May 10, 2009-05-10 **Third**

ISRAEL'S HIGH-TECH CATCH-UP PROCESS: THE ROLE OF IPR AND OTHER POLICIES*

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Acronyms

ICT-Information and Communications Technology; MNE-Multinational Enterprise;
IP-Intellectual Property; IPR-Intellectual Property Rights;
STE-Science, Technology and Higher Education;
VC- Venture Capital; SU-high-tech start up company;
IPO-Initial Public Offering or Offerings;
OCS-Office of the Chief Scientist, Ministry of Industry and Trade (Israel);
NCRD-National Council for Research and Development;

*** A version of this paper will be published in Odagiri et al *Intellectual property rights and catch-up*, Oxford University Press 2010, and permission is gratefully acknowledged. Thanks to GRIPS for sponsoring the research and to Prof. R. Nelson, to Prof. H. Odagiri and to the other organizers of the project for providing very useful guidelines and comments on the previous drafts. Thanks also to PRIME (NoE), Venture Fun Project, for financial support. We are very grateful for the deep understanding of several critical issues which we obtained from interviews with U. Galil, D. Inbar and A. Suhami who made a significant contribution to this paper.**

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INTRODUCTION

Between 1993 and 2000 Israel succeeded in developing a high impact Venture Capital (VC) industry and related Start Up (SU)-intensive, ICT-oriented Entrepreneurial High-Tech Cluster (EHTC) which fuelled its economic growth during the last years of the decade and even more intensively after recovery from the 2001-4 global high-tech and capital markets crisis.[1] With the possible exception of high-tech in the Cambridge area which has a relatively higher component of Life Sciences/Medicines and Drugs, Israel's EHTC was one of the most successful examples of a high impact Silicon Valley type cluster (Bresnahan et al 2001, 2004; Carmell and de Fonteney 2004) beyond the US. From approximately 300 SU in 1993 the number of such organizations rose to above 2000. Likewise the growth of VC organizations and total capital under management: from 2 or 3 organizations (and relatively small amounts raised and invested) in the early 1990s to about 130 VC and Private Equity organizations and over 8B$ under management towards the end of the decade. These trends together with others e.g. the acceleration of ICT-related patents, the quadruplicating of high-tech exports to which we must add the significant 'export' of companies (i.e SU acquisitions by MNEs), of company shares and of technology -- strongly suggest that ICT oriented, high-

[1] Throughout this paper the concept of ICT includes 'Electronic' and ICT-based Medical Devices. Also the term 'high-tech' will be used interchangeably with 'ICT-oriented high-tech' or 'ICT related high-tech'.

tech Catch-up took place during that decade (Avnimelech and Teubal 2006). The acceleration of patenting and the strong increase in the GNP share of total, national R&D in the last 15 years from somewhat over 2% in the early 1990s to over 4.5% further reinforce this view.

Israel's high-tech catch-up process was the result of an extended Innovation and VC- led evolutionary process which took place during 1969-2000. A summary of a phased analysis of this process is presented in Section 2[2], which also introduces Israel's IP regime whose impact is the central objective of this paper. In Section 1 we present *necessary initial conditions* that allowed the phased process to take place, the main focus being expansion of the Science, Technology and Higher Education (STE) infrastructure both during the state's first 20 years (1948-68) and during pre-state times. This section also analyses the institutional development which led to Israel's Innovation Policy[3].

In Section 3 we analyze five case studies of ICT companies which played important roles in the evolution of Israel's high-tech cluster since 1960. They include both hardware and software companies which had a significant period of independent existence and others which did not. This chapter spotlights the role played by IPR protection in the evolution of these firms. Section 4 briefly extends the analysis to consider some of the IPR- related issues associated with the evolution of Israel's generics biopharmaceutical industry

A main conclusion of the paper is that IP protection (both domestically and in foreign markets), in all its forms, was important for the evolution of high-tech firms and for the emergence of the cluster in which they operated. This in turn reflects the *distinctiveness* of the Israeli case in particular the high level of available skills. A related point concerns the catch-up itself: while STE and the IP regime were quite developed in the early years of the State, this was not so regarding high-tech industry; R&D, Commercial Innovation in the Business Sector; nor was it so regarding required social technologies and institutions (Nelson 2006) such as Innovation Capabilities and start up and venture capital companies. The process of building these elements in a systematic way began during the late 1960s and continued during the next thirty years; and it is our belief that such or a related process was *sine qua non* for the subsequent development of high-tech and achievement of ICT catch-up during the 1990s. Section 5 elaborates our conclusions.

SECTION 1: FROM CREATION OF THE STATE (1948) TILL SYSTEMATIC SUPPORT OF R&D IN THE BUSINESS SECTOR (1969/70)

1.1 Economic Growth and Structure during 1948-5[4]

The three salient features of the economy since the establishment of the State of Israel in 1948 were free immigration, resulting in a very high rate of population growth; large capital-import;

[2] Based on Avnimelech and Teubal 2006 and 2008a,b,c.
[3] The 'initial conditions' represent Phase "0" (1948-68 period approximately) of the phased evolutionary process.
[4] Most of the information in this subsection was collected from Halevi and Klinov-Malul 1968

and rapid growth of total and per-capita product. The opening of the country, which in 1948 had a Jewish population of about six hundred thousand, led to a strong influx of immigrants till 1951; and ever since there has been a continuous, though reduced, stream of immigration.

The main economic challenge was to maintain or increase the level of per capita income which required additional capital and education and skills. During the pre-State mandate, a large part of both was provided by the immigrants themselves but not so for most of the immigrants that came after 1948; raising their educational level became a national priority.

Coping with the challenge required importation of capital (domestic saving was not enough); both government and public institutions raised loans and grants abroad. Consequently the public sector gained control over a very large part of investment resources and hence of economic activity in general.

