approach to social development that underlies the Triple Helix Model. Rather, contrary to the focus on academic capitalism (Slaughter and Leslie 1997, Slaughter and Rhoades 2004, Hoffman 2011), the Triple Helix Model regards university-industry ties as an imperative for innovation and development and as synergetic, rather than exploitative, relations. Overall, it is on such matters – of a model void of power, hierarchy and historical context – that the Triple Helix Model is most criticized.

1.3 Critique of Triple Helix Model

Criticism of the Triple Helix Model comes from two directions. First are those who challenge the premises of the Model and expose its ideological roots. In this group are the many studies of academia-industry relations that highlight power-asymmetries among the sectors. In the words of Yang et al., the Model "treats the roles of different innovation actors (universities, industry and government) symmetrically, which promotes the impression that innovation is the result of non-hierarchical collaborations around mutual development objectives." (2012: 347). Prominent among such critics is the "Academic Capitalism" school, led by Sheila Slaughter, Gary Rhodes and Larry Leslie. This research tradition stresses the impact of the industrial sector and other commercial interests on academia and the tilting of academic research in the direction of such capitalist, profit-oriented interests. Benner and Sandstrom (2000), for example, call attention to the impact of research funding on the institutionalization of Triple Helix ties: research sponsors, they claim, "steer the attention of potential applicants in a specific direction" by, for example, setting criteria for evaluation and "influence the expectations and orientations of the applicants."

Others add that the Model is archetypical American and, with that, flattens cross-national variations in the triple-sectoral relations or in innovation systems in general. Therefore, while the Model portrays three-sector relations as a necessary condition, industrial development in Europe has long been anchored in industry-academia partnerships. Therefore, contrary to the Triple Helix Model's imagery of innovation systems, Fogelberg and Thopenberg show that "[t]he mutual development that Arenas promoted was based on the tradition in the Swedish welfare model, i.e. a two helices industry-government partnership between large organisations, rather than on a Triple Helix process.” (2012: 355). From this perspective, the Triple helix Model reflects American definitions of innovation in the post World War II era, immersed in a culture of commercialization of the public good.

The second line of criticism of the Triple Helix Model includes the many calls for amendments to the Model, rater than replacing it. These calls are not taken as a challenge to the Model, but rather as a way to increase the Model’s relevance to varying conditions worldwide and to adapt it to changing circumstances. In fact, Etzkowitz and Leydesdorff are themselves among those conceiving of extension- models, suggesting “triple helix twins” (Etzkowitz and Zhau 2006) or “N-tuple helices” (Leydesdorff 2011).

One direction for extension and adaptation of the Model, and with that a challenge of-sorts to its original formulation, includes the call for amendment to the geographical scope. Such challenges, which also speak to the American-centric tone of the Triple Helix Model, come on the basis of the adaptation that is required from the Model’s region-based analysis to its aspiration to speak for national systems. Specifically, the Triple Helix Model is scoped for regions, as it was developed from lessons of Silicon Valley and Route 128, yet it is used interchangeably with NIS, which is scoped for whole national economies and is guided by national policy. This “mismatch” between regional-, city- and national systems of innovation challenge the generalizability and applicability of the Triple Helix Model. Gray (2011), for example, calls for STI learning to occur between cities or between regions, rather than between countries. He concludes by saying that “it may make more sense for my international colleagues to spend more of their time visiting Albany, NY, Sacramento, CA, Raleigh, NC or one of the other host of states that have developed highly diversified approaches to supporting economic development via CSRC and less in our nation’s capital.” (2011: 132). Overall, this call for amendment is a call for careful application of the framework suggested by the Triple Helix Model beyond its original formulation for regions onto national-, city- or cross-border innovation layouts.

Most of the calls for amendment to the Triple Helix Model come on the basis of expanding the number of social sectors intertwined into the innovation system. Some calls are for the addition of a single, fourth strand to the university-industry-government model. Most importantly, both Leydesdorff and Etzkowitz (2003), Marcovich and Shinn (2011) and Yang et al. (2012), who wrestle with the definition of this amorphous social sector, suggest the adding of ‘the public,’ ‘society’ or ‘NGOs and local community organizations’ (respectively) as the fourth helix to the original triple–strand formulation. The involvement of civil society, nongovernmental organizations or local community is found to be of particular importance in the development of specific sectors of innovation, such as eco-innovation (Yang et al, 2012). Lately, Leydesdorff (2012) went as far as to suggest an N-tuple Helix model-of-sorts, as an acknowledgement of the diversity of stakeholders involved in the innovation process in the 21st century (see also, Carayannis and Campbell 2009). Yang et al. summarize these various helix models of innovation by comparing among Triple Helix, Triple Helix Twins, Quadruple Helix and N-tuple Helix models (Table 1, 2012: 377).

Others add a time dimension to the helixing. Specifically, Marcovich and Shinn (2011) not only add a strand for ‘society’ but also identify four phases to the formation of a field-level triple helix. They find that in the emergence of the research field of Dip-Pen nanolithography is phased into stages, each of which is characterized by binomial links: phase 1 includes academic instrument research (and involves university/society link); phase 2 describes the transformation from instrument to tool and the start up of a company (university/industry link); Phase3 is includes the development of a mature firm and commercialization (industry/society link); and Phase 4 is when confirming of ‘‘nanofication’’ occurs (society/industry link).

Marcovich and Shinn’s work, while addressing the general theme of time and process, also speaks to the specificity of the model to one sector or another. The possibility that triple helixing is sector specific also emerges from the work of Etzkowitz and Zhou (2006), who suggest that Triple helix Twins are formed due to the gap between innovation and sustainability in some sectors or due to the differences in economic emphases of sectors.

Overall, the many calls for expansion of the Model to additional geographical scopes, additional social contingencies, and most importantly additional helices, reflect the complexity of innovation and the intricacies involved in specifying the system that springs innovation. Our work here follows this line of expansion of the original Triple Helix Model. Through a thorough analysis of the systemic components of Israel's successful innovation economy, we propose an extension to the original formational of the Model by adding additional helices and, with that, specifying socio-political contingencies for innovation in Israel.

1.4 The Case of Israel

Israel's innovation economy is flourishing and still many concerted efforts are made to maintain Israel's edge in the global knowledge- and innovation economy. Israel also boasts a solid foundation for a Triple Helix format, with most active academic, governmental and industrial sectors.

University. Israeli academic institutions, two of which predate the founding of the State of Israel[1], include 9 universities and dozens of colleges and, remarkably, 46% of Israeli adult population attained tertiary education. And while the quality of science education, from elementary to high schools, is in lower middle OECD range, the success of Israeli academia is expressed in a high rate of scientific publication, high ranking of universities, international awards for Israeli science[2], and patent productivity of universities[3] – all of which contribute to Israel's repeated ranking as #1 worldwide in quality of scientific research institutions according to the Global Competitiveness Report. The leadership of Israeli universities is noted in particular in

1 Technion (Israeli Institute of Technology) held classes starting in 1924 and The Hebrew University of Jerusalem in 1925.

2 Most notably, of the 10 Israeli Nobel Prize laureates, 6 received the award for scientific excellence: 4 in chemistry and 2 in economics.

3 In terms of PCT patents field by universities and public labs; OCED 2012.

computer science, mathematics, economics, and chemistry [4] and national plans set several specific scientific fields as national priority[5]. Such leadership is also evident in Israel's leadership in patenting in specific fields, most notably IT (see, Figure 1.3). In 2011 reports Israel ranked 4th worldwide in patent production ratio[6]. As noted in Chapter 4, all seven of Israel's research universities have a technology transfer arm, with Weitzmann Institute's YEDA founded in 1959, much earlier than noted TTOs elsewhere in the world.

Industry. Israel's first high-tech firms were Tadiran and Elron Electronics, founded in 1962 and thus Israel's celebrated software sector came following a strong IT standing was set (see, Braznitz 2007). Israel's noted standing in education and STI productivity quickly lured high-tech multinationals to invest in Israel, with Motorola being the first US firm to set an Israeli arm in 1964. Notably, the main activity of multinational tech companies in Israel is R&D: Microsoft and Cisco Systems built their first R&D center outside in the US in Israel; Motorola set its largest R&D center in Israel; Intel, which started operating in Israel in 1974 and has 2 manufacturing facilities, has 4 R&D centers in Israel and Google holds 2 R&D centers in Israel. Overall, in 2012 over 240 foreign companies established R&D centers in Israel. By 2000 Israel's "Silicon Wadi" cluster was recognized as equal in strength to Boston, Helsinki, London, and Kista (Sweden), second only to Silicon Valley (Hillner 2000). R&D-related products comprise more then half of total industrial exports (excluding diamonds). And Israel ranked 11th worldwide in company R&D

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4 According to Shanghai ranking of universities 2001: in computer science Weitzmann Institute ranks 11th worldwide; Technion 15th, Hebrew University 26th and Tel Aviv University 28; in Mathematics, Hebrew University 22nd, Tel Aviv University 32nd and Technion in group 51-75; in Economics both Hebrew University and Tel Aviv University in group 51-75.

5 Specifically, the national I-CORE project specifies policy priority for the following higher education and research fields: molecular basis of human diseases, cognitive science, computer sciences, and renewable and sustainable sources of energy. And the Israeli Biotechnology Fund set brain research, nanotechnology and biotechnology as its priority sectors.

6 Utility patents granted per million population: 195.0; outranked by Taiwan (287), Japan (279) and US (261); Global Competitiveness Report 2010-11.

spending[7] and is leading among OECD countries, in particular in knowledge-intensive industries (see, Figure 1.4). With 2010 gross domestic expenditure of R&D (GERD) standing at 4.40% of GDP (excluding defense) and an average annual growth of 4.1% in 2005-10, Israel stands as an OCED leader in R&D-related expenditure; 52% of GERD in 2008 came from private sector funding. All these factors, including the ingenuity of founders, account for the success of Israel's knowledge-intensive industry even in the face of the challenges of political uncertainty, wars, and geographical distance (see, Chorev and Anderson, 2005).

Government. Several laws guide Israeli policy regarding STI, revealing policy emphasis on only on education but particularly on R&D.[8] Several core government program stand successfully: for example, MAGNET program – which was established in 1994, is managed by the Office of the Chief Scientist of the Ministry of Industry, Trade & Labor, aims at supporting technology initiatives in Israeli industry – had a budget of 57 million USD in 2011; the 1991-1998 incubators program which came to alleviate stress of large and highly educated immigration from the former Soviet Union and spun some 500 graduating companies with 50% success rate (Trajtenberg 2000); and a 2010 Ministry of Finance initiative titled "relative advantage" (יתרון יחסי) is aimed at locating financing sources for Israeli start-up companies. In addition, several measures of The Higher Education Plan 2011-15, which aims at improving higher education and research, were implemented: doubling of in Israel Science Foundation funding (from 75 million USD in 2011 to 139 million USD by 2015) and a 362 million USD I-CORE (centers of research excellence) project. Still, Israel's STI policy is regrettably at the jurisdiction of several ministries (Ministry of Industry, Trade and Labor, Ministry of Science and Technology and Ministry of Education

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7 Israel's score 4.7 (on scale of 6); Global Competitiveness Report 2010-11.

8 Encouragement of Industrial Research and Development Law 5744-1984 (amended as late as 2006); Law for the Encouragement of Capital Investment, 5719-1959 (amended as late as 2011); and laws for preferential treatment of R&D investments in the Negev and Galilee.

and there is no comprehensive national STI plan or strategy.[9] With that, the path of Israel's STI policy is unique in comparison to other emerging economies: Israel's successful IT industry builds upon already present R&D and educational capacity and then was spurred by a "market-failure-focused, industry-neutral S&T policy" (Breznitz, 2007). As noted in OECD reports, in comparison to other OECD-member countries, Israel's innovation policy is lagging (see, Figure 1.5).

Without challenging the important role of these three sectors, which are core to the Triple Helix Model, in the success of Israel's innovation economy, are these the only institutions involved in spurring innovation in Israel and thus influencing Israel's innovation economy? What additional institutions shape Israeli innovation? Are these additional institutions "helixed" into the traditional 3-helix model?

Drawing upon discussions of our research team, we concluded that the 3-helix model, which identifying the core institutions and articulating their tights and entangled relations, does not fully capture the institutional complexity of Israel's innovation. Rather, Israel's innovation requires the helixing of several additional strands into the traditional 3-strand, Triple Helix Model. Specifically, we propose that any description of Israel's innovation system by the helix model of innovation requires the addition of at least the following institutions:

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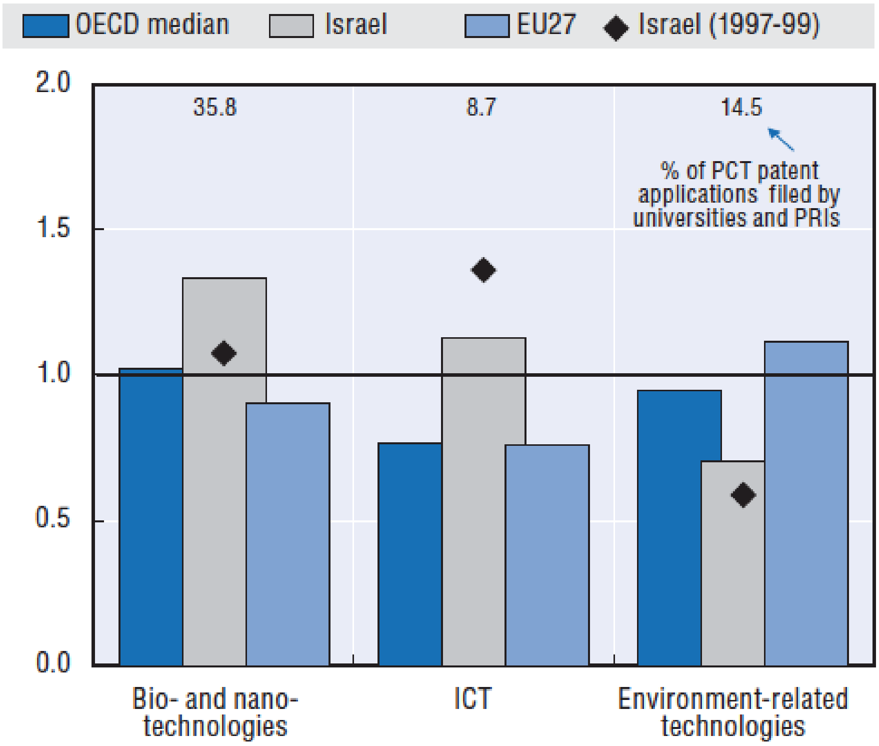
[9] For comprehensive review of policy, updated to 2007, see Getz and Segal (2008).