During 1950-65 population more than doubled with GNP expanding more than five times, at an average rate of growth of 11.4%. This means that at 2,165 Israeli Lira (at 1956 prices) per capita GNP was more than 2 ½ times greater in 1965 than it was at the beginning of 1950 (an average rate of growth of per capita income being 6.3%).

Manufacturing emerged as a major branch of the economy during WWII, and represented around 21% of Net Domestic Product at factor cost in 1952 with the share increasing somewhat between 1958 and 1965. (Halevi & Kilinov-Malul op. cit. p. 109).

Food and Textiles were the dominant branches of manufacturing both in 1951/2 and 1962/3 although the combined share of both declined from 42.7% to 34.7%. The most important changes are in what looks like the most technologically sophisticated sub-sectors: Machinery and Electrical equipment whose combined share increased from 5.1% to 8% during the 11 year interval, and Transport Equipment whose share increased threefold from 1.9% to 6.7%. In absolute terms and given the very high rate of growth of overall product and of industry in the period, these changes are of even greater significance (Halevi and Klinov-Malul, op. cit table 38, p.108).

1.2 R&D and Building the Science, Technology and Higher Education (STE) Infrastructure[5]

It should be noted that the establishment of Israel's STE infrastructure began long before the state achieved independence. Concurrently with the expansion of agricultural and urban settlement (which started in the 1880's,) scientific teaching and research institutions were also being established, particularly immediately after WWI. These were frequently staffed by highly accomplished, active scientists who had obtained their knowledge and training abroad. They included a university (The Hebrew University) an Engineering Institution of Higher Learning (the Technion- Israel Institute of Technology) both founded in 1925; and later but

[5] Much of the material of this subsection was obtained from NCRD 1971:***Scientific Research in Israel, 1971,*** Center of Scientific and Technological Information

before WWII The Weizmann Institute of Science and The Volcani Center for Agricultural Research. Thus, by the time the state was established in 1948, a firm basis for the development of science and technology already existed; as did institutions of higher learning for the training of scientists, engineers and agronomists, as well as some research institutes particularly in agriculture and medicine.

Applied Research

The first years saw a number of attempts to foster applied or directed scientific research. The first central mechanism envisaged was the creation and support by the Government of publicly–owned and managed, specialized applied research institutions.

In 1959 the National Council for Research and Development (NCRD) was established and entrusted with the formulation of a national policy for *directed/applied research* and the coordination of activities of government Ministries under whose auspices R&D was conducted. Since agricultural research was already flourishing, the emphasis was given to public institutes for industrial research.

However, until the late 1960's there was no mechanism for the direct support of applied R&D and innovation *in* industry nor for the setting of R&D priorities. The industrial sector was focused on supporting the basic needs of the expanding population. The source of technology and knowledge *was imports of knowhow and well established techniques.*

Universities

Bar Ilan University was established in 1955, and Tel Aviv University in 1956. These were private bodies receiving considerable Government support from the outset.
1959 saw the establishment of the cores of the Universities of Haifa and the Negev.

1.3 Innovation Policy: Direct State Support for Industrial R&D [6]

In May 1966 in the midst of Israel's first recession, a committee was convened to look into the organization of government-backed R&D. Its mission was to review the fourteen civilian public research institutions and suggest recommendations for their restructuring and management.

The economic crisis convinced the authorities that the ability to convert basic science into practical technology was the key to national economic success. Therefore the Committee recommended encouragement of applied research, with special emphasis on industrial innovation. The main recommendation was that the Government's program for directed or applied R&D (including the relevant applied research institutions) should be operated by the ministries directly involved through the newly created Chief Scientist Offices (one for each Ministry) rather than by the Prime Minister or Government with the help of the NCRD.

[6] This sub-section and the next rely extensively on Breznitz 2008: (Chapter 2). See also Teubal 1984, 1993; and Breznits 2007.

The institutional innovation most relevant to high-tech catch-up was creation of the Office of the Chief Scientist (OCS) at the *Ministry of Industry and Trade.* Its policies resulted in the eventual (early 1970s) dominance of *direct* support of R&D within firms over support to the public research institutes.[7] This shift to direct support was predicated on the nomination of a powerful outsider as Chief Scientist (Yitzhak Yaakov).

Yaakov moved on five fronts

1. *Explicit formulation of the goals and aims of the OCS* e.g. support R&D in firms (whatever the technology/industry) while contributing to reduce their risk; promoting exports of science based products; and bottom-up determination of project i.e. letting firms decide what projects to undertake as long as they involved *bona fide* R&D[8]
2. *Sharp increase in direct, grant-based support of R&D in firms*
3. *A program of national projects* which allowed the OCS to give 80% grants to up to 8 projects (financed by a World Bank loan).
4. *Adjudicating the status of "approved factory" to science based firms,* giving them all the benefits provided under the law for the encouragement of capital investment in development towns[9]
5. *Proactive Stimulation of Demand for R&D by firms:* urging managers of firms to come up with ideas and submit projects. (see Breznitz 2008)[10]

Eventually the OCS became a quasi independent agency with many of its provisions incorporated into the 1985 Law for the Encouragement of R&D. The outcome was a significant strengthening of Innovation Policy in Israel. Moreover, 'Israel became the first state in the world to employ as its main Science & Technology strategy a set of policies that are both neutral and horizontal in regard to industrial sectors and technology' (Breznitz p. 57). The aim was to stimulate activities and capabilities throughout industry without targeting particular industries or technologies (Teubal 1997, Breznitz 2008). Determining in what areas specialization would take place in the long run was left to the private market.

1.4 Other Factors Underpinning the Development of ICT

The State Bureaucracy

Another important antecedent to Israel's ICT industry was a major computerization and software development programming effort at the Ministry of Finance (MOF) intended to computerize tax assessments. A special course was arranged to train software programmers. Graduates of this program and of the computer unit of Israel Defense Forces ' . . . later become the early leaders of the Israeli Software Industry' (Breznitz, op. cit).

7 Support of commercial innovation could be direct or indirect (through support of the STE infrastructure), see Teubal and Andersen 2001.

8 This is the basis for the concept of Horizontal Programs or Horizontal Policies (Teubal 1997)

9 This would give MNE's the same favorable tax treatment they could find in Ireland.

10 The OCS thereby began to act as a node in a 'Collective Learning about Innovation', network which encompassed and increasing number of firms

Education and the Labor Force
While waves of immigrants from less developed countries during the 1950s lowered the average level of education, the growing institutional underpinnings of Israel's educational system and its research-oriented Universities enabled Israel to rapidly upgrade its labor force. The numbers of students in natural sciences, engineering and agriculture (excluding medicine) increased from 1800 in1949/50 to 37400 in 1969/70; and the numbers of PhD's awarded in these fields increased from 10 to 196 (NCRD 1971, pp. 24). The number of qualified Scientists and Engineers in R&D per 10000 inhabitants was 20 in 1969/70 (presumably most in the Defense sector which took off faster than Civilian R&D performing industry).

The Military and the Defense R&D sector
Starting in the 1950s, RAFAEL (acronym for Armaments Development Authority) was the first, and for many years, almost the only body in Israel to conduct high-tech 'industrial' R&D, with a focus on computers (analogue first and then digital). Its R&D capabilities were diffused to other defense and civilian companies and organizations e.g. Israel Aircraft Industry (IAI) in 1962; Elbit, who later developed the country's first minicomputer; and the Technion's newly created Electronics Lab, two of whose members were instrumental in founding Elscint in 1969).

An important factor in expanding the Defense R&D sector was the French military embargo, imposed on the eve of the Six Days War (1967). Its upshot was a decision to shift from niche weapons systems to the development of main weapons' platforms. Large amounts of resources were immediately allocated to Defense R&D and other functions in order to ensure rapid growth of Israel's high-technology defense industry.

An indirect effect of this was the creation of strong incentives in the labor and education markets to acquire science and engineering skills (Halperin and Berman 1990), consequently during the 1968-74 period Israel had the or one of the highest growth rate of scientists and engineers employed in industry in the world: 260 percent, twice the rate attained by Japan during its miracle decade (Halperin and Berman 1990).

Breznitz mentions, and we agree, that 'There is no doubt that the structural transformation of Israel would never had happened so quickly without the thrust given by the defense sector. This is especially true till the early and mid 1980s when the negative, crowding out effects, started to overwhelm the positive effects of the strategy'.

1.5 The low share of 'Industrial' R&D' in aggregate National R&D expenditures during the late 1960s

During 1969/70 total Civilian R&D in Israel represented 1.1% of GNP (NCRD 1971, pp.24-5); while Civilian plus Military R&D represented 2.2 % of GNP, up from 1.1% in 1959. Of total Civilian R&D Universities received the highest share (61.9%) and Industry the lowest (12.8%). The Government's share was 25.2%, mostly through the applied research Labs (section 1.2 above).

Thus while the overall country R&D expenditure in terms of GNP in 1969/70 was not so far from that of advanced countries at the time (especially if one considers Defense R&D), its distribution, particularly the share of industry in total Civilian oriented R&D was far below what is 'normal' for advanced countries, and that which was achieved in Israel during the high-tech catch-up period of the 1990s.

1.6 Conclusions: Israel's Strengths in STE &Weakness in Commercial Innovation

Our analysis strongly suggests that Israel's high-tech achievements during the 1990s were the outcome, among other things, of a systematic process of building and reinforcing the STE infrastructure and National System of Innovation during the three decades that preceded implementation of an explicit Innovation Policy oriented to *direct* support of R&D projects at firms starting in 1969. A further, crucial aspect was Defense R&D and related Military-Civilian technology transfer, interaction and knowledge/manpower flow.

Implementation of a program extending a 50% Grant to the R&D of approved projects of firms, was the outcome of a process of re-organization of government sponsored R&D after 1968, which led to the creation of a special agency in charge of promoting innovation in firms (the OCS). This subsidies program was *Horizontal & Neutral* that is (i) open to all firms submitting R&D projects whatever the underlying technology and industry; and (ii) a common rate of R&D subsidization across firms and projects. The long term consequence of this program was the generation of 'competitive advantages' in the three main R&D intensive, ICT areas which became central in the entrepreneurial cluster of the 1990s: software, communications hardware & software, and medical devices. [11]

Yet these '*strong initial conditions'* (that make Israel an atypical case among developing or industrializing economies that eventually attained catch-up) should not be confused with high-tech Catch-up itself. The distinction between physical technologies and social technologies and institutions (Nelson 200) is important in this context. Thus while Israel of the late 1960s had achieved Catch-up in Science, some Physical Technologies and some Social Capabilities (e.g. those related to STE governance and the OCS to underpin subsequent Innovation Policy) --- it had not yet achieved full high-tech catch-up which would also require attaining a sustainable frontier level of Commercial Innovation, High-tech industry and related Social Technologies (e.g. Management Skills, Venture Capital, Start Up companies, etc).