Figure 1.4

Technology Productivity, by Field 2007-9: Israel in Comparison to OECD Countries
(Index based on PCT[10] patent applications)

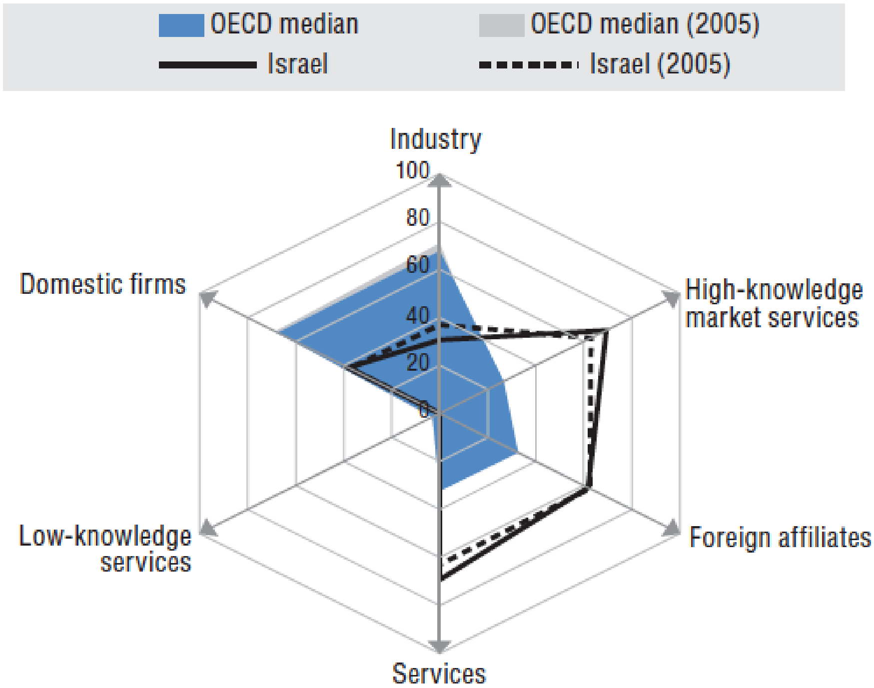


Source: OECD STI Outlook 2012, p. 4.

10 The Patent Cooperation Treaty (PCT) is the 1970 international patent law treaty harmonizing patent registration procedures and patent protections.

Figure 1.5

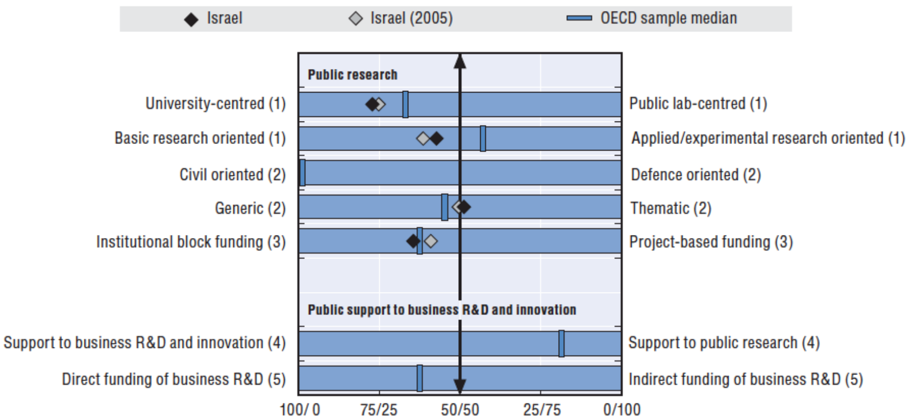
R&D Investments: Israel in Comparison to OECD Countries
(% of total business enterprise R&D (BERD), 2009)



Source: OECD STI Outlook 2012, p. 4.

Military. In spite of the secrecy concealing much of Israel's defense-related R&D, the Israeli defense sector has a fundamental impact on the development of Israel's IST sectors. Much of Israel's R&D sponsorship was directed at defense projects and the Israeli Defense Forces (IDF), along with the Israeli military industries, stand to be both a client for innovation and a producer of innovation. By 1980s estimates, 65% of the national expenditure on R&D were defense related, with only 13% oriented towards civilian industries) and about half the scientists and engineers employed in the industrial sector worked in defense industries (Peled, 2001: 5). IDF also influences innovation by way of its alumni, through spin-offs and cultural imprinting: many of Israel's start-up spun off knowledge gained during compulsory military service, much of Israel's business network is built off ties that were formed during military service, and skills of teamwork and initiative-taking born of military culture heavily imprint Israel's STI work culture (see, de Fontenay and Carmel, 2004; Senor and Singer, 2009). Overall, the prominence of military R&D in Israel's STI is fueled not only by Israel's security concerns but also draws upon the spirit of Vannevar Bush's *Science – The Endless Frontier* (1945), which is the constitutive document for STI policy ever since. In addition to the principle of public funding and sponsorship of STI, Bush also set a central role to military R&D through collaboration with university- and industry-labs. The IDF operates according to this logic, also building DARPA-like R&D centers within the military.

Figure 1.6:
Overview of National Innovation Policy Mix, 2010: Israel in Comparison to OECD Countries



Source: OECD STI Outlook 2012, p. 4.

Financial sector. With Israeli economy overwhelmingly dominated by the public sector until the early 1980s, much of the funding for education, science and R&D came from government sources (ministries, government-controlled banks and public agencies). Trajtenberg (2000) reports that while until 1980s financial support was directed solely at National R&D Labs, academic and agricultural R&D, and the (presumably weighty) defense-related R&D, the "beginning of government support for industrial (civilian) R&D in Israel dates back to 1968: a government commission, headed by Prof. Ephraim Kachalski (Katzir)[11], called for the creation of the Office of the Chief Scientist (OCS) at the Ministry of Industry and Commerce, with the mandate to subsidize commercial R&D projects undertaken by private firms." Still, even after the massive privatization of the 1980s and the mounting pressure on sufficiency of higher education institutions, governmental subsidies and government-sponsored programs heavily influenced the sprinting of knowledge-intensive industry in Israel. For example, Lach (2002) calculates that "an extra dollar of [R&D] subsidies increased long-run company-financed expenditure on R&D by 41 cents." Following the first Israeli firms to register on American stock exchanges, with Elscint beings the first Israeli IT company to go public on NASDAQ in 1972, many more followed to seek private funding. In 2012, Israel was second only to China in Nasdaq-listed companies: in 2012 over sixty Israeli companies are listed on Nasday, of more than 250 Israeli companies that has IPO on Nasdaq since 1980 and with 33 new Israeli listings in the year 2000 alone. Here emerge a few paths for innovation funding. In comparing Israel R&D intensive companies registered on US- and Israeli stock-exchanges, Blass and Yosha (2002) show that the companies listed in the US use highly equity-based sources of financing and are more profitable and faster-growing, whereas those listed only in Israel rely more on bank financing and government funding and are slower to grow. With the global opening of Israeli industry and financial sector, and with added boost from the Yozma government initiative to give tax incentives to

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11 Prof. Ephraim Kachalski was a chemist and among the founders of the Weizmann Institute. Upon his appointment as the 4th President of the State of Israel (1973-1978), he Hebraicized his last name to Katzir.

foreign VC investments, came the entry of venture capital into Israel: between 1991 and 2000, Israel’s annual venture-capital expenditures rose nearly 60-fold, from $58 million to $3.3 billion and the number of companies launched by Israeli venture funds rose from 100 to 800 (IVC, 2012). With that, Israel is the largest venture capital in the world outside the US (Breznitz, 2007). This VC infusion has been found to directly impact high-tech growth in Israel (Avimelech and Teubal, 2006). In addition to the shift from public- to private funding, as of late there is also a shift from venture capital to private equity funding and a growing number of “angels” and “angel funds” (IVC, 2012). Overall, over the course of the past four decades we see a dramatic change in the finance base for STI in Israel, while Israel is also turning into a global player in STI financing.

Social sector, civil society or the non-profit sector. Following in the steps of earlier discussion by Leydesdorff and Etzkowitz (2003), Marcovich and Shinn (2011) and Yang et al. (2012), it is evident that Israeli civil society is indeed increasingly influencing the course of STI development. Under the canopy of social sector innovation and entrepreneurship come many different initiatives, varying by goal (to create socially-minded ventures or to close social gaps in ICT access, use and creation), by sponsorship (governmental, corporate philanthropy or non-profit bodies) and therefore by being more or less formal. Operating formally as drivers of social innovation and entrepreneurship, many more Israeli NGOs are focusing their attention to innovation and social-innovation-minded international NGOs, such as Ashoka (see Chapter 6), are now operating in Israel. Some, like Olim BeYakhad (עולים ביחד) which works with educated and skilled Ethiopian immigrants, focus on social innovation, especially among weakened populations; others, like or The Hub TLV, give home also to tech or artistic innovation; and other, like Presenentse mentorship club, focus on supporting business and tech ventures. And, such socially-minded innovation and entrepreneurship initiatives are increasingly professionalized (see, אברוצקי ואשכנזי, 2011). With that, Israeli civil society is spurring the redefinition of innovation and development to include social innovation and social entrepreneurship. For one, the Prime Minister’s Prize for Innovation, which is distributed since 2010 and is a part of Israeli participation in Global Entrepreneurship Week, is giving equal credence annually to technology- and social inventors. In addition, Israeli civil society is imprinting STI industrial connections. For example, Rothchild and Darr (2005) show how much of the links between academia and industry in Israel depend on informal networks of affinity: much of the exchange of know-how and practice between the Technion and a partnering incubator depend on cyclical models of network relations among Israeli-born managers or, separately, among Russian-born scientists. And, as noted earlier, much of Israeli high-tech sector is traceable to social ties formed during military service, which still remains a "melting pot" for the Jewish non-Orthodox segment of Israeli society. This results also in the isolation, and marginalization, of any Israeli-Arab tech venture; this itself sprung civil society initiative to close the Jewish-Arab gap, with for example The Arab-Israeli Center for Technology and Hi-Tech working as a non-profit organization since 2008 in response to the high unemployment rates among highly educated Arab Israelis by encouraging their placement with Israel high-tech firms.

Diaspora, Social network relations closely tie Israeli society with two social groups outside its borders: the Jewish- and Israeli diasporas. It is estimated that in 2010 Israel was home to only 35% of the world's Jewish population, with Israel's Jewish population only slightly bigger than the Jewish population in the US alone. Still, with Israel declarably the home for the Jewish people, the worldwide Jewish diaspora ha strong relations with Israel and, specifically, has also impacted STI sectors. Initial support of Israeli institutions, most notably of academia, were philanthropic donations; many of the buildings, programs, and prizes in Israeli universities are named after their sponsors. As of late, it seems, more such sponsorship comes as a form of investment (Shimoni 2008 and Silver 2008 in Schmid et al., 2009): sponsorship medical- and agriculture research that comes as a form of partnership and investment.

In addition, Israel is also linked with an Israel diaspora, comprising of Israelis who reside outside of Israel: By 2008 estimates of the Ministry of Immigration and Absorption, the Israeli diapora is estimated at 12.5% of Israel's Jewish population, with some 60%

residing in the US. While decreed as Yordim for many years, the stigma that came with emigration from Israel has slowly been lifted and Israelis who found success abroad have followed in the way of Jewish philanthropist and investors to contribute to Israel's growth. Such "circular immigration" or "Brain Circulation" (Saxenian, 1994, 2006) has been translated to IST: Israeli-heritage ties were the bridges to bring several global high-techs firms, most notably Intel in the 1970s, to establish branches in Israel (Orpaz, 2012). More formally, several government initiatives reach out to the highly educated and affluent Israeli diaspora: programs targeting "returning scientists" and activities such as that of the California-Israel Chamber of Commerce Israeli foster and maintain relations with the aim of linking business and academic communities of Israelis outside of Israel with Israel's innovation economy.

In addition to the impact of these two diasporic communities outside of Israel, it is upon Jewish diasporic ties that Israel's high-tech sector grew. Specifically, Israel's knowledge-intensive industries, and particularly its post-1990 high-tech boom, relied upon waves of high-skill immigration: the 19991-1993 wave of immigration from the former Soviet Union served as a critical human capital infusion for Israel's high-tech sector (see, Avimelech and Teubal, 2006; Chorev and Anderson, 2006).

In summary, in attempting to apply the Triple Helix Model to the Israeli case we came to the realization that the three-strand formation does not cover the full breadth of institutions, or sectors, that are tightly involved in the success of Israel's innovation economy. Rather, we find that to the university-industry-government formation, one must add 4 so-called strands: the military, financial sector, civil society and the diaspora. With that, the Israeli innovation system is best described as a **7-helix model**. The structure of this book follows this logic: each team member focused her or his research on a specific strand, regrettably with the exception of the "strand" of diasporic ties.

1.5 Structure of this Book

Following on the review of the conceptual background and critique here (Chapter 1) and the introductory note by Henry Etzkowitz (Chapter 2), the book offers a total of 6 chapters, each devoted to the exploration of a single innovation helix in Israel.

Chapter 3, written by Alexandr Bucevschi, focuses on innovation in Israel's industrial sector, by focusing patent as and on the inter-helix relations that are reflected in patenting. With empirical verification of the Israeli industry (Teva Pharmaceuticals Industries Ltd. and Elbit Systems Ltd.), looking at the affiliations of patent owners and inventors appearing in applications, he demonstrates the connections between one helix and its different sectors and between it a other helices. With that, Alexandr identifies patterns that set a basis for future causal studies as well as allowing for an early look into the influences global changes have over local industries and their patenting policy.

Chapter 4, written by Navah Berger, sets to map out the characteristics of the mechanisms used for translating academic knowhow into commercialized technologies, namely university technology transfer offices. All seven[12] Israeli research universities have a cohesive model of technology transfer that plays a role in innovation creating the field of study. By exploring their three technology transfer strategies (patenting, licensing and spin-offs), Navah reveals the extent to which commercialization of academic knowledge is well ingrained into Israeli academia, thus setting Israeli academia is a solid basis for Israel's booming innovation economy.

Chapter 5, written by Amy Ben-Dor, analyzes the role that government initiative splay in fostering innovation in Israel, specifically exploring the gender bias in such government initiatives. Specifically focusing on the Tnufa[13] Program of Israel's Ministry of

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[12] Israel's two additional universities do not have TTOs: Open University is primarily a distance-learning institution and Ariel University of Samaria was given the status of a university only in 2011.

[13] "Tnufa" translates to momentum, or upswing

Trade and Industry, which is aimed at supporting young entrepreneurs, Amy reveals the maintenance of social inequalities and reproduction of gender differences through the review procedures of proposals coming before the Program. In this manner, Tnufa Program is a gendered program, exposing the gendered, specifically masculine tone of the different helices.

Chapter 6, written by Noga Caspi, offers a study of Ashoka-Israel as an exemplar of the impact that civil society, or non-profit, organizations have on the field of innovation and entrepreneurship. Studying the project portfolio of Ashoka-Israel, Noga reveals that through promoting the creation of social value, A-I has reframed social activity with notions of innovation and entrepreneurship. In this way, she argues, Ashoka-Israel becomes involved in innovation work in Israel.

Chapter 7, written by Ohad Barkai, centers on the funding of research. Relying on his own compilation of research funding information that is publically available, he creates a series of network maps of Israeli institutions that are involved in funding of research, specifically medical research, in Israel. Ohad Barkai then concludes that a variety of organizations are involved in funding of medical research in Israel: government agencies (such as Israel Science Foundation), pharmaceutical and medical firms (such as Novartis), and non-profit organizations (such as Israel Cancer Association). And since Ohad studied the number of research projects funded, rather than the size of the funding, it is clear that the major sponsors of research in Israel are not the big-budget organizations but rather the non-profit organizations. Ohad’s conclusions reinforce the importance of the civil society “helix.”