SECTION 2: THE EVOLUTION OF HIGH-TECH, INNOVATION POLICY, IP PROTECTION AND PATENTS

2.1 Three Phases of Venture Capital and High-tech Evolution (1969-2000)

By the late 1960s a significant STE infrastructure had been built. Together with the new institutional setting for Innovation Policy (expressed by establishment of the OCS) it set the

[11] For the notion of Horizontal Programs see Teubal 1997.

stage for a 25-30 year evolutionary process which lead to ICT catch-up during the late 1990s.The following brief analysis of the process is based on an 'extended' Industry Life Cycle (ILC) perspective (see Abernathy and Utterback 1978 and Avnimelech and Teubal 2006, 2008c). There are three phases: the Background Conditions Phase (Phase 1, 1969-1984); the Pre-Emergence Phase (Phase 2, 1985-92) and the Emergence Phase (Phase3, 1993-2000).

The first *Background Conditions phase* is characterized by high quality universities, a set of public applied-research institutes (of declining importance and scope), and a large pool of qualified scientists and engineers. Innovation policy was initiated during this phase with the OCS's Grants to R&D program followed by the Bi-national Industrial R&D program (BIRD) which promoted collaborative commercial innovation between a US and an Israeli firm. a Financial incentives were extended to MNE's which, together with other factors, led to a strong MNE R&D presence in Israel (Motorola, IBM, DEC, Intel, etc.). Furthermore huge investments in the defense industries (in software, communication and instrumentation) were undertaken. The outcome was strong growth of R&D-performing companies, including a number in the Communications/Electronic areas with significant direct and indirect effect on the future of Israel's innovation system (Elscint, Scitex, Tadiran, ECI, Elisra, Fibronics, RAD among others)

The second *Pre-Emergence Conditions Phase* (1984-92) includes a number of domestic macroeconomic and liberalization policies such as the successful price stabilization program of 1985 and the liberalization of capital, foreign trade and foreign exchange markets. These in turn corresponded to other changes in the global market such as enhanced capital movement and opportunities for non-US SU to float in NASDAQ (Israel was quick to make use of such opportunities), deregulation and liberalization of communications and communications equipment markets in a number of large countries; and internationalization of U.S. Investment Banks (and their search of investment opportunities in Israel). On the real side of the system we observe a sharp restructuring of the Military Industries (which generated a potential pool of technological entrepreneurs which could then benefit from the OCS's Grants to R&D program), enhanced innovation capabilities and enhanced links with the US; and business learning and experimentation with respect to SU and VC operations, organization and strategy.

The outcome was an expansion of informal VC activity; an increased rate of SU formation leading to a critical mass of startups (300 in 1992); appearance of the first Venture Capital funds; and creation of companies like Lannet and M-Systems. Moreover, individuals (foreign and returning Israelis) and some organizations like Advent Private Equity came to Israel in search of new investment opportunities in high-tech. Underpinning the above was an additional OCS priority: supporting SU foundations and growth and couple with this, promoting the establishment of a domestic Venture Capital industry. Also new government

programs were implemented: the Inbal program (1991-first targeted VC policy, a failure), the Magnet Program (1992), and the Technology Incubators Program (1992)[12]

The *Emergence Phase* (1993-2000) was triggered by the implementation of the successful Yozma Program which targeted a domestic VC industry and market, and indirectly, an entrepreneurial high-tech cluster. The end of the first Gulf War and initiation of the Oslo Peace Process contributed to reduce Israel's isolation, making it more attractive for business and investments; and the disappearance of the Soviet Union brought in large number of immigrant scientists and engineers who had a strong impact on high-tech growth. Meanwhile, the Grants to R&D and other Programs continued to expand (despite the increasing role of VC). The outcome was Emergence of a high impact domestic VC industry and high-tech cluster (with strong links with U.S. capital markets). Underpinning this accelerated process of ICT oriented high-tech growth were the new innovation opportunities resulting from the ongoing ICT Revolution, from the Liberalization of Telecommunications, and from the rapid growth of the Internet. We also observe a monotonic growth of the NASDAQ index and of global ICT markets. Table 1 presents the quantitative growth of the various Innovation Policy programs during Phases 2 and 3.

Table 1 : OCS R&D Support (Million Dollars)

Year	*Total Grants* ***(Growth)***	**Grants to Business Sector R&D**	**MAGNET Budget**	**Technology Incubators**	**Royalties (Growth)**	**BIRD-F* Awards**
1985	106 (2.5%)	106	0	0	6 (33.3%)	NA
1986	110 (2.8%)	109	0	0	7 (16.7%)	NA
1987	113 (2.7%)	112	0	0	8 (14.3%)	NA
1988	120 (6.2%)	118	0	0	9 (12.5%)	NA
1989	125 (4.2%)	122	0	0	10(11.1%)	NA
1990	136 (8.8%)	133	0	0	14(40.0%)	NA
1991	179 (31.6%)	171	0	4	20(42.9%)	12
1992	199 (11.2%)	177	1	16	25(25.0%)	10
1993	231 (16.1%)	199	40	24	33(32.0%)	12
1994	317 (32.2%)	172	10	27	42(27.3%)	10[13]
1995	346 (9.1%)	294	16	31	56(33.3%)	12
1996	351 (1.4%)	279	36	30	79(41.1%)	13
1997	397 (13.1%)	309	53	30	103(30 %)	12
1998	400 (0.8%)	305	61	30	117(14 %)	14
1999	428 (7.0%)	331	59	30	139 (19%)	9
2000	440 (2.8%)	337	67	32	135(11 %)	8
2001	431 (-2.0%)	328	64	32	145(5.2%)	11

[12] Another underpinning of the above events and processes were global trends such as the continued ICT Revolution, creation of the software industry, new ICT sectors, and the fabless model in the semiconductor industry.

Year	*Total Grants* ***(Growth)***	**Grants to Business Sector R&D**	**MAGNET Budget**	**Technology Incubators**	**Royalties (Growth)**	**BIRD-F* Awards**
2002	383 (-11%)	291	58	27	153 (1.4)	10
2003	369 (-3.4%)	283	53	26	133(5.4%)	11

Source: Avnimelech and Teubal 2006b

2.2 Israeli Patents in the US

The patent data show an enormous increase in patenting and in ICT-related patenting during the 80s and particularly during the 1990s (reaching a total level of 600 patents a year towards the mid 1990s) of which 25% were in Computers and Communications. This gives us a first indication of the growing patenting activity of Israelis in the US towards the mid 1990s.

The process of ICT catch-up however should be reflected in other measures e.g. a *comparatively* high level of overall per capita patents relative to leading countries during the 1990s and a *comparatively* high share of the ICT-relevant patent classes. This is effectively what happened: average per capita patents during 1992-7 reached 10.2 in Israel and 25.2 in the US (Israel is third after the US and Japan). Moreover during 1985-1994 the share of Computers & Communications in total US patents grew from about 7% to 15% whereas in Israel it grew from about 8% to 25%. [14]. Also the share of Computers & Communications + Electronics reached approximately 45% in Israel and presumably about 30% in the US.

We conclude that in terms of Catching Up, the patenting data confirms the other information we have that there was a significant Catching Up process going on with respect to ICT during the 1990s.[15]

2.3 Innovation Policy-Commercial Innovation co-evolution

The OCS was the Government agency in charge of Innovation Policy, understood here as direct support of innovation in firms through subsidies or other 'incentives' programs. Its creation in the late 1960s and the early Grants to R&D of firms Program' (see section 1.3) were not the result of well established high-tech interest groups nor lobbies, since these did not exist at the time in Israel. The policy motivation here was to enhance social/economic welfare by inducing an innovation-based economic growth. IPRs were neither considered nor affected in a fundamental way. The vision at the time was that the strength of Science and the existing high quality, skilled manpower available in the country could be used to promote development.

[14]Trajtenberg and his colleagues collected detailed data from the USPTO, and created **a new classification scheme** for the 400 main USPTO patent classes. The 400 patent classes were assigned to 35 technological sub-categories, and those in turn were aggregated into the following six categories: Computers and Communications. Electrical and Electronics, Drugs and Medicine, Chemical, Mechanical and Other.

[15] While the patenting data alone would also suggest 'Catching Up' in Drugs and Medicines this is not confirmed by the other information, excepting for the 'generics' segment.

This OCS frequently adjusted the existing Grants to R&D Program and created new programs in response to changing circumstances some of them endogenous. Thus the inclusion of Software innovation within the Grants to R&D program during the 1980s was the outcome of its increasing importance (originally not considered as part of 'industry'); while implementation of the Magnet Program in the early 1990s (which supported 'generic', cooperative R&D involving consortia of firms and Universities) was the outcome of the accumulation of firm-level innovation capabilities which had resulted from more than two decades of implementation of the Grants to R&D program. Similarly, Yozma -- which triggered emergence of the VC industry and entrepreneurial high-tech cluster of the 1990s -- was a policy response to both the weakened impact of the regular Grants to company R&D program during the second half of the 1980s and the new opportunities for invention and inventor companies (SU) opened up by the expansion and globalization of NASDAQ during the 1980s. [16]

The above process seems to some extent to have been an *Innovation Policy-Commercial Innovation co-evolutionary process* (Avnimelech and Teubal 2005)[17]. The simplest dynamic sequence looked as follows: (i) *early* Innovation Policies (sometimes together with changes in the environment) generated both new opportunities and new problems which existing market forces and innovation system could not solve or exploit without new policies and new policy interventions (thus early policies were not only a response to market/system failures but themselves originated new market/system failures); and this led to (ii*) new* Innovation Policies which overcame such failures. Since early policies contributed to create pre-emergence conditions which the Yozma program would leverage into a Venture Capital industry entrepreneurial high-tech cluster during the 1990s, *Innovation Policy-Commercial Innovation co-evolution was critical for underpinning Israel's high-tech Catch-up*.

2.4 Israel's ICT- related IPR

Israel's patent regime was introduced during the British Mandate in 1924 (the Patent Ordinance) and was later revised in the Patent Act of 1967 which extended the term of patent protection from 16 years from the date of the grant of the patent to 20 years from the date of patent application. It was not before the mid 1990s that other substantive changes took place. Israel's Copyright Act too was based on the British code introduced in Israel as part of the British Patent Ordinance. At the time both the Patent and Copyright Ordinances were well developed and represented the IP standards of the most advanced nations.

In 1988 and subsequently in 1999 Israel expanded its Copyright Act to protect computer software (70 years of protection). In 1999, as part of its obligations under the TRIPS Agreement, Israel also introduced a new law aimed at protecting Layout designs (topographies) of integrated circuits.

Israel was an early signatory to all the major relevant treaties of the World Intellectual Property Organization. Thus in 1950 Israel became a signatory to the Berne Convention for the Protection of Literary and Artistic Work, which laid the bases of the international

[16] Thus innovation policies during 1969-95/6 were linked through time (Avnimelech and Teubal 2008a).
[17] It also suggests a possible Innovation Policy-ICT catch up co-evolutionary process

protection of copyright, and to the Paris Convention for the Protection of Industrial Property (focusing on patents). Israel is also a signatory to the Patent Cooperation Treaty (PCT) as of 1970, which essentially provides a process through which a firm in any signatory country may with relative ease apply, within a stated period (30 months from the first filing date) for patent protection both in its country of origin and in any other country within the signatory group. The strong domestic IP protection and associated infrastructure and capabilities accumulated by domestic firms have enabled Israeli firms to effectively exploit the possibilities of getting effective patent protection beyond Israel's borders.[18]

Overall the strength of Israel's *ICT related IPR* was similar to that of developed countries with the possible exception of the last 10-13 years where it has, to a large extent, undergone a process of (relative) weakening. Thus the recent amendment of the Copyright Directive (2007) did create some visible gaps between the level of protection provided by Israel and that of other developed countries e.g. in the area of software. Also the most notable element lacking in the new Copyright Directive is absence of legal provisions that would prohibit the bypassing and circumvention of Digital Rights Management devices (Pugatch 2007).