Chapter 8, written by Avida Netivi, focuses his study on Talpiyot[14] Project, which is a military program designed to build a cadre of innovative R&D personnel for the Israeli Defense Forces (IDF). The selected excelling recruits are sent for physics, CS, or mathematics studies at The Hebrew University of Jerusalem, while also

[14] “Talpiyot” translated to solid and magnificent structure, or fortress.

going through military training and introduction to defense-related industries. Avidah's study, which started with the assumption that the military is an N-th helix in Israel's system of innovation, concludes that Telpiyot project is in itself an expression of a Triple Helix Model. Talpiyot's curriculum triangulates among university studies, industry experience, and officers' military training. On the basis of such analysis, Avidah continues with a consideration of the innovation system as helixed (interlinked strands) versus hybrid (fused).

One helix proposed for Israel's N-Tuple helix model, namely diaspora, was not analyzed because of shortage of research collaborators. We encourage others who are interested in studying Israel's miraculous entry into the global innovation economy to explore the importance of long-standing relations between Israel and the Jewish worldwide diaspora as well as the new and still tenuous relations between Israel and the worldwide Israeli diaspora.

1.6 Concluding Comments

The Triple Helix Model offers us a starting point for an analysis of the innovation system in Israel. We are inspired by the Model's highlighting of multi-sectoral formation and its emphasis on the interlacing and recursive relations among these many stakeholders. In this work, we take the Triple Helix Model to be a methodological tool for generalizing innovation formation and dynamics. First, relying on the Model's triple-sectoral formation and accepting its metaphor of intertwined helices, we here expand to analyze the Israeli case as a 7-sector innovation-economy. Second, relying on the Model's suggestion of multiple points of interaction among the helices and the transformative effects that such interaction has on each of the involved institutions, we analyze the cross-cutting relations among the Israeli military, academia, industry, financial sector, civil society sector, and the Israeli government. We contend that Israel's innovation was spurred, and still thrive upon, the helixed relations among all 6 strands 9and by extension also the 7th helix of diasporas). It is these helixed strands that formed the “critical mass” of innovation in Israel and turned the once isolated and labor-driven economy into the hothouse of innovation for the global knowledge economy.

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Chapter 2

Israel's Innovation System: A Triple Helix with Four Sub-helices

Prof. Henry Etzkowitz

It is fitting that the Triple Helix, with universities as a key innovation actor, along with industry and government, has been taken up in Israel, a knowledge-based society, rooted in Talmudic scholarship and scientific research. Biblical literature provided legitimation for the creation of the Jewish state while science helped create the economic base that made state formation feasible. In this case, the establishment of a government followed the creation of (agricultural) industry and academia as the third element in a triple helix. Nevertheless, a triple helix dynamic can be identified in the earliest phases of the formation of Israeli society, well before a formal state apparatus was constructed. Founding a state was a key objective of industry and academia but these intertwined helical strands did not accomplish the objective without assistance from other sources nor is innovation in contemporary Israel, along with many other societies, solely a triple helix phenomenon.

Several analysts have identified additional helices as relevant to innovation (Drori, Ch. 1). However, if everything is relevant than nothing is especially significant and a model that originally posited the transformation of the university from a secondary supporting institution of industrial society to a primary institution of a knowledge based society is vitiated. A second academic revolution expanded academic tasks from education and research to include entrepreneurship as a third mission. An entrepreneurial university, interacting closely with industry and government, is the core of a Triple Helix. By engaging in such relations an academic sector may, depending upon its previous experience, maintain or gain, relative independence. Triple Helix actors must also continually renew their commitment to entrepreneurship and innovation, lest they fall back into traditional roles and relationships.

What is the source of the Israeli Triple Helix? The contributors to this volume have identified seven helical strands as constitutive of the Israeli innovation system. I suggest that these strands may be grouped into primary and secondary categories: the primary strands are the classic triple helix (university-industry-government) while the secondary strands are supporting linkages, like the two diasporas (Israeli and foreign), or hybrid organizations like the military and non-governmental organizations (NGOs). Thus, the resulting Israeli innovation system takes the form of a Trivium and a Quadrivium consisting of three primary and four secondary strands, in a variety of relationships with each other in different historical periods. The Innovation Trivium and Quadrivium are the constellation of core and supporting actors that constitute a knowledge-based innovation system.[15]

2.1 Triple Helix Origins

The triple helix innovation model originated in the analysis of MIT's role in the renewal of New England, a region suffering industrial decline from the early 20th century (Etzkowitz, 2002). MIT was founded in the mid 19th century, with industry and government support to raise the technological level of the regions' industries but by the time it had developed research capabilities many of those industries had already left the region, to move closer to sources of raw materials, lines of distribution and less expensive labor. It was in this context, during the 1920's, that the governors of New England called together the leadership of the region in a Council to address the region's economic decline. Given a unique feature of the region, its extensive network of

15 The classic Trivium and Quadrivium were the core and supporting academic disciplines that constituted the knowledge-base of medieval Europe. See Etzkowitz, Ranga and Dzisah, 2012.

academic institutions, it is not surprising that the governors included the academic leadership of the region in their call.

However, their inclusion of academia had an unexpected consequence, transforming the usual public-private partnership model into a unique configuration- a proto-triple helix with a proclivity to originality. Triads are more flexible than dyads that typically take a strong common direction or devolve into opposition and stasis (Simmel, 1950). Industry-government groups typically repeat timeworn strategies to attract industries from other regions in a zero sum game or attempt to revive local declining industries that may be beyond resuscitation. The inclusion of academia along with industry and government introduced an element of novelty into the government-industry dyad. A moment of collective creativity occurred, during the discussions of the New England Council, inspired by the leadership of MIT's President Karl Compton. A triple helix dynamic, with the university as a key actor in an innovation strategy, was instituted that was highly unusual at the time.

The Council made an analysis of the strengths and weakness of the New England region and invented the venture capital firm to fill a gap in its innovation system, expanding a previously sporadic and uneven process of firm-formation from academic research into a powerful stream of start-ups and growth firms. A coalition of industry, government and university leaders invented a new model of knowledge-based economic and social development, building upon the superior academic resources of the region. This was not an isolated development but built upon previous financial and organizational innovations in the whaling industry and in academia. In New England, industry and government, inspired by an academic entrepreneur and visionary, William Barton Rogers, earlier came together in the mid 19th century to found MIT, the first entrepreneurial university, thereby establishing the preconditions for a triple helix dynamic in that region.

2.2 From a Double to a Triple Helix

In a remote province of the Ottoman Empire in the early 20th century, Jewish agricultural settlements and an agricultural research institute created a triple helix dynamic that assisted the formation of the State of Israel. An industry-academia double helix provided the knowledge-based foundation for the Israeli triple helix. It preceded the founding of the state of Israel and indeed supplied many of the building blocks from which it was constructed. In a possibly unique configuration, state formation built upon scientific research and an agricultural industrial base. Before the Technion, the Weizmann Institute and the Hebrew University, there was the Jewish Agricultural Experiment Station in Atlit, founded in 1909 by agronomist Aaron Aaronsohn, with the support of Julius Rosenwald, an American-Jewish philanthropist (Florence, 2007).

Hints in the Bible of agricultural surplus, a land flowing with "milk and honey," were investigated in an early 20th century context of desertification in Palestine. The station's researchers hypothesized that a seeming desert had a greater carrying capacity than was expected and thus could support a much larger population. Aronsohn and his colleagues' advances in "arid zone agriculture" opened the way to the transformation of a network of isolated agricultural settlements into a modern urban society. The Atlit research program, conducted in collaboration with the US Department of Agriculture, was then introduced to California.

However, in California, arid zone methods were soon made superfluous by hydraulic transfer projects, from north to south, of enormous water resources. Arid agricultural methods remained relevant in the Israeli context of scarce water resources. Israel's first high tech industry was based upon the development of drip irrigation techniques in the late 1950's that preceded the IT wave by decades. Labor saving methods of agricultural production were also driven by ideological concerns of not wanting to be dependent upon hired Arab labor. Science-based technology was thus at the heart of a developing Israeli society as well as a key link to a Diaspora that supplied infusions of support from abroad.

The Atlit agricultural research institute transformed itself into an intelligence network on behalf of the British during the First World War, betting that assisting the exit of Palestine from the Ottoman Empire could provide a pathway for the creation of a Jewish state (Florence, 2007). The Atlit network was uncovered, and some of its members perished, but it had already provided significant information on invasion routes that assisted the British takeover of Palestine. Its leader, Aaron Aaronsohn, died in a plane crash over the English channel in 1919 while bringing maps to the post-war Paris peace conference. The Institute itself did not survive its repurposing but its mission was taken up by other agricultural research units.

A linkage between helices and the translation of social capital from one sphere to another was another element of the state building project. The Balfour Declaration, issued by the British government in 1917, favored a “national home” for the Jewish people in Palestine, without prejudicing the rights of other peoples, and was the first such statement by a major power. Although the Declaration was part of a geopolitical balancing act to gain support for the British war effort, and may have occurred for that reason alone, British-Jewish scientist Chaim Weizmann’s accomplishments gave it a boost (Weizmann, 1949).

Weizmann’s invention of a bacterial method of producing the feedstock for explosives assisted the British war effort. Weizmann, a professor at Manchester University was able to transmute this discovery into support for a projected Jewish state through his relationship with Arthur Balfour, the Foreign Secretary, and an MP from Manchester. Weizmann dual roles as an eminent scientist and as a political leader in the Zionist movement coincided and he used an achievement in one arena to advance his goals in another. The Diaspora, of which he was a member in that era, aggregated international support for the state-building project.

Science also served to legitimate the new state of Israel. Albert Einstein was offered the presidency of the newly founded state of Israel. While the aura of his renown was one reason for the offer, that fame was primarily based on his scientific achievements. When Einstein turned down the position, the presidency was offered to another scientist, Chaim Weizmann, who accepted. The fact that the position was offered to two scientists in a row suggests that science was implicitly seen as legitimating the state, while also recognizing its role in the founding of Israel.

2.3 Innovation Trivium and Quadrivium

Identification of additional secondary contributors to innovation is a useful task but their relationship to the primary helices, and the roles that they play, should be specified. For example, the Israeli military may be viewed as a hybrid entity. In addition to the usual functions of a military, the Israel Defense Forces also serves as an educational institution for virtually the entire society, intermediating between secondary and university education and as an industrial development platform, spinning off aircraft and software industries. It has some of the characteristics of an independent helix but remains a part of the state, embodying hybrid elements that give it some of the characteristics of an independent institutional sphere.

It is a significant actor in Israeli society, having a significantly higher profile than the militaries in most societies. Therefore we locate it in the “Quadrivium” of support helices that comprise hybrid organizations or links with other societies. The military derived from the “Shomrim”, watches mounted by isolated settlements while nascent governmental institutions were a confluence between the networks of settlements and more general support structures such as the Jewish Agency, a mix of local and Diaspora efforts. A proto-state was constructed from these elements prior to independence.

The Israeli Diaspora played a key role, along with government, in founding Israel’s venture capital industry. After several unsuccessful attempts at developing a venture industry, government hit on the idea of combining public and private elements, providing government funds to encourage private partners to participate by reducing their risk. Key to the efforts success was the recruitment of members of the Israeli Diaspora, working in financial and venture capital firms in the US, to return to Israel and participate in the Yozma project and the funds that emanated from it. [16]

2.4 Israel: A Triple Helix Society

This volume, analyzing Israel's innovation actors, makes a significant contribution to triple helix theory and practice by providing evidence of their relative salience. Identifying multiple contributors to the innovation project is a useful exercise but not all helices are equal. A key contribution of the triple helix model is that it identified the increased significance of the university in a knowledge based society and the fundamental importance of creative triple helix interactions and relationships to societies that wish to increase their innovation potential (Durrani et al., 2012).

We can also identify the qualities of an emergent social structure that encourages innovation. Multiple sources of initiative, organizational venues that combine different perspectives and experiences and persons with dual roles across the helices are more likely to produce innovation and hybridization than isolated rigid structures, even with great resources behind them. The Israeli experience takes the triple helix model a step beyond organizational innovation by demonstrating the significance of triple helix roles and relationships to the creation of an innovative society.

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[16] Author discussion with Yozma founders at the 3rd Triple Helix Conference in Rio de Janeiro, 1999. FINEPE, the Brazil Development Agency invited Yozma representatives to the conference and held side meetings to arrange transfer of the Yozma model to Brazil. FINEPE added an additional element, "FINEPE University," a series of workshops held around the country to train entrepreneurs in "pitching" to venture firms.

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Chapter 3 – Industry

Patent Applications and the Quadruple Helix: Mapping Connections in the Israeli Industry

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Inventors, researchers and entrepreneurs interact with one another for the sake of innovation, be it practical products or not. Between them, funds, social connections and political support are exchanged and negotiated and thus the complex system of innovation we see today is created and maintained. And it is these interactions which have been the subject of inquiry for sociologists and policy researchers for the past few decades. Thus a researcher’s goal can be: to find a way to understand the way innovation is created by social actors, and to identify the reasons behind differences over time and across borders. Ever since the advent of the original Triple Helix (TH) model in 1995 (Etzkowitz and Leydesdorff, 1995), attempts have been made to refine the descriptive capacity of the model in order to encompass the wide breath of activities occurring within the knowledge economy. Though the TH model managed to explain the relationships between three major market forces of academia-industry-government, or AIG, (Etzkowitz & Leydesdorff, 2000), there is evidence of a potential four helices if not more (Leydesdorff, 2010; Metcalfe, 2010; Markovich & Shinn, 2011), with the fourth most likely representing a wider civil society (CS) not associated with AIG bodies (Leydesdorff & Etzkowitz, 2003). Though the latter possibility has not been completely

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accepted so far, perhaps newer methods of inquiry can be used to support existing evidence.

Finding the data to support and establish the TH model, and then expand it to contain another helix, is a matter of great difficulty. Studying the ways innovation changes and the factors responsible is been impeded by the lack of a consistent, reliable, data rich and especially, accessible source of information. Gathering information on the way corporations innovate is not simple due to the fear of corporate spying, which makes the researcher’s work that more difficult. However, one possible solution to this problem lies in the relatively new methodology of patent analysis (Trajtenberg, 1990; Griliches, 1998; Trajtenberg, 2002). Patents, as by-products of the knowledge economy, contain data in regards to key players behind an innovation, namely the owners and inventors of a patented idea. Through them we can focus on the owners, inventors and their characteristics instead of the first level nature of the IP itself. The activities in almost any field of innovation (Trajtenberg, 1990:172) and the changes over time, differences in ownership, and innovation networks present can be studied in detail (Henderson, Jaffe & Trajtenberg, 2000; Singh, 2004). Even so, by looking at the end result of the patenting process (granted patents and citation references in the descriptions), only a fragment of the innovation is mapped out.

Knowing that patents go through several stages, how soon could we start looking at the patenting process and its products in order to have significant information? This leads to the methodological usefulness of patent applications and their possible applications in innovation policy studies. Could we use them to look at the interactions occurring behind patented innovation? Trajtenberg (2002) utilized raw patent applications to study exportation of patented innovations originating in Israel. Thus, the potential of patent application analysis has to be investigated further due to its potential consequences for future research. Obtaining significant information from the earliest stages of the patenting process means researchers can have access to more information sooner, which could be major boon for innovation policy research due of the speed with which markets and networks can change. Quicker and easier access to information in regards to helix connections, local implications of global changes, and any other aspect that can be extracted from patent applications can save time in identifying potentially significant threads of study and possibly help improve the reliability of predictive studies (thanks to the temporal proximity between models and current events).