Links with Commercial Innovation
Contrary to Innovation co-evolving with Innovation Policy, there is no evidence suggesting a virtuous IPR-Commercial Innovation co-evolutionary process, at least during most of the period leading to ICT catch-up during the late 1990s. As discussed below, the existing IP regime in Israel was probably very favourable throughout the above ICT-Catch-up process since a robust IP regime existed since the 1920s. The lack of IPR-Commercial Innovation co-evolution would seem to be due to the general adequacy of the existing patent system and, compared to Advanced Countries, a relatively strong IPR for the Software, Electronics and other ICT oriented high-tech industries.[19]

SECTION 3: CASE STUDIES OF CATCH-UP IN FIRMS AND THE ROLE OF IPR/PATENTS

The five companies described here jointly span phases 1-3 of the evolution of Israel's entrepreneurial high-tech cluster during the 1969-2000 period (see SECTION 2) as well as the post 2000 period where a significant high-tech recovery from the global crises was registered. All have been technological leaders in their field; all --- with the exception of Checkpoint who became an Israeli multinational --- were eventually acquired by a foreign multinational. Over and beyond sales of products and services and licensing of technology, all five companies generated value added from 'the sale of company shares' (to the public at large through an IPO in NASDAQ and/or from being acquired).

[18]If a firm chooses to file for a patent say in the US within the prescribed period, and if the patent is granted, the original date of application to the PCT is the relevant date for determining precedence during litigation.

[19]Lack of IP protection-commercial innovation co-evolution does not imply that strong IP protection was not a critical condition for successful innovation and also high-tech catch up (see following sections).

While this set of companies is not a 'representative sample' (very difficult to define here) it does express the different types of companies that operated in Israel during the last 30 years or so, in terms of the Hardware/Software/Services(or 'Solutions') distinction; in terms of the *main* type of value added or economic outputs generated (goods/services - Elscint, M-Systems and CheckPoint; technology - Saifun; company shares - Mirabilis) and in terms of strategy/business model. Our analysis will focus on the effects of IPR in the achievements of these companies.

3.1 Elscint[20]

3.1.1 Overview

Elscint, was the flagship of Israel's civilian oriented ICT sector at the beginnings of this industry during the 1970s. Its substantive lifetime spans all three phases, ending in 1998 with the divestiture of most of its operations to GE and Picker. It was a 'hardware' oriented company specializing in the design, production and sale of complex medical imaging equipment and devices starting with Nuclear Medicine (Scanner and Gamma Camera) and followed successfully by CT Scanners (Tomography), MRI; Ultra Sound and Digital Fluoroscopy. Founded in 1969 by Elron and Avraham Suhami --- an Electronics Engineer who, after receiving his PhD, briefly taught at the Technion of Haifa and became the company's CEO till the mid eighties --- Elscint is one of the leaders in Israel in number of patents held. Its equipment was innovative both in the way the devices were designed, and in the way the data gathered by the devices was processed.

Elscint's 'demonstration effect' was considerable. In the presence of widespread commercial 'failure' in innovation (Teubal et al 1976) it demonstrated that companies undertaking large scale civilian R&D projects could grow and succeed commercially. Elscint was the first Israeli hi tech company to undertake an IPO in NASDAQ in 1971. Its sales grew to about 20 M $ towards the end of the 70s.

The company also became the single most important early incubator of high-tech entrepreneurship and innovation capabilities in Israel's medical instrumentation area which became an important sub-sector of Israel's high-tech cluster during the 1990s and beyond. During its approximately 25 years of independent existence, 10000 people entered and left the company (maximum employment of the company was 2500); and there exist consensus that the learning and experience they carried with them had a strong impact on the future of Israel's high-tech.

3.1.2 Source of knowledge/technology for Elscint[21]

Israel's first engineering school-the Technion- was the source of the scientific knowledge and technical knowhow which enabled Elscint to produce its high quality products. In all of the company's products the underlying electronics technology was superb, a direct result of the high quality academic research background. An important background factor was the transfer

[20] See also Teubal 1982

[21] This and the following material of this case benefited greately from the August 2008 interviews with Drs. Suhami and Inbar

from *RAFAEL* (Armaments Development Authority of the Ministry of Defense) to the Technion of a whole group of researchers who transformed the Faculty or Department of Electrical Engineering into the Faculty or Department of Electronics (see Section 1).

3.1.3 **Early IP Constraints, the Agreement with GE and some Implications**

A critical component of the Gamma Camera was patented in the US by Hal Anger. Having invested much time and money in developing and patenting an alternative, Elscint concluded there was no hope in circumventing that patent, and decided to develop a Nuclear Scanner instead. GE who had no scanner and saw in Elscint's Scanner a very good product signed a supply agreement with the company. While Elscint's high quality production capabilities rather than patents were the key factor from GE's point of view, licensing issues concerning the Anger patent explain the non-renewal or non-extension of such an agreement. The agreement with GE had very important 'dynamic' effects on the growth of Elscint, namely it facilitated its IPO in NASDAQ (Israel's first), its access to funding from Discount Investment, and the subsequent growth of the company.