The first step is establishing the feasibility of patent application analysis as a methodological tool. In this paper I set out to identify how patent applications, as ‘by-products’ of the innovation system, can help identify interactions between helices and explain key differences between different industry sectors. Furthermore, what do patent applications, by two separate Israeli industry sectors, reveal in regards to the interactions between different helices and what can this method establish about the differences between the two sectors assuming they exist? The leading hypothesis is that by taking the information on innovators and assignees present within patent applications and mapping out their respective affiliations to different helices, we can see how one helix interacts with the others and how different industry sectors change their innovation policy over time. This was tested by working with a small population of corporations in Israel and analyzing the contents of their patent applications over a period of thirty years.

3.1 Existing Models and Methodologies

Recent innovation studies have attempted to build models which can explain the social mechanisms and forms of organization responsible innovation and its present form. First, models focused on localized systems, the national innovation system developed as a way to describe specific patterns for each nation (Freeman, 1995; Lundvall & Borrás, 2005). The focus of this paper is the Triple Helix model suggested by Etzkowitz and Leydesdorff (1995) which described innovation as the result of a three-way interaction between academia, industry and government. By borrowing the conceptual and visual model of a triple-helix, the writers created a far more flexible framework for understanding relations in a knowledge economy. But the TH model is far from being complete and the quest for its refinement is an ongoing process.

3.1.1 From Triple to Quadruple Helix Models and the Civilian Society

Is the academy-industry-government (AIG) combination sufficient to contain all of the observable actors present in an innovation and knowledge based world? We can only assume this was the underlying question for those who analyzed data and found no adequate place to fit it into the TH model. We would think that “academy-industry-government” are general categories capable of containing most, if not all the possible organizations present in a knowledge oriented economy. However quite the contrary has been shown in recent years, with studies suggesting that certain elements are too important to be designated as “just another” part of the AIG network (Metcalfe, 2010, p. 506-509). This of course raised a number of critical questions in regards to the TH model. Where do we place intermediating organizations that have direct roles in innovation itself? What about non-profit organizations seeking new ways to deal with social challenges, goals that do not fit into the product oriented definition of innovation? These are questions that debate what can be considered an independent helix.

Out of the infinite possible candidates (Leydesdorff, 2010) possible to divide into their own independent helix, the concept of a civilian society seems like the best option thus far. Since its initial proposal (Leydesdorff & Etzkowitz, 2003) the idea of a civilian society as key player in the innovation world is a very attractive option. Leydesdorff and Etzkowitz considered the civil society (CS) “as the foundation of the enterprise of innovation” (2003, p. 57) and studies do demonstrate the potential of the CS fourth helix (Markovich & Shinn, 2011). Independent individuals can innovate without having to be directly linked to a company (Fleming & Marx. 2006) and non-profit organizations innovate or support innovations that are not linked to the same general goals of the AIG networks (Caspi, 2012).

While my colleagues set out to add further proof for the civil society (Caspi, 2012; Barkai, 2012) in Israel by looking at potential CS organizations, I approach the subject from a different perspective. Using the definition of the civil society as “the arena, outside of the family, [and] the state” (CIVICUS, 2011), which can innovate and own innovations, I seek the data which shows evidence of this fourth helix. Despite the crucial role of AIG organizations, actors belonging to the CS could potentially influence or interact independently with the rest for the sake of attaining innovative goals (Table 1). Furthermore, we would see evidence of products resulting from cooperation between one of the AIG-CS helices and the rest.

Working within a four-helix framework there must be away to contend with changes over time and national borders. Leydesdorff (2010) attempted to resolve this through his N-tuple helix model; however, such an attempt could lead to a loss of the model’s parsimony. We cannot ignore local-global interaction effects (Saxenian, 2004), nor the changes different helices go through over time. Instead I view these two elements as built-in elements of the knowledge economy, factors that can be studied if they leave behind evidence. In this sense, when looking at the interactions between one helix and the rest, if evidence of interactions is present, then we would also find information on changes over time as well as data on local-global influence. What remains to be seen is whether or not one data source, namely patent applications, is capable of providing all of this information.

3.1.2 Approaching Patents as Sources of Information

Though theoretical models assist us in understanding social interactions, they must be grounded in reliable empirical data. To do so, information sources in regards to the interactions between organizations and bodies which exist in the different helices must be identified. Methodological practices have been concentrated so far on the analysis qualitative information such as reports issued by companies, personal interviews and any other publication produced by the actors present in a knowledge economy (journal publications, statistical reports, PR release, etc.) to name a few. The main issue with these methods lies in obtaining sufficient data within certain limits of time and resources, but there are alternatives. One solution can be found in the study of patents.

Table 3.1 Potential Cooperation Types within a Quadruple Helix Model

Single Types	Hybrid Types
Academic Institution [A] Industrial Company [I] Government Institution [G] Civil Society (CS)[a]	Binary associations: A-G; A-I; A-CS; I-G; I-CS; G-CS Ternary associations: A-I-G; A-G-CS; I-G-CS; A-I-CS Quaternary association: A-I-G-CS

[a] The CS can be either an organization or a private individual.

Patents are a valid source for looking at innovation for a variety of reasons, but especially due to its direct link to the innovators themselves. Since patents are granted as a form of protection and monopoly over novel ideas and devices, they are only granted when sufficient novelty is proven. Once a patent is granted "an extensive public document is created. The front page of a patent contains detailed information about the invention, the inventor, the assignee, and the technological antecedents of the invention, all of which can be accessed in computerized form." (Trajtenberg, 2002:341). An increasing number of studies has begun using patents to understand innovation practices (Henderson, Jaffe & Trajtenberg, 2000; Jaffe, Trajtenberg and Fogarty, 2000; Singh, 2004, Trajtenberg, 1990), but these have focused mostly on comparison between nations, the value of innovation. The greater potential lies in analyzing the connections between those involved in the innovation process that lead to the patented invention, as found in evidence of citations, inventors and owners of a patent (Henderson et al., 2000).

However, as Trajtenberg points out, not all research and innovation results in patents meaning only a limited number of interactions can be observed. Though the entire patenting process cannot look at innovation which isn't done for the sake of a patent, it is possible to increase the range of innovations by looking at the earliest stage of patenting, namely patent applications. This is the earliest stage when basic information on assignees, inventors and application countries is publicly available (Appendix 1). Since assignees are owners of a patent and by extension any possible future profit, they are assumed as a main driving force behind an innovation. When interactions occur at this level we can assume that secondary parties, such as startups (Chesbrough, 2002) or universities, appearing as assignees alongside a major firm, had a strong enough influence on the innovation process as to warrant a percent of the patent rights. This case can also occur at the inventor level, where researchers who contributed significant work to an innovation are mentioned in the patent application but they themselves are not directly affiliated with the principle assignee (Fleming & Marx, 2006).

These elements of interaction are the subject of this study. Though they only represent the part of actors responsible visible in patents the amount of patent applications should compensate for this. By looking at the cases of cooperative patent ventures, key actors responsible for an innovation (whether considered novel or not) as well as possible changes in policy of cooperation over time can be identified and investigated further. Since the main focus of this paper is establishing the feasibility of patent application analysis as a method to study helix-level interactions (when working with a civil society oriented QH model) two Israeli companies were selected as case studies. By analyzing the assignee and inventors affiliations and other relevant data present in their patent application, I demonstrate what this methodology is capable of doing for the study of innovation, especially helix-level interactions.

3.2 Israel Patent Applications: Methodology

Selection of case studies was based on practical and analytical considerations meant to expand the range of possible interactions. Israel was the prime choice due to accessible information and familiarity of the researcher with certain companies currently active in the country. Additionally, Israel has a strong innovative presence in global markets (Senor & Singer, 2009; OECD, 2008) as well as a powerful patenting policy (OECD, 2008:170-171).

Two companies were selected: Teva Pharmaceuticals Industries Ltd. (Teva) and Elbit Systems Ltd. (Elbit). The two were chosen due to their ability to fulfill a set of preselected criteria: single helix affiliation (industry), separate sector affiliation (pharmaceuticals compared to defense systems and electronics), lengthy patenting history of over 60 patent applications each and a significant market presence. The aim was to find a large enough sample to look at how a specific helix, industry, could be connected to other helices and how these connections change over time. By choosing companies from two separate industry sectors, I hoped to verify whether within helix sectorial differences would be evidenced through patent application data.

Teva Pharmaceuticals Industries Ltd., founded in 1901, started as a distributor of imported medicines (Teva, 2012). Today, the company occupies a position in the top 20 pharmaceutical product manufacturers in the world. Though focusing mainly on the production of generic medicines, namely products based on expired patents, “TEVA manufactures 71 billion tablets a year in 77 pharmaceutical and API facilities around the world. Over 1.5 million TEVA prescriptions are written each day in the US alone, 1,052 prescriptions per minute” (Teva, 2011). TEVA also invests in the innovation of products and processes as evidenced by the existence of patented goods, especially the Copaxone drug for multiple sclerosis, which brought many of its profits. TEVA presently operates in in 60 countries, having started its ascent with a series mergers and acquisitions early in its history (Teva, 2012) beginning with local Israeli companies and later spreading across national borders. Subdivisions in Hungary and the United States of America were established and these account for some of the newer patents applied in recent years. Thanks to its large stake in the pharmaceutical industry, Teva stands as a unique sector within the industry helix, and as such is bound to have its own specific policies of cooperation and interaction with outside entities.

Elbit Systems Ltd. is responsible for defense electronics and communications technologies and through its subsidiaries holds a key position in the industry. Since its founding in 1966, when it first appeared under the name Elron Electronics Industries, the company belonged to the Israel Ministry of Defense-Research Institute. Since then it has expanded its defense related research over several branches: Elbit Systems (defense electronics), Elbit (communications) and Elbit Medical Imaging. In 2000, the firm merged with El-Op thus establishing a monopoly of defense related technologies which weren't under the ownership of the state. However, the two companies had been working for much longer on joint projects (and thus any patents before the merger will be considered as part of Elbit's principle effort). Other critical acquisitions and mergers include: Tadiran Communications (merged in 2006), Shiron Satellite Communications and BVR Systems (both merged in 2009). As a civilian organization Elbit is in the unique position to patent its innovations unlike other military technologies which, for reasons of security would most likely not be revealed in public sectors. Despite providing technologies to bodies such as the Israeli Defense Forces, the company is capable of supplying other nations and groups of interest with its technologies. Thus Elbit is not only a part of the defense industry sector, but it is also uniquely connected to the local government in such a way that its patenting policy could be influenced by secrecy and still visible. Though it itself is not a hybrid organization and belongs solely to the Industry helix, the potential connections responsible for its patents might lie at the border between other helices such as the government and private citizens not working for the military. Using Elbit and Teva as the foundation of this study, patent applications from the two companies were extracted through the public website of the Israeli Patent Office (IPO).

After the initial data gathering process began, two major difficulties were encountered and dealt with. First of all, patent applications provided only the names of assignees and inventors but gave no information as to their affiliations. This meant that each individual owner and inventor mentioned was searched for via the use of internet resources. Assignees were verified for affiliation with the primary owner (i.e. Teva or Elbit). When inventors were mentioned, their affiliation was verified by directly searching their patent and employment history (when available), using self-reported information available through networking websites such as “Linked-In”. When such data was not present, an inventor’s complete patenting history was analyzed and if he did not patent for a different firm (than Teva or Elbit and their subdivisions) then that inventor was affiliated to primary assignee. Once affiliations were successfully identified, assignee and inventor affiliations were consolidated into six general cooperation categories (Table 2, Appendix 2) which were then assigned to each patent. These categories were chosen according to the basic binary association types seen in Table 1 while adding two additional categories: no cooperation (invention belongs solely to the studied corporation – Ind. 1) and cooperation at the helix level (Ind. 2 – more than one firm is involved in the patent, yet we still don’t see between-helix cooperation). Furthermore I keep in mind the possibility of tertiary and quaternary associations even if they are not present as an independent category here. These five categories serve as the principle focus for the helix interaction study presented here.

Second, the IPO does not present information regarding inventors in a consistent manner. Similar to the European Patent Office, the IPO does not demand from assignees to provide inventor information, unlike patents processed through the United States Patent and Trademark Office or patents filed through the World Intellectual Property Organization (WIPO). For the IPO, assignees can serve as the inventor, which means that the potential for connectivity analysis is greatly diminished. To overcome this issue, whenever individuals were mentioned as assignees alongside companies, they were identified as inventors (under the assumption that these individuals were also directly connected to the innovation). Nonetheless, many patent applications remain without any inventors mentioned.

Table 3.2 Assignee and Inventor Cooperation Categories

Cooperation Type	Definition	
	Assignee	Inventor
Ind. 1	Assignee is the case study corporation [a].	Inventor employed by case study corporation.
Ind. 2	Case study corporation and any unaffiliated company.	Inventor employed by corporation other than case study.
Ind.-Ac.	Assignee is case study and academic institution.	Inventor affiliated with the academia.
Ind.-Civil Soc.	Assignee is case study and individual inventors otherwise unaffiliated.	Unaffiliated innovator.
Ind.-Gov.	Assignee is case study and government related organization.	Innovator affiliated with government organizations.

[a] Teva, Elbit and their subsidiaries.

Ultimately the complete sample size consisted of 200 patent applications, the first 100 for each company, applied between 1960 and 2005. The following chapters discuss the descriptive and correlational data resulting from a comparison between Teva and Elbit patent applications.

3.3. Solving the Puzzle: Helix Interactions as Viewed in Patent Applications

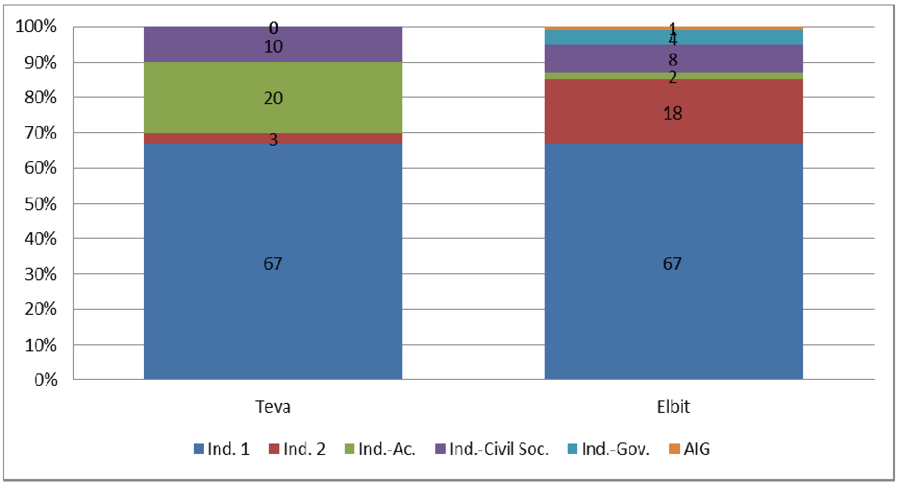
3.3.1 Where Do You Belong? Affiliations within Patent Applications

Inventors and assignees responsible for patenting an idea are arguably the primary force behind an innovation. The latter provide the resources, incentives and goals for innovation, while the former are responsible for generating novel ideas of practical use (of course this depends on how we define innovation, but for the sake of this paper I remain close to the notion of a marketable product). Assignees and innovators usually work together in the same environment since the innovators are employed by the assignee. However, there are other ways of cooperation, considering ideas can come out of anywhere, including the academia (Etzkowitz & Leydesdorff, 2000), the government, other industrial sectors and smaller companies (Chesbrough, 2003) and perhaps civil society organizations or independent citizens as well. This is how different sectors and helixes interact, influence and support each other through innovation, entrepreneurship and networking, for the sake of creating a novel product and securing it by patent rights.