3.1.4 **Elscint's Patenting Strategy and Management**

Elscint's unique approach to patenting, conceived and implemented by Dr. Inbar as part of his overall management of the firm's R&D, focused on *building a protective patent wall*. This meant patenting everything new, "you write down and apply for **everything,** because you never know what will turn out to be relevant when they sue you". A related point was encouraging original R&D by promising monetary remuneration to anyone whose work led to novel technology and was worthy of a patent application. Elscint was indeed an extremely prolific company with 139 patents issued before divestiture. Since patent attorneys were scarce in Israel during the seventies/eighties Dr Inbar adopted a two pronged strategy to access capabilities and to reduce costs: including as many new inventions as possible into one patent application and establishing a patent office in the company's premises.

3.1.5 **Litigation**

During Elscint's existence, there were about 12 occasions where the company received letters from other companies warning it of possible patent infringement, to which it replied in kind mentioning its own patents that were infringed by the warning company. In all but on case, the complaints were dropped. Elscint was sued by Johnson & Johnson (J&J) in 1980-81 for infringement of their CT patents. The companies met in court, and shortly after negotiated an agreement, the outcome of which was granting to Elscint licensing rights to all of J&J's patents, and payment of Elscint's legal expenses. Elscint sued twice in Europe and won, although it was stated that the compensation received was not worth the trouble it took.

3.1.6 **Patents and Divestiture**

In November 1998, General Electric Medical Systems acquired the Nuclear Medicine and MRI divisions of Elscint, including a unique MRI gradient system concept and technology for $100 Million. In the same year, Picker International acquired the Computerized Tomography (CT) Division of the company[22]. While patents were part of the company's assets that were to

[22]In 2001 Philips Medical Systems purchased Elscint's former CT division from Picker.

be sold, they were not an explicit part of the negotiations. Domestic R&D and production (and to some extent marketing) continued to operate as before from the former company's premises at the Haifa Science-Based Industries Park.

3.2 M-Systems

"M-Systems Flash Disk Pioneers Ltd.", creator of the "DiskOnKey" was established in Israel in 1989, and sold to its competitor and strategic partner SanDisk in 2006 for $1.55 billion. Flash Memory is a silicon chip-based component invented by Toshiba. Growing sophistication in both software and hardware would make Flash Memory chips, which have no moving parts, functionally advantageous over disks and the preferred storage media for a variety of military, consumer and industrial devices, and crucial to mobile devices. M-Systems was a central player in this evolution. In order to be used effectively, *raw flash* needed a technology for connecting it to the systems' information channels (the "bus") and a *Flash Translation Layer (**FTL**)*. The latter works in conjunction with an existing operating system (or, in some embedded applications **as** the operating system) to make raw flash memory appear to the system like a disk drive.

3.2.1 **Company Creation and Initial Activity/Strategy**

M-Systems founder Dov Moran earned a B.Sc. in Computers and Electronic Engineering (with honors) from the Technion in 1977 and was for seven years head of the Navy's microprocessor unit. In 1989 Moran convinced a US company (Miltope) to invest in a new company that started developing a *flash disk*. Seeing the drop in flash memory prices and the growing mobile market, Moran decided to drop military contracting, and to concentrate on the civilian market. By adding a controller and file system to raw flash memory, M-Systems created a device that was commercially viable.

3.2.2 **Patents and Early Strategic Partnerships**

Applied for in 1993**,** the patent for M-Systems' method for disk-emulation on flash implemented by its TrueFFS® (True Flash Filing System) disk-emulation software program was issued in 1995 (USPTO patent No. 5404485). The patent covered a general method for handling data on flash devices which was utilized in M-Systems' products. Using Toshiba's flash memory chips, and M-Systems designed circuits, Toshiba – owner of many flash memory patents and producer of the chips - and M-Systems collaborated on developing its first solid state data storage, eventually to be called "FlashDisk" and "DiskOnChip

M-Systems' first strategic agreements (with Maxtor and Intel) were negotiated, and at times, signed before the TrueFFS® patent was granted: When the patent was issued M-Systems also announced the signing of its TrueFFS® Software marketing agreements with two of the world's leading telecommunications companies. The agreements granted each company the right to use M-Systems's TrueFFS® software in certain of their telecommunications products.

3.2.3 **Diffusion of M-Systems Filing Systems**

In March 1996 M-Systems's TrueFFS® became the standard file system for computer memory cards installed in laptops. Before this happened, the company had to settle a patent dispute concerning its file system with SanDisk. Subsequently agreements were made with Intel Nokia and Motorola.

3.2.4 **The DiskOnKey**

During 1999 M-Systems filed a patent (U.S. Pat. #6,148,354, granted in 2000) for connecting a flash disk to the USB channel of computers. Initially the idea was presented to IBM and to another of M-System's customers. Only IBM saw its worth, and an agreement was made prior to the issuing of the patent. Subsequently IBM introduced the first USB flash drive on the market; M-Systems sold the first few thousand units to IBM at a loss.

3.2.5 **Strategic Agreements with Flash Memory Makers**

Not being a flash memory producer itself, M-Systems depended on the various flash chips and other components produced by other companies for its devices:

Samsung

In July **1996** M-Systems and Samsung announced the signing of a cooperative agreement according to which they would combine Samsung's expertise in the production of one type of flash memory (NAND), and M-Systems's TrueFFS® controller. In another 2003 agreement, Samsung agreed to provide M-Systems with a specified portion of its raw flash component manufacturing capacity available to third parties at more favorable pricing terms compared to a previous arrangement. M-Systems in turn granted Samsung a license to all of its patents for any products produced by Samsung until the expiration of the last to expire licensed patent. In exchange for the license, Samsung agreed to pay M-Systems a fixed stream of payments throughout the term of the agreement.