Analysis of assignees, innovators and their respective affiliations as mentioned in 200 patent applications belonging to Teva and Elbit, allowed mapping of a general situation in the two industries as well as changes in the interactions between helices over the years. By looking at the differences in cooperative patterns between the two organizations, and comparing the total percentages of cooperation per individual cooperation-category a story emerged. Patent application provided enough information to look at the way a specific helix interacts with the others, demonstrated that the Civil Society does indeed have influence, and that different organizations belonging to the same helix behave in different ways.

Teva and Elbit share some of their cooperative practices but not the most important ones. As assignee affiliations revealed, both firms have a tendency to own the large majority of their patents, without cooperating with other organizations (Figure 3.1). In fact, 67% of total patent applications have Teva or Elbit and principle assignees and sole owners of the patent (Ind.1 category of cooperation). Though studies, such the one done by Chesbrough (2003), would suggest larger firms cooperate with smaller start-up companies, present data shows that the majority of innovation is still done by the major companies themselves or owned subdivisions. Cooperation with external companies is not the main driving force of innovation, though little can be said as to the quality of innovation that results from such cooperation. When combining both inventor and assignee affiliation, only 33% of the patent applications, in the sample showed any evidence of cooperation with other industry firms not owned by the two organizations or with entities otherwise belonging to separate helices. The two corporations were fairly similar in their cooperation with Civil Society bodies (Ind-Civil Soc. Cooperation category), 10 and 8 patent applications for Teva and Elbit respectively, but these only account for 9% of the entire patent application sample.

Figure 3.1 Division of Patent Applications by Cooperation Categories



Combining these data with observations on the changes over time, cooperation with external organizations has only been occurring for the past 25 years (Figures 3.2 and 3.3). The large percentage of innovations resulting from inside Teva and Elbit increase over time, though this is most likely due to factors relating to company size, mergers with additional companies and an increase in R&D activities as the firms moved towards the level of multi-nationality. In general, the number of patents applied for in Israel has been increasing constantly (Getz, Leck, Natan, Even-Zohar & Hafetz, 2011). Furthermore, the potential of civil society interactions with the industry appears to be highly limited. Though the reasons are not directly evident from the patent application itself, the nature of civil innovation is probably related to innovation that is not directly marketable or patentable. Another possibility is that individual researchers began working with companies only after they began patenting through the WIPO system, thus ensuring their names were mentioned in the patent application itself (in relation to the IPO issue mentioned before). Individual researchers have more to lose in terms of financial gains when dealing with large corporations because in such cases the firms are those who have most of the negotiating power when it comes to IP rights versus payment. If the WIPO system demands that all inventors be named, then individuals have gained a significant boost in personal property rights ensuring their legal standing when faced with powerful firms. Additionally, individual inventors could also profit from increased publicity resulting from a patent issued by a large company, thus increasing their future possibilities.

Differences between Teva and Elbit's patenting become apparent when looking at the rest of their cooperative ventures. Teva demonstrates a higher percentage of cooperation with academia related bodies such as Yissum Research & Development Company of the Hebrew University of Jerusalem, the Technion Research & Development Foundation Ltd. and Ramot - Technology Transfer of Tel Aviv University, where cooperation with these bodies accounted for a total of 20% of patents applied. Teva showed increasing interaction with academic bodies up to the last patent application sampled (in 2001). The most likely explanations for this is the stronger influence universities have been seeking for the sake of profits (Etzkowitz & Leydesdorff, 2000:117-119; Henderson et al., 2000). Although Universities play an important role in innovation, the interaction with other helices is not a uniform matter as evidenced by Elbit's 2% cooperation with academic institutes. Despite working with more than one university per project (Weizmann Institute of Science and its technology transfer institute Yeda Research and Development

Company Ltd. Alongside Technion Research & Development Foundation Ltd.), Elbit appears to prefer cooperation with industries in the same sector, over interacting with external organizations.

Elbit's second major cooperation category Ind. 2 is responsible for 18% of its total patents. This cooperation with in-sector companies such as Tadiran Communications, Shiron Satellite Communications and BVR Systems remained increased after 1985 (when these firms began their activity) and remained stable up to the last patent applied in 2004. From what we know now, these companies were later gradually merged with Elbit and today form such of its major subsidiaries. Thus if we were to look at patents applied today we might observe an increase in Ind. 1 cooperation. However, the far more interesting implication is the possibility of identifying future mergers through increases in Ind. 2 type cooperation with specific firms.

Additional differences between Elbit and Teva are the variety of cooperative interactions. Teva cooperated with only 2 external helices, whereas Elbit's patents are the result of 4 possible interactions with the other helices. Out of the total 15 patents filed with assignees not belonging to the industry helix, 5 patents were done with the cooperation of government affiliated industry, Refael Advanced Defense Systems one of which also brought in the Technion Research and Development Foundation Ltd. resulting in a true tri-lateral cooperation envisioned by the TH model. Though the information is largely descriptive, the similarities and differences present in the interactions visible in patent applications are extremely useful for further research. The biggest problem with helix interaction studies is identifying the actors responsible for an innovation. From the data presented above several possible questions can be asked in regards to the differences between the two companies. For example, why does Elbit demonstrate a higher variability in its cooperation with external bodies, but does with less projects that Teva? The patent application data on assignees and innovators provides a quick and easy way to focus a researcher's questions when approaching the field with qualitative data. Additionally, the data regarding patents granted based on applications, could be studied to see whether one form of cooperation is better than another (this was done for this study, but correlational was insignificant due to the small amount of patents resulting of between-helix interactions).

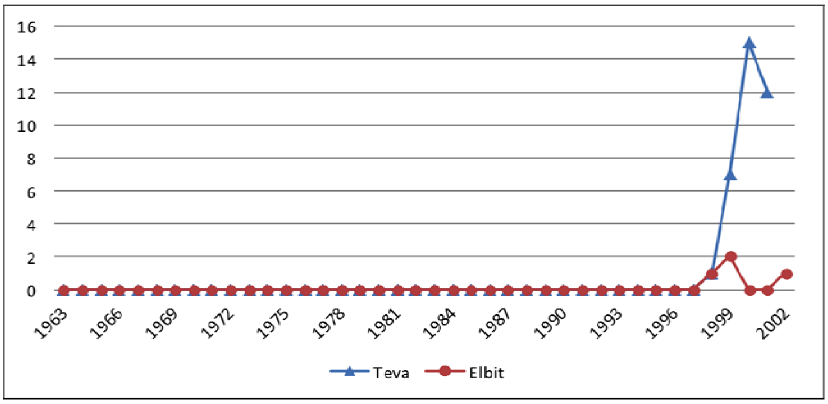
3.3.2 Israel versus the World: Local-global changes visible through patent applications.

As data from patent applications was researched, it was discovered that they can also provide further insight into the elusive effects that global changes have over local innovation policy. Though it has been shown that Israel's major tendency is to export patents to the United States (Trajtenberg, 2002) two additional patterns became evident in patents filed through the IPO system. First, Israeli companies increasingly filed patent applications through the World Intellectual Property Organization (WIPO) but the two different industry sectors did not act the same in this regard.

The history of the WIPO begins in 1967 when it was first promulgated as a body to supervise over existing IP treaties. Later it went through several revisions: joining with the United Nations, obtaining the rights for patent application processing thanks to the Patent Cooperation Treaty and the still continuing process of harmonizing with the EPO (Granstrand, 2005). Interestingly, despite being part of the WIPO bodies and treaties since their beginning, Israel does not seem to have filled its patents through this system until the signature of the WIPO Copyright Treaty in 1997 (WIPO, 2012). In fact, Teva and Elbit have filed only 39 total patent applications through the WIPO (only 4 by Elbit), and those few appearing for the first time only in 1998 (Appendix 3).

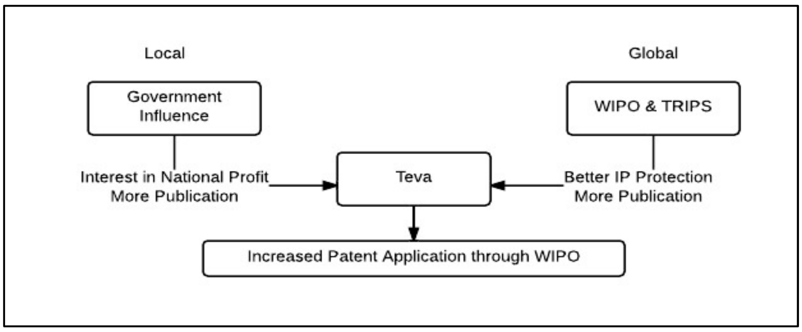
Thought the treaty was an important part of the visible process there might have been other factors at work. One potential explanation for this specific change lies in the adoption of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. Since its early establishment and through its various redefinitions, the TRIPS agreement was meant to increase standardization of Intellectual Property Rights (IPR), with particular benefits in the pharmaceuticals sector (Smith, Correa & Oh, 2009, p. 684-685). This factor and the potential for increased stability achieved thanks to the Doha Declaration in 2001 serves as an explanation for TEVA's slower start in the adoption of WIPO patent filings and its subsequent boom (Figure 3.4) in filing solely through the system. The sudden spike of patents filed through the WIPO around the Doha Declaration suggest that TEVA jumped at the opportunity for securing its IPR for a wide range of countries, and probably gaining better control over specific markets despite its strength with generic products. In essence TEVA is expanding its patenting influence outside of Israel due to change in international policy and there is clear evidence visible in its patenting history.

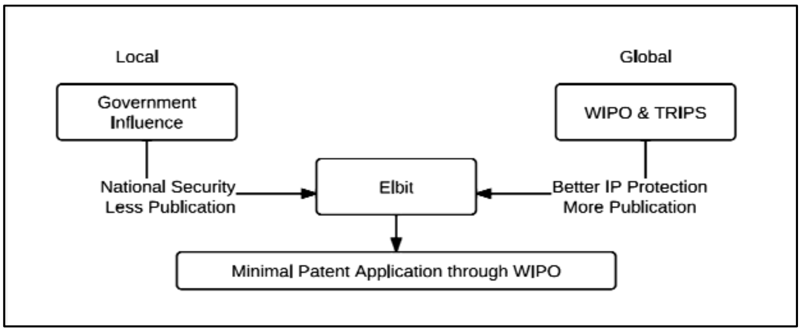
Figure 3.4. Patents Filed through the WIPO System by TEVA and Elbit (1963-2002)



On the other hand we have Elbit and its significantly smaller amount of patent applications filed through the WIPO system. One key reason for this would be the nature of Elbit's innovations, namely that they serve defense industries. Despite its self-proclamation as a non-governmental entity (Elbit, 2012), Elbit and its subsidiaries is still a major provider of defense technologies in Israel. It stands to reason that this particular industry sector has no interest in exporting its products to foreign nations simply because of security reasons (which could also be partly specific to Israel and the position its military occupies in respect to other government entities). Though such evidence is not directly present in the patent application data, it is likely that interaction between government organizations (such as the military) and Elbit influenced the quantity of globally patented innovations. If such a thing could be proven (though it stand to reason that such data would be difficult to come by due to security concerns), then we would be witnesses to an interaction of one helix, the government, with another, the industry, when global changes in IPR are in direct opposition to local interests (Figure 3.5). While Elbit's global patenting policy is curbed by national interests, Teva can only bring further profit by increasing its global presence which means it can only enjoy encouragement to patent through the WIPO system.

Figure 3.5 The Nature of IPR – Interactions Between Local and Global Bodies or Legislatures and Effects on WIPO Patenting





Though it does not reveal the full picture, patent application analysis, in both cases, provides us with reasonable information in regards to practices within the Israeli industry. Both companies are affected by global IPR policy changes, but whereas TEVA might react as other pharmaceutical industries, Elbit demonstrated the impact local-global interactions can have. Using these data we can infer that TEVA has a higher degree of freedom in regards to its patenting policy and by extension the countries where it can produce and sell its innovations, whereas Elbit is limited due to specific conditions found in Israel and the nature of defense industry sectors.

3.4 Discussion and Conclusion

This article attempted to highlight the potential utility of patent applications in innovation studies. By looking at the assignees and innovators similarities and differences between different industry sectors were identified. While the descriptive nature of the data seems like a limiting factor for any statistical conclusion as far innovation quality or changes in specific innovation policy is concerned, the ability to map out differences between actors in the AIGCS network is not without merit. Identifying the key spots of interaction with the organizations belonging to a sector other than the industry can give a strong indication for future study paths. As I proposed, the fact that Teva and Elbit demonstrated a different rate of cooperation with the academia but similar interaction with individuals (which are CS affiliated) serves as proof that there are specific processes within companies that are later evidenced in patent application. Since access to information of the inner workings of a company are harder to come by, the visible connections available in patent applications can provide much more precise indication for innovation policy studies. In essence, patent applications point out the place for a researcher to ask the relevant “why” questions. Thus we might as why Teva cooperates with the academia but not with any government affiliated body, and why do we not see any evidence of such interactions in patents?

Furthermore, patent applications were seen here as capable of providing early indication as to the results of global changes when interacting with local or sectorial uniqueness. The changes following the adoption of the TRIPS agreement become evident immediately in patent applications for one industry but not for the other. Policy researchers could then use this method in the future to quickly gauge the impact of global policy changes on specific, localized industries or sectors.

However, before patent application analysis can be declared as uniquely beneficial tool for innovation studies, the statistical significance that it may provide would need to be further tested. Despite considering 200 patents a reasonable sample, little statistical significance could be obtained due to the small sample sizes for each condition of cooperation (a total of 45 patent applications authored or owned in cooperation with non-industry elements). Thus it is for a future study to modify the conditions of patent application analysis searching for specific types of cooperation and then identifying rates of success, changes over time and their connection to evidence not present in patent applications themselves. Until this happens, patent application analysis, as discussed and evaluated here, can be used a guiding method to identify future directions of innovation policy for selected industry sectors.

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Chapter 4 – Academia

The Role of Academia in a Knowledge-Based Economy: Case Study of the Seven Research Universities' Technology Transfer Offices in Israel

Navah Berger

The Global Competitiveness Report (GCR) (2012) states that innovation is one of the twelve pillars of competitiveness in which the focus lays on each country's technological advancements. Although the emphasis is placed on technological innovations, non-technological innovations, know-how, skills and working conditions embedded in organizational structures are relevant as well in materializing innovations. In the past labor and market variables provided a sufficient infrastructure for living conditions. The report claims that technological innovations are the main source for improving standards of living in the 21st century. There needs to be an environment that is conducive for innovative activity. Israel is one of thirty-five innovation driven world economies. How is an innovative climate formed and developed? The report states that the key components are academia, industry and government; extensive collaborations in research and technological developments between universities and industry alongside the enforcement of intellectual property protection policies. For innovation to flourish a constant flow of activities and movement need to occur between different sectors.

Etzkowitz, and Leydesdorff (2000) developed an analytical model to describe the institutional linkage between academia, industry and government. The Triple Helix Model studies the network overlay of communications and expectations that reshape institutional arrangements. Its main emphasis is to create a "knowledge based economy” which allows and enables industry and universities to have more of a say in government policy.

Leydesdorff (2012) has added that the non-linear systematic model that measures innovation remains in transition due to integrating and differentiating forces. “Integration among the functions of wealth creation, knowledge production, and normative control takes place at the interfaces in organizations, while exchanges on the market, scholarly communication in knowledge production, and political discourse tend to differentiate globally… The Triple Helix indicator can be extended algorithmically, for example, with local-global as a fourth dimension or, more generally, to an N-tuple of helices.” A few of my colleagues (Bucevschi, 2012; Caspi, 2012; and Netivi, 2012) have adopted Leydesdorff’s view of the model and elaborated on the matter portraying the case of Israel, yet for the sake of argument, my examination and discussion will be from within the framework of the standard Triple Helix Model.

Israel is home to some of the most innovative technologies; companies such as Google, Cisco, Microsoft, Intel and eBay found their home in Israel. As an executive from eBay stated in the book *Start-Up Nation: The Story of Israel’s Economic Miracle*, "The best-kept secret is that we all live and die by the work of our Israeli teams." A country that has a close proximity of research universities, large firms and start-ups, expertise in all fields from around the world, and an environment of venture capital, military and government R&D funding all are central elements in deciphering what makes Israel an innovation capital of the world.

4.1 Academic Innovation and Technology Transfer in Israel

The character of innovation in Israel is largely attributable to the academic excellence of its research universities and institutes. Israel is ranked number one in its quality of scientific research institutions.

Israel is home to the 4th highest percentage of academic degrees which translates into human capital that is so valued in a knowledge-based economy (GCR, 2012). The history of academic excellence began before the state was established and has been a top priority to this day. In a land that lacks natural resources Israelis depend on their academic achievements and innovative technologies to survive.

Albert Einstein one of the founding fathers of the Hebrew University of Jerusalem said, “Intellectual growth should commence at birth and cease only at death”. This statement portrays the academic ethos of the State of Israel. Before the birth of Israel in 1947 and the development of adequate infrastructure, government, organized military, or industry Israel had academia. Intellectual growth has been the cornerstone for all academic research and discoveries. In 1925 both the Hebrew University of Jerusalem and the Technion- Institute of Technology had their opening ceremonies. Within a decade the Weizmann Institute of Science opened its doors (1934).

Over the past two centuries a paradigm shift has altered the role of the university. The first shift began when universities took upon themselves the role of research alongside that of educating. A research university is a university with two main purposes; to conduct research and to train graduate students on how to conduct research (Rogers et al., 2001). A second academic revolution arrived in the mid-20th century creating a new model; the entrepreneurial research university. The entrepreneurial university encompasses and extends the research university. Entrepreneurial activity is a step in the natural evolution of a university system that emphasizes economic development in addition to its more traditional obligations of education and research. It has the ability to enhance the commercialization of university inventions by defining a focused strategic direction by creating academic goals and in translating knowledge into economic and social utility (Etzkowitz, 2003). This revolution created the technology transfer offices that have been established in almost every research university in the world (Rothaermel et al. 2007).

Technology transfer has been defined as; the process whereby invention or intellectual property from academic research is licensed or conveyed through use to a for-profit entity and eventually commercialized (Friedman and Silberman, 2003). Universities are non-profit organizations that rely on grants, government aid, and donations to survive. Universities struggle with internal conflict regarding common goals of academic faculty and decision makers. An inventor's goal when conducting research is to receive public acclaim while the university's goal is to attract funds from licensing of patents and inventions to support future research. Technology transfer offices (henceforth, TTOs) were established to contrive and implement systematic technology commercialization programs that assist in the circulation of funds back into the university. The first university technology transfer office was established in 1925 at the University of Wisconsin at Madison, since then over 300 US universities have established TTOs (Bukofzer et al., 2003). TTOs are the vehicle to create collaborations between business partners and researchers, assist in contractual, administrative, and financial agreements while protecting the rights of the researcher's IP.

Studies that have been done on TTOs conduct through comparative studies between countries. Bukofzer et al. (2003) compare TTO systems in the US, Britain, China, Japan, Germany, and Israel. They illustrate the economic contribution that TTOs have assumed since 1981, claiming that the Bayh-Dole act is the "Magna Carta" for university technology transfer that had a global influence. Gupta and Reisman's (2005) comparative study focuses on India's post-independence technology transfer (TT) policies and practices and compares their findings in Turkey and Israel (all three gained independence in the 20th century). They give three different models of institutionalizing TT as a means to development that arose in the respective countries.

There are numerous elements that can interpret the impact and effectiveness of TTOs; including characteristics of the technology, the transfer agent, the technology recipient market, political, organizational, and academic partners (Bozeman, 2000). Only one independent case study has been completed of Israel's technology transfer. Maital and Meseri (2001) conducted a survey analysis of university-technology transfer organizations in Israel. Their survey examined how Israeli TTO's evaluate projects and how they perceive the success or failure of the projects. They claim that technology transfer is a complex process and recommend that there is a need to adopt a systematic approach in which the interactions among research, development, innovation, commercialization, marketing, and distribution are studied as an integral whole; all the participants in the process of innovation (industry, government, and academia) need to be included. They suggest a study to be conducted using the model of the Triple Helix.

Rothaermel et al. (2007) summarized the discourse on TTOs in their detailed and all-inclusive analysis of all the streams of research found on the topic of university entrepreneurship. They found that four major themes developed; entrepreneurial research university, productivity of TTOs, new firm creation and environmental context including networks of innovation. They suggest that this framework be used in future research on the subject. I used their outline together with the Triple Helix Model as my main guideline in conducting my research and mapping out the current field in Israel.

In the 1960s Israel's research institutes understood that there is a need to transfer academic knowledge into marketable products that can benefit society and boost economic growth. This institutional awareness of the larger picture led to the creation of a vibrant innovative culture. It excels in transferring research from university labs into innovative products that have influenced and touched on all aspects of the national innovation system. Ndonzuau et al. (2002) state that there has been a shift in paradigm in the mission of universities and they now include "service to society" in their mission statement. The TTOs have taken upon themselves this mission as stated on Yissum's homepage: "Through our support and encouragement of research, development, and education, we are dedicated to turning science into commercial products for society's use and benefit." (http://www.yissum.co.il/overview)

The method and emphasis of study varies depending on the discipline in which it is being researched. Bozeman (2000) claims that the discussion of technology transfer amongst sociologists will link technology transfer to innovation. As I am a student of the discipline I will be mapping out the characteristics of Israeli TTOs as part of a larger discussion on innovation.

Research Question: Based on the Triple Helix Model, what are the characteristics of Israeli TTO that makes them an integral player in innovation?

4.2 Methodology

In Israel there are seven university-associated TTO that provide a valuable forum for connecting Israeli researchers and early stage projects with the industry through their commercialization efforts; investments, sponsorships and partnerships from national and multi-national companies enthusiastic to benefit from Israeli born innovations. Israeli universities were among the first in the world to develop TTOs and is home to some of the oldest, largest and most profitable TTOs in the world. The unified technology transfer model amongst the research universities is due to government regulations against public institutions holding business activities (Committee for academia-industry, 2005).

The tradition of technology transfer began with the Weizmann Institute of Science (1959) and the Hebrew University (1964) and has evolved over the years into a model of excellence that all the research universities have implemented. Therefore, my research will include the entire field; the seven research universities technology transfer offices found in Israel; The seven research university affiliated TTOs are; Bar–Ilan Research & Development Ltd of Bar-Ilan University, BGN - Ben-Gurion University of the Negev, Carmel- Haifa University Economic Corp. Ltd, Ramot - Technology Transfer of Tel Aviv University, T³ - Technion Technology Transfer, Yeda - Research & Development of Weizmann Institute, and Yissum - Technology Transfer of the Hebrew University.

In order to conduct my research I explored the channels available for collecting date. I found that Israeli TTOs do not have a culture of sharing information and participating with researchers. In a report conducted on academia-industry relations (שפר ופרנקל, 2003) the researchers stated that the unwillingness of university parties to cooperate and provide quantitative information (as such available on American TTOs by Association of University Technology Managers (AUTM)), an incomplete picture was drawn. The second challenge I faced was finding statistics from previous years that would be essential in constructing a historically based claim. 2012 was the first year that the Central Bureau of Statistics conducted a survey of the activities of Israel's research universities' TTOs (supported and initiated by the Israel National Council for R&D of the Ministry of Science and Technology).

Under these restrictions my research portrays the current state of the field through the use of available public information provided by; the Central Bureau of Statistics, the official websites of each of the TTOs (Bar Ilan Research and Development (BIRAD) n/a), the Israel Technology Transfer Organization (ITTN) website, and university annual reports. Because of my dependency on public sources for collecting data, there are discrepancies and missing statistics in regards to a few of the sub-topics (number of license agreements and collaborations signed).

The next three chapters will look into the different ways in which Israel's TTO characteristics are portrayed through their linkages and participation with the other two helices. Chapter one outlines the importance aspects in the TTOs organizational arrangement; age, size, know-how, environment and supporting networks. Chapter two has two sections one that touches upon relevant government policies and regulations regarding IP ownership, and a second that describes one of the most successful and complex funding programs offered by the Office of the Chief Scientist. The Magnet Program embodies the Triple Helix Model; linking academia-government-industry in the process of creating innovative technologies. Chapter three takes a closer look at the technology transfer process, from the moment the researcher makes a discovery until his IP becomes a relevant and marketable product that an industry partner can utilize. Through these chapters I hope to be able to draw a complete picture as to the characteristics of Israeli TTOs and their role in advancing innovation based on the Triple Helix Model.

4.3 Organizational Construction and Environmental Climate

Siegel et al. (2001) provide co-authors Bercovitz, Feldman, Feller, and Burton analysis regarding organizational forms of a TTO. They claim that organizational structure and form matter in supporting the overall productivity of the company. They explain that factors such as; transaction output, the ability to coordinate licensing and sponsored research activities, and incentive alignment capability are vital for organizational success. In this section we will look at some of the relevant findings regarding organizational structure and geographical climate of the Israeli university TTOs that facilitate in making them invaluable entities in transferring university IP into marketable products.

4.3.1 Age of the TTO

The age of the TTO is a factor and tool for measuring the productivity of the company. Older companies have more experience in formal management and specialized know-how enabling them over time to produce large quantities of profitable arrangements with industry (Siegel et al., 2003). It takes time to establish a portfolio of invention disclosures, patents, and to sell licenses. It usually takes a three to seven year lag from the time the license agreement is signed until it begins to generate income. Technology diffusion causes license earnings to grow gradually, so younger TTOs tend to lag significantly in the earnings relative to older TTOs (Friedman and Silberman, 2003). The newer TTOs learn from the older companies how to raise the quality of their patent profiles. In Israel the two oldest TTOs are amongst the most successful in the world; Yeda's annual revenues reach 60 million dollars, followed by Yissum with 36 million dollars (Inter-Ministerial Committee, 2005).

Table 4.1 Year of Founding of Israeli Technology Transfer Offices

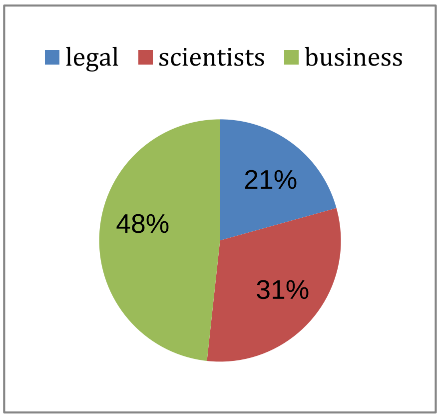
TTO	Home University	Year Established
BIRAD	Bar Ilan University	n/a
BGN	Ben Gurion University of the Negev	1986
Carmel	Haifa University	2002
Ramot	Tel Aviv University	1973
T3	Technion	2007
Yeda	Weizmann Institute	1959
Yissum	The Hebrew University of Jerusalem	1964

The age of the TTO needs to be contemplated in analyzing the other characteristics such as the size of the staff, number of available technologies, spin-offs and collaborations with industry partners. The TTO that does not fit nicely into the age theory is Technion's T3. Their success might be due to the Institute's international reputation of excellence along with other factors. The technological incubator in Haifa and the construction and maintenance of informal networks of innovation, composed of entrepreneurs within the incubator, Technion scientists and industry have created a wide range of relationships, both formal and informal, that are tied by their shared use of library and laboratory services, interchange of knowledge, know-how, and practices (Darr and Rothschild, 2005).

4.3.2 Management Practices

There are different aspects that are addressed in the discussion of the complexities of creating an effective team. Different considerations can be deliberated on as to who is most qualified to work in such a dynamic atmosphere. In order to maximize efficiency there needs to be a combination of employees with a mix of scientific and business backgrounds in order to create a competent and complementary team (Rothaermel et al., 2007). Lockett et al. (2003) add that successful TTOs must also have substantial networks with outsiders and have many initiatives to promote the availability of technology. Siegel et al (2003) describe that TTOs staffing practices are divided into two; those that have a staff made up of either scientists and lawyers or scientists and businessmen/entrepreneurs. These two styles of staffing practices point out the difference of opinion as to what management can do to capitalize on their efforts in managing researchers' intellectual property. The latter model relies on outsourcing for legal matters, which would allow for more efforts to be placed on the marketing and business aspects. Siegel et al (2003) claim that having a team of business oriented minds is more conducive and effectual in the process of turning university IP into marketable products.

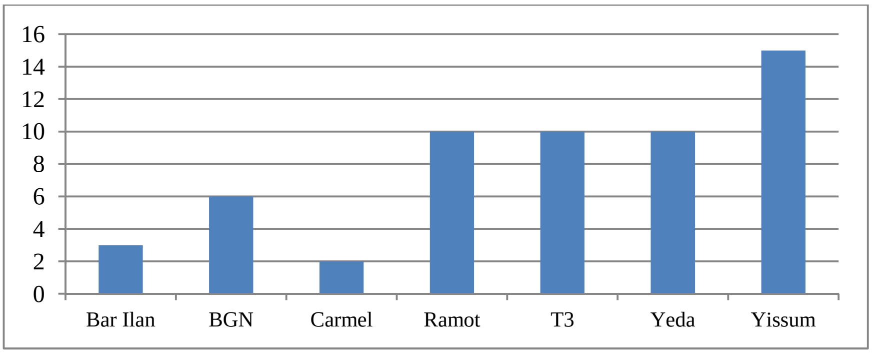
Figure 4.1 TTO Staff



In Israel we find that the TTO staffing model is made up of a combination of all three types of employees; scientists, lawyers, and businessmen, excluding for the two smallest and youngest TTOs (Bar Ilan and Carmel). Five of the Israeli TTOs have employees with science, marketing, business development, patent registration, and legal backgrounds. They hire people who have industry experience with academic qualifications. The consensus similarity in organizational structure of the TTOs portrays the understanding that a well-rounded, diverse, and qualified team is necessary for a successful technology transfer office to function and in the reorganization of commercial opportunities (Lockett et al., 2003).

The second aspect is the size of the TT, measured by the number of employees, which plays a significant role in the quality and effectiveness of the TTO (Rogers et al., 2001; Friedman and Silberman, 2003). When taken into consideration the amount of available technologies, there is a problem that the offices have limited amounts of human resources and are unable to give proper attention to all projects due to lack of staffing specializing in specific fields. This issue is especially problematic in the smaller research universities.

Figure 4.2 Number of Professional Staff in TTOs



4.3.3 Networks in Hi-Tech Environment

The seven research universities are situated throughout the country; from Haifa in the northern part of the country to Be’er Sheva in the south. Three universities are located in the center of the country; Tel Aviv University, Bar Ilan and the Weizmann Institute. In Israel’s capital the Hebrew University of Jerusalem is situated. All seven of the research universities and their associated TTOs are located in “technopolis” (Rogers et al., 2001) cities and/or have erected centers for technological advancements. These cities have hi-tech parks, hubs and incubators that have collaborated and partnered with the universities and their activities. Many of the world's leading IT and medical equipment companies have set up R&D centers and laboratories in Israel either on or close to campuses amongst them; IBM, Cisco, Motorola, Intel, Applied Materials, HP, Nestle, Marvell, Microsoft, Yahoo!, Philips, Elbit Systems and Google (Senor and Singer, 2009).

Haifa is home to the Technion Institute of Technology (T3) and Haifa University (Carmel ltd.) and hosts the largest and oldest hi-tech park in Israel. Matam (Hebrew:מת״ם- מרכז תעשיות מדע-*Merkaz Ta’asiyot Mada)* was founded in 1970 and today employees over 8,000 people. BGN- Ben Gurion University, KUD and the Municipality of Beer-Sheva have recently partnered to develop the Advanced Technologies Park (ATP) in Beer-Sheva. The new project hopes to facilitate significant advancements in R&D and the hi-tech industry (http://cmsprod.bgu.ac.il/Eng/BGN1/Industry/Advanced+Technologies+Park/). The center of the country has been named “Silicon Wadi” for it has an extremely high density of hi-tech industries and parks that are affiliated with the universities. Jerusalem has a campus of “science-rich industries” (Hebrew: קריית תעשיות עתירות מדע, *Kiryat Ta'asiyot Atirot Mada*) known as Har Hotzvim. Hi-tech parks in close range of research universities make them easily accessible and appealing to industries for creating joint ventures.

There are four medical schools in Israel found in each of the hi-tech centers in the country; Ben Gurion University of the Negev- Joyce &

Irving Goldman Medical School, Technion- Bruce Rappaport Medical School, Hebrew University of Jerusalem- Hadassah Medical School, and Tel Aviv University-Sackler Faculty of Medicine. Hospitals affiliated with universities, specifically those with medical schools have a positive effect on the output of the TTO (Siegel et al, 2003; Friedman and Silberman, 2003). The environment of medical research makes for an easy transition in developing generic technologies and inventions that improve the medical field. Based on the marketability that medical inventions have compared to other disciplines we find that the largest numbers of technologies are coming from the fields of life sciences and medicine. In 2009 most of the revenues from sales and gross royalties can from these two fields (92%).

Although the phenomenon of technology transfer has existed since the 1960s, only in 2004 did an organization establish that would represent the common interests and goals of the universities' TTOs. The U.S.-Israel Science and Technology Foundation (USISTF) sought to form a non-profit organization that would unite the various technology transfer offices throughout Israel. The purpose of the Israel Technology Transfer Network (ITTN) is to permit Israeli generated IP to translate more easily into marketable products for the benefit Israel and the United States. The Israel Tech Transfer Organization (ITTN) serves as the umbrella organization for Israel's technology transfer companies. The organization has 12 partners; seven research university affiliated TTOs and five hospital and research affiliated TTOs. The ITTN's vision includes adding additional members from government owned medical centers and research institutions to enable the advancement of collaborative efforts between the entire technology transfer community in Israel and its counterparts around the world. The ITTN represents the interest of its member organizations before the Knesset, government authorities, ministries, agencies, and committees.

In June 2012 the first annual ITTN conference assembled which brought together leaders in technology transfer, government representatives, noble prize laureates and patent attorneys from around Israel and the world. As this was the first year that the conference commended connecting the members of the technology transfer community we do not have any way of measuring the value of such an event. In the future I hope that the networking opportunities will result in the actualization of changed policies and additional collaborations on the national and international fronts. http://www.ittn.org.il/index.php

4.4 Government Relations

Governments have implemented different strategies to improve technological advancements that will provide economic growth. One of the modes of successfully achieving economic growth is by investing in the research and development of cutting edge projects. Israel has the world's highest R&D intensity; 4.27% of its gross domestic product (GDP) is spent on R&D, over twice the average of all OECD countries (OECD Report 2011). Israel is a country that endorses so much of the R&D done in its laboratories, therefore the government needs to create policies for the protection of intellectual property and expand the options and opportunities for collaborative R&D projects between academic and industry. Israel's excellent innovation capacity is partly due to the government's procurement policies (GCR, 2012).

4.4.1 Intellectual Property Policies

In September 2004 a government decision was passed allowing full ownership of intellectual property to be granted to a research institute (החלטה חכ/122). This decision includes clauses regarding the bureaucratic procedures of technology transfer, division of revenues between researcher and institute and a clause stating that any research that is funded by a ministry is to receive up to 5% from the revenues, but not exceeding the given research grant. According to Israeli law, patents are property of the employer. This means that in any case that a patent is registered by a university faculty member (while working under the university framework) and there is not a contract with a third external party or a term that states otherwise, the IP belongs to the institute (Committee of the Council for Higher Education, 2005). The government does not place a lot of restrictions on IP ownership or pass sanctions because it wants to encourage scientists' discoveries.

4.4.2 The Office of the Chief Scientist and the Magnet Program

In Israel the government plays an active role in technology development and transfer. According to the cooperative technology policy paradigm (Bozeman, 2000) the government's roll can be as a research performer (supplying applied research to industry), or as an agent, developing policies affecting industrial technology development and innovation. It is an umbrella term for cooperation among three sectors; industry, government, and academia i.e. Triple Helix. Furthermore a government technology planning and coordinating role can maximize productivity and innovation. The Israeli government encourages the relationships and collaborations between academia and industry by awarding financial assistance for R&D. Promising research projects worked on in university labs through all various stages can find a partner for developing their inventions (Committee of the Council for Higher Education, 2005). The government project that most clearly embodies the cooperative technology paradigm is the Magnet program from the Office of the Chief Scientist (OCS).

The Office of Chief Scientist (OCS) is the main government body responsible for R&D in Israel. The Magnet Program (http://www.magnet.org.il/) was established to promote technological innovation with the goal of preserving Israel as an international industry competitor. The MAGNET Program from the Office of the Chief Scientist of the Ministry of Industry, Trade & Labor, has been sponsoring innovative industry oriented technologies and research in order to strengthen Israel's technological capabilities and enhance its competitive edge since 1994. Over 250 companies have so far benefited from collaborations with the research universities in the country (see appendix for project collaborations). All the seven research universities have taken advantage of the government funded grants through the Magnet program (Magnet Report, 2012). The program facilitates for research to transpire without the university or researcher having to face financial risks that most research projects entail. The results of the projects need to be implemented for the Israeli market and provide an added value to the economy. As well, Magnet and the Office of the Chief Scientist do not take part in any of the royalties from successful projects, allowing both academia and the industry partners to flourish.

Magnet established four main tracks to advance the collaborative activities between industrial companies and academia; Nofar, Kamin, Magneton, and Ma’agad (Consortium). Magnet operates alongside the traditional Research Committee that deals with product development and activities that encourages entrepreneurs to establish new companies. The collaboration is always considered as the tool to achieve the goal and not as the goal itself. Magnet's main goal is to allow companies to develop cutting edge technologies with the know-how from the universities in addition to all the other activities of the company.

Nofar is a purely academic research program for basic and applied research. The goal is to bridge the gap between the academic know-how and the needs of the industry by creating scientific breakthroughs that would spark the interest of a company to invest in further R&D steps. The program operates according to the Director General Instruction 8.7 – Enhance the Initial Applied Research – NOFAR – which provides the complementary requirements of the R&D Law. The grant is provided for twelve month duration and is given a budget of up to $100K. Assistance by the company which must pay 10% of the budget that is not granted by the OCS. As part of the agreements with the industry partner, who had invested in the project, the company receives the rights to be the first to negotiate the acquisition from the TTO responsible for the technology.

Kamin was launched in 2011 making it the newest addition to the Magnet program. The program assists in translating the basic research into technologies that will interest industries. It is the first stage of the Nofar program, and different from the other programs because it does not rely on an industry partner. Kamin is for projects up to a $100K budget that is subsidized up to 90% by the OCS. The researcher needs to prove that it is innovative, the only one of its kind and has industrial relevance.

Magneton is a dual cooperation between one academic group and one industrial company. The purpose is to foster technology transfer for increasing the feasibility of a technology resulting from an academic research, before implementation by leading Israeli company for further development. In order to receive the grant the technology has to already be in its first stages – in the lab. The project must be innovative, original, has technological probability and can prove that there is a company needing of the technology. The IP has to be owned by the research institute (TTO) and that it can. The program operates according to the Director General Instruction 8.6 –Encouragement of Technology Transfer – MAGNETON – which provides the complementary requirements of the R&D Law. The program period is for up to two years duration and a budget of up to $800K. The industry partner assists the research group in transferring their research into marketable products. The framework of the program allows for an appropriate environment for testing the marketable potential of the technology. Without the program the company would have difficulty in their R&D process. By the end of the project the company can decide if it wants to continue the R&D independently.

Ma’agad (Consortium) is the banner program of Magnet. It is the most complex of the programs providing assistance for collaborations between TTOs and industrial partners to develop generic technologies that are of importance to the international market. Based on technology unionizing (the sharing of IP licenses), teams of industry developers and academic researchers work cooperatively to develop next generation technologies and products in a specific field. The program operates according to the Director General Instruction 8.5– Encouragement of Generic Technology Development and Assimilation – MAGNET – which provides the complementary requirements of the R&D Law. The consortium projects run for a period of three to six years with government support of 66% of the projects budget.

4.4.3 New Developments

The Planning and Budgeting Committee (PBC), the Higher Education Council and the Ministry of Finance announced that a bid will be made public to a select a private company that will be responsible for the commercialization of knowledge (a TTO). This decision has the potential of changing the entire TTO field in Israel. The company will receive an eight year contract with the government and will promote the institutions of higher education that are funded by the state. The revenues of the company will be divided: 70% to the research institute and the company will benefit from the remaining 30%. The PBC will partially fund the company during its first four years; up to 15 million nis. This government initiative demonstrates government support and encouragement to strengthen the ties between academia and industry to promote innovations and entrepreneurship in Israel. As of now the project has not been established, but it represents the continuous expansions of policies, support and relevance of technology transfer to society

(http://www.themarker.com/career/1.1690986)

4.5 Industry Relations: How IP Translates Into Commercialized Technologies

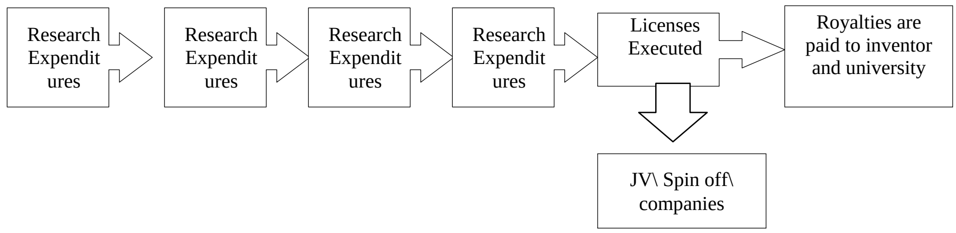
Companies in a wide spectrum of industries are developing collaborations with external entities from discovery to distribution. Some of the rationales behind this phenomenon include; minimizing risk, obtaining access to new markets and technologies, speeding products to market, and the combining complementary skills and know-how. The source of innovation is embedded in the network of inter-organizational relationships where know-how is vital; creating corporative projects with universities and research institutes (Powell et al., 1996 and Zomer et al., 2010).

There are cultural and organizational differences in the measuring of success as well as in understanding the driving forces behind academia and industry. These differences have the possibility of creating difficulties when promoting innovation. Academia has traditionally been knowledge-based, curiosity driven, has a broad scope of disciplines, plays an educational role, and measures achievements by number of publications. On the other side of the spectrum industry is production based, business oriented, confidentiality worshiped, and is measured by its economic achievements. Academic researchers consider money as a means of scientific progress and discovery, while business and industry view money as the main objective, with science only facilitating the objective (Ndonzuau et al., 2002).

Over the past years the cultural gap has declined and more opportunities for collaborations have blossomed. Increasingly engaging in interactions with industry, the core of the university system has expanded to include activities outside the ivory tower with the goal of transforming inventions into innovations for the betterment of society and to enhance the university system's cash flow and capital endowments. Israeli TTOs have collaborated with industrial companies in many aspects and through different channels. The most recent report by the Central Bureau of Statistics (2012) states that total revenue from IP and royalties amounted to 1.568 billion NIS in 2008 and in 2009 1.834 billion NIS.

The technology transfer process begins when research money is granted to a research project, which facilitates in a discovery that the researcher can submit for disclosure, followed by the TTOs obligation to protect the IP in the form of a patent, once the technology is patented, the university owns the intellectual property rights and is able to license the technology and commercialize it, which then is matched with an industry partner willing to pay for the license to use the IP, and finally the return of monies which flow back into the university in which the royalties are granted to the researcher and the university (Rogers et al., 200; Friedman and Silberman, 2003).

Figure 4.3 Technology Transfer Process



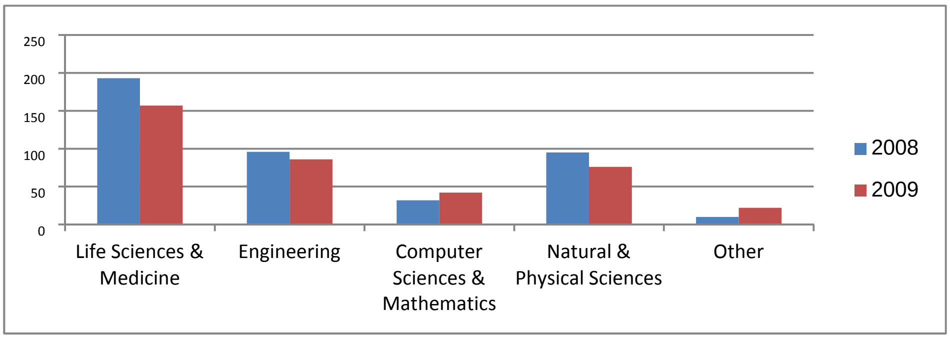
Today there are 1,099 available technologies amongst the seven TTOs in all areas and fields; agriculture, chemistry, nanotechnology, cleantech, communication/IT, computer sciences, mathematics, environment, nutrition, homeland security instrumentation, life sciences, biotech, materials and processes, medical devices and diagnostics, pharmaceuticals, physics/ electro optics, and services (http://www.ittn.org.il/technology.php).

The most prevalent method for transforming the available technologies has been direct licensing of the IP, yet over the years TTOs have shifted their methods and have started using more innovative bailment structures and venture capital spin-out models (Sigel et al., 2001; Ndonzuau et al., 2002; Rubin et al., 2003).

4.5.1 Patent

Israel produces the 4th most patents in the world annually (GCR, 2012). Patent is an exclusive right of use granted by the state to the owner of the invention for the use of the invention for a limited time. In Israel patents can be issued for novel, useful, and non-obvious inventions by the Israeli government or by authorities abroad (Rubin et al, 2003). In 2008-2009 1,128 applications were filed. Because a patent is only valid in the countries where it is granted there is the question as to what is more profitable; patent in Israel or abroad? 94% of patents are registered abroad. All seven of the companies agree that the main means in protecting IP is registering a patent. Since their establishment and through the end of 2009 13, 593 patents have been filed; only 1, 991 in Israel (15%).

Figure 4.4 New Patent Applications by Fields: 2008 and 2009



4.5.2 Licensing

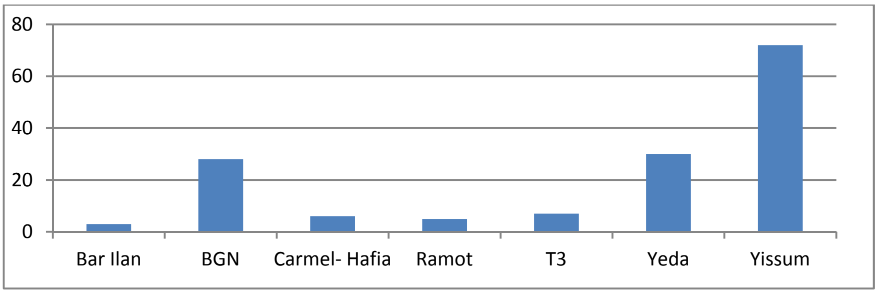
The TTO will search for potential licensees that have the "technical, financial, and marketing capabilities to develop the invention into a product or service and to bring it to market." Feldman et al. (2002) and Rogers et al. (2001) describe licensing as involving selling a company the rights to the university's inventions in return for revenue in the form of upfront fees at the time of closing a deal, and annual, ongoing royalty payments that depend upon the commercial success of the technology in a downstream market. In order to most efficiently accomplish this task, TTOs develop and maintain continuous relationships with industry. The TTO will contact several potential industry partners that might find the given invention valuable to their companies, with luck a match will be made, and the TTO and licensee will negotiate the license agreement. The advantage of this mode of commercialization is that the university is able to benefit from the revenues with still enabling the scientist to peruse his research without having to commit time and efforts in the commercialization (Lockett et al., 2003).

4.5.3 Spin-Offs

University originated researched based spin-off companies are an important channel of technology transfer. A separate corporate entity is formed for the development and exploitation of the university invention (Rubin et al., 2003, Lockett et al., 2003, and Zomer et al., 2010) These entities are owned jointly by private sector and the university. Spinoffs are an alternative solution to licensing. This alternative works best under two circumstances; when an invention may not be easily patentable for licensing agreements and when the university prefers a more direct involvement in the commercialization of a new technology (Lockett et al., 2003). Rogers et al. (2001) claim that spin offs are particularly effective mean of technology transfer because they create jobs and boost the economy.

Over the fifty years Israeli TTOs have facilitated in the establishment of 151s pin off companies as of 2011, of which 44 are currently non-operating. Israel does not have a policy regarding the division of ownership creating a wide range of percentages, from 0.01% to 91%. Most of the spinoffs are privately owned, except for four that are traded on the stock exchange (Central Bureau of Statistics, 2012).

Figure 4.5 Spin-Offs and Companies



4.6 Conclusion and Recommendations

The current picture of Israeli TTOs is drawn through an institutionalist and comparative perspective that looked into the phenomenon of technology transfer and the diffusion of innovation through the use of TTO as the vehicle that translates academic knowledge into commercialized technologies. Israeli TTOs are an integral part of Israeli innovation; the seven TTOs have implemented the same TTO model that has been successful for Yeda and Yissum. The characteristics of an Israeli TTO are of organizational competency, geographically situated near and/or part of hi-tech parks, allowing them to collaborate with industry and have government policies that support their R&D and enhance their likelihood for finding partners in relevant industries. The tight networks and linkages between the three helices (academia-industry-government) provide for a vibrant cultural for the TTOs to flourish and influence future innovation.

The picture drawn here and the characteristics described in case of Israeli TTOs should be developed into a larger, more all-encompassing study. I recommend that qualitative and quantitative research methods be utilized in order to fully comprehend the internal mechanisms, motives, agendas, funding, promotional program and considerations behind the technology transfer process in Israel. For this to be possible managers and decision makers responsible for technology transfer need to realize that there are beneficial aspects and results that will arise from studies. Further research can explore the field by assisting in relevant theories of organizations, globalization, innovation and science-technology. Willingness of policy makers, executive managers, academic faculty and industry leaders to participate in in-depth interviews would add depth to the discourse and create an environment of knowledge sharing. Furthermore, my concern regarding the quality of quantitative data available brings me to suggest that an Israeli organization, such as the ITTN take responsibility of reporting conclusive statistics on the TTOs activities to encourage more participation with industry partners and create a healthy competitive climate.

Although the phenomenon of technology transfer is over fifty years old in Israel, this past year (2012) has generated many interesting developments and public interest in the field of technology transfer. Firstly, the Israeli collages have requested to be recognized as institutions with IP that have financial potential to be transferred into technologies for profit, as reported to The Marker (http://www.themarker.com/career/1.1730871). How and will the collages change the character of the TTOs, will they enhance the awareness of technology transfer, can they compete with the available technologies that are offered by the seven TTOs, or will they have a negative effect? Secondly, initiatives such as the bid for a private company to run a government supported TTO will take years before we can analyze and conceptualize the pros and cons of the project.

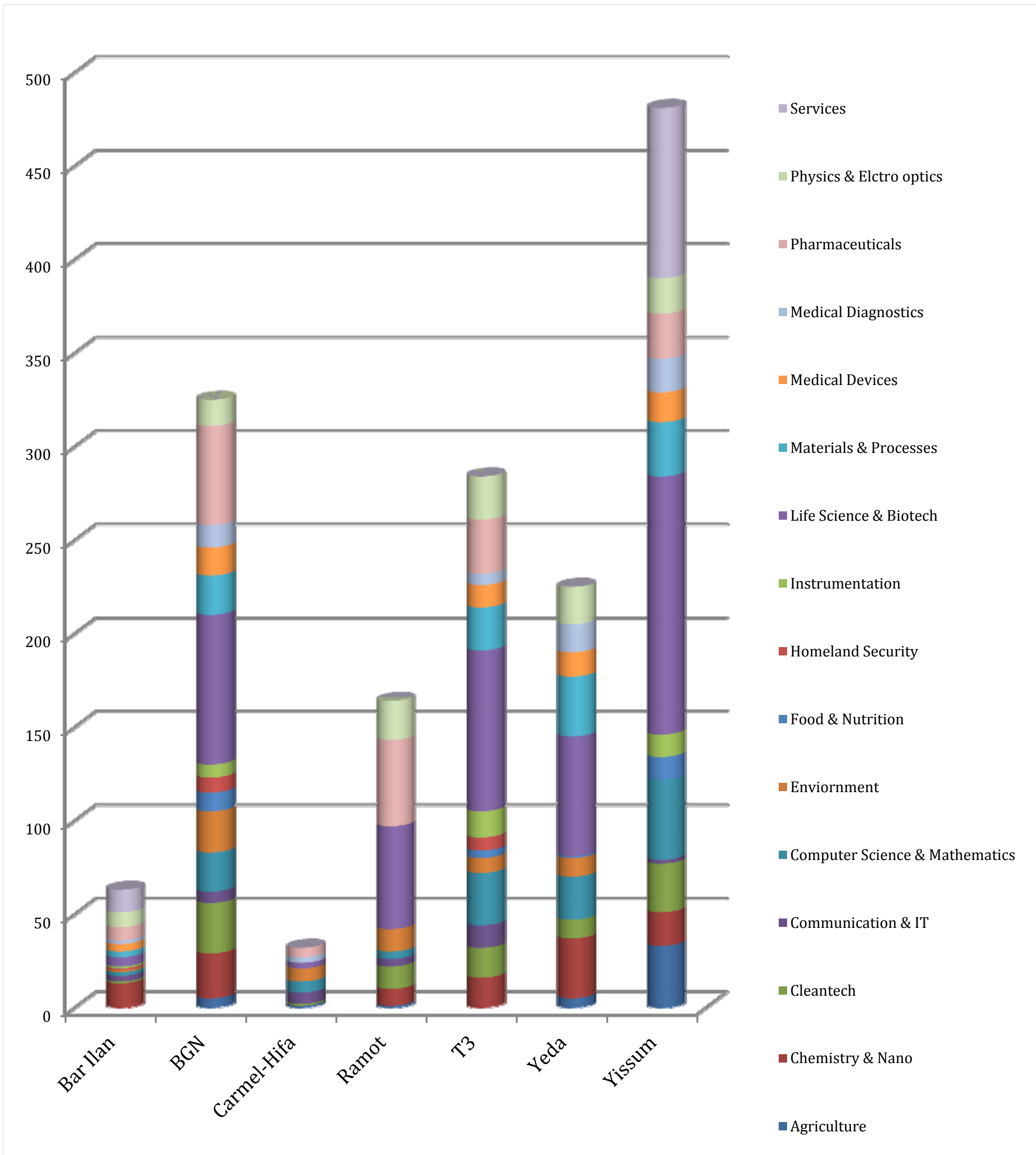
Technology transfer and the commercialization of knowledge are central themes in diffusing Israel's technological achievements in the local sphere and should be further analyzed through the lenses of broader global movements and trends.

Appendix 4-A: Magnet Program
(Source: Manget Report 2012)

Magnet Program	Name of Company	Academia Partner
Magneton	InSightec	Hebrew University
Magneton	DipTech	Hebrew University
Magneton	Plasan	Technion
Magneton	Albit Systems	TAU
Magneton	Enzymotec	Technion
Magneton	BI	Technion
Nofar	LNBD	Technion
Nofar	Light Nanotech	Hebrew University
Nofar	VIDAC Pharma	Ben Gurion & TAU
Nofar	Bio Rad	Technion

Appendix 4-B: TTO Patents by Field

(Source: http://www.ittn.org.il/technology.php)



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Chapter 5 – Government

Feminist Discourse and Supporting Technology Innovation with Triple Helix Model

Amy Ben-Dor

Abstract: This study applies feminist critique to the analysis of initiatives to encourage innovation in Israel. I apply the Triple Helix Model to investigate Tnufa, which is a governmental initiative, which is administered by the Chief Scientist Office in the Ministry of Industry, Trade, and Labor and is aimed at encouraging technology R&D. I argue that while Tnufa is set to encourage technology R&D without consideration for any social characteristics, such as race or gender, in effect this initiative reproduces and perpetuates social order, preserves social capital differences, and thus acts as a locus of gender discrimination. My findings show that women entrepreneurs are hardly supported by Tnufa, whereas male entrepreneurs, who are endowed with greater social and cultural capital to begin with, receive suc support from Tnufa. Such traditional gendered initiative further marginalizes women from governmental funding, creates fixed mental framing and may contribute to Israel's developmental lag.

Chapter 6 – Civil Society

“Ashoka Israel” Promoting Social Innovation: Civil Society as an Added Dimension of the Helix Model of Innovation Analysis

Noga Caspi

Abstract: The chapter investigates the relation between civil society and processes of innovation and entrepreneurship, in the light of the triple helix model of government-industry-academy. The research in the field calls for an expansion of the model into a quadruple helix, by adding a helix representing civil society. This chapter focuses on social entrepreneurship as an expression of innovation in this sector. The subject of the research is “Ashoka Israel”, an organization that promotes social entrepreneurship by supporting entrepreneurs and providing them with acknowledgment, funding and networks. “Ashoka” promotes the creation of social value, thus addressing social needs.

Artifacts of the organization were analyzed in order to determine the extent of innovation in the activity of Ashoka and the ventures that it promotes. In addition, ways in which this social sphere of innovation interacts with the other helices of the model were examined.

The findings show that these ventures are indeed innovative, that civil society dose carry a significant role in processes of innovation and entrepreneurship in Israel, and that there are some tight relations to the public and privet spheres. However, these findings are limited since they are based solely on Ashoka’s activity. Therefore the findings present a grounded-theory development in the field of the helix model and the third sector research, and invite further, more systematic research of social entrepreneurship in Israel. Such research should shade light on various types of social ventures and relations to the state, which were recognized in this paper but not elaborated.

Chapter 7 – Financial Sector

The Israeli field of research funding: Implication for the helix model

Ohad Barkai

Abstract: The objective of this study, focusing on the Triple Helix model of innovation, is to emphasize the importance of adding a fourth helix to the current model, specifically a helix that represents the "civil society", and especially non-profit organizations (NPO's). NPSo are not generally considered as entrepreneurial or innovative organizations. Yet, through this research, I intend to reveal some of the relationships between the helices, demonstrating the contribution of those NPOs to the innovation process. In order to do so, a "network map" will be created, relying on open financial information regarding research funding in Israel, compiled from governmental, academic, industrial and NPOs sources. The importance of such mapping is to find indications that the fourth helix should be added to the model.

Chapter 8 – Military

“Talpiyot” Project as a Security Triple Helix

Avida Netivi

Abstract: This chapter investigates Talpiyot program, which is a project operated jointly by in IDF and Defense Minister in Israel and set to train R&D officers for security system in Israel. Through analysis of Talpiyot, the chapter considers the role of a 'Military' helix in Triple Helix model of innovation, which is not included in the original model. While Etzkowitz & Leydesdorff’s original formulation of the Triple Helix model of innovation wrestles with triangulated networks and hybridity, this analysis of the Talpiyot program concludes that Talpiyot is a hybrid organization that integrates several domains or features of organizations. Based on detailed analysis of Talpiyot’s development, this chapter concludes that the military R&D in Israel is not a distinct helix with connections to other helices, but rather it is its own tri-helixed configuration and thus is a hybrid organization.

In its descriptive capacity, the chapter details the history and structure of Talpiyot project. Talpiyot is an elite track for IDF recruits who exhibit outstanding educational abilities. The recruits go through a dual-training program that combines academic science studies in The Hebrew University of Jerusalem with military training. Graduates of the program serve as R&D officers, moving between security industrial labs, leading academic projects, and government agencies. The chapter follows Talpiyot starting with initial ideas about the need for coordinated security R&D in 1974, to the founding of Talpiyot in 1979, and beyond – through the program’s development stages and the debates over its role and form.

In its analytic capacity, the chapter problematizes the notion of a “military helix.” First, the chapter argues that focusing in “military” obscures the expansive and complex array of security-related

innovation in Israel, which extends far beyond the domain of the IDF to security-related industries and to security-related government agencies. Second, the chapter shows that the security innovation in Israel does not exist as a distinct helix because all of it parts are embedded in other helices and especially on the government helix. Therefore, the security domain is a segment of the general model, similar to other sectors, such as medicine and agriculture.

Talpiyot program is a hybrid organization that embodies the integration of features from each of the three helices central to the original model. Talpiyot exists at the overlap among, or juncture of, the helices of government, industry and academia. Its hybrid nature is the cause for the objections raised against it, which pointed to its insular character (being its own system of innovation). In addition, the hybrid nature of Talpiyot is challenged to affect the various helices from which it is composed and to create a balance between its diverse parts.