Toshiba

A number of M-Systems' devices were developed and introduced in partnership with Toshiba and Toshiba was a single source for some of the devices – which it also manufactured and assembled. In 1998 a Development and License agreement and a Master Purchase Agreement were signed with Toshiba, under which the Mobile DiskOnChip, the DiskOnChip Millennium Plus were sold to customers under Toshiba`s trademark without obtaining M-Systems' prior consent, subject to Toshiba paying specified royalties.

In 2003 new agreements, were made, under which Toshiba was committed to provide M-Systems with a specified portion of its flash component manufacturing capacity, improved the overall terms for the purchase from Toshiba of raw flash components and DiskOnChip products. M-Systems licensed to Toshiba its patents and certain other IPR's, including those relating to the DiskOnKey. The agreement included a joint venture, cross licencing and Toshiba investing in the company.

AMD

In May 2001, AMD - Intel's major competitor in processor production - and M-Systems signed a strategic agreement to jointly develop sophisticated high-density flash data storage

solutions for the rapidly growing mobile data storage market. The agreement tapped into AMD's ability to produce advanced flash (needing low power) with M-Systems' widely supported and easy-to-use TrueFFS(R) (this agreement too was expanded in 2003)

Agreement with Saifun[23]

While all the previous agreements were with major producers of mainstream technology flash memory chips, the October 2000 agreement with Saifun Semiconductors was for the development of a non-volatile memory chip of a different kind. M-Systems invested $10 million in the company (a quarter of the $40 million that Saifun raised during that round of financing), and the companies agreed to cooperate to develop data storage products based on Saifun's patented NROM™ chip technology.

3.2.6 **Litigation**

The DiskOnKey became the source of a number of patent suits, one against JMTek, a corporation based in Washington State, for infringement of one of its patents. The suit was validated a year later and resulted in an out of court settlement. Terms of the agreement included JMTek recognizing M-Systems' patents for the architecture for its USB flash drive and its TrueFFS technology.It also entered into a licensing agreement with M-Systems and agreed to make running royalty payments of its USB flash drive products. Another suit, this time by Trek Technology (Singapore) PTE Ltd. ended less successfully: M-Systems was stated to have infringed Trek's Patent and awarded Trek Technology damages of a quantum to be assessed.

3.2.7 **The USB-related Strategic Agreement with SanDisk and Sale of company**

M-Systems and SanDisk (formerly SunDisk) had been competitors for many years – each concentrating on a different niche in the flash memory market. However, once the USB drive arrived, both companies had reason for cooperation. A Strategic Agreement for developing the next generation of the USB drive was signed with SanDisk in 2004 with the new standard announced in 2005. This was a strategic collaboration and patent cross-license agreement to jointly develop and promote the next-generation USB flash drive platforms.

In July 2006 M-Systems was acquired by SanDisk.

3.3 Check Point

Check Point Software Technologies (Check Point) is one of most successful companies of Israel's software industry. Founded in 1993 it is a NASDAQ-traded global company focusing on Internet security with revenues of $US 730 million in 2007.[24]

Today Check Point has more than 1800 employees and its headquarters in Tel Aviv and Redwood City, California. The Company has numerous offices in the U.S. and subsidiaries in about 30 other countries. Check Point's products provide Internet and Intranet security solutions by regulating the flow of traffic between computer networks. The aim is to prevent

[23] For a case study of Saifun see below 3.4

[24] Check Point. *Corporate Fact Sheet (2008*) www.checkpoint.com

intrusion to the network, provide data security, protection of virtual private networks (VPN), etc.

3.3.1 **Source of Technology, Origin of the Firm and Strategy**

Mr. Gil Shwed the co-founder, Chairman and Chief Executive Officer of Check Point was a "computer geek" in his adolescence. During his service in the Israeli Defense Force, Shwed developed security solutions for internal military computer networks which allowed for different levels of access to different users of networked computers. This paved the way for creating the platform on which Check-Point was based, namely, regulating the interconnections with the Internet and providing secure intranet communications.

Together with two colleagues from the army, Shwed developed software that would provide internet security solutions for businesses. In 1993 the three colleagues founded Check-Point. They had already developed their first product - FireWall-1, a product based on a technology entitled *Stateful Inspection* which was originally invented and patented by Shwed in 1993 (US patent number 5,606,668 - and subsequently by Check-Point (US Patents No. 5,606,668, 5,835,726 and 6,496,935). Eventually "Stateful Inspection" became the industry standard for enterprise-class network security solutions.

From the beginning the company's business model was very much based on the creation and commercialization of proprietary products. The strategy and outlook of Checkpoint's founders was to secure technological and market leadership in what would become a new global network and market. Another objective was to create a large domestic company: a strategy that would seem to exclude the Merger and Acquisition 'Exit' strategy of many other Israeli ICT companies like Mirabilis i.e selling the company to a foreign multinational.

3.3.2 **Importance of Intellectual Property Rights**

Check Point's products are protected by a combination of up to four layers of protection: trade secrets, copyrights, trademarks and patents. *Stateful Inspection* is protected by patents as well as by trademarks (INSPECT ™); while *Application Intelligence*-a software package which aims to detect and prevent application-level attacks- by patents, copyrights and trademarks (for example by the brand puresecurity ™).[25] The company reports that it "derive(s) most of its revenues mainly from the sale of products and licenses, and related software updates".[26]

Up to a year ago Check Point had six U.S. patents granted and more than 25 U.S. patents pending. It also has additional patents and patent applications worldwide. The company uses standard licensing agreements aimed at protecting its IPRs.

3.4 Saifun

3.4.1 **General Background and Original Source of Knowledge/Technology**

Established in 1997, Saifun focused on new chip innovations in the computers' non-volatile memory (NVM) area. Its NROM technology introduced significant advances to the NVM

[25] Check Point. *Check Point Application Intelligence* (November 2007) http://www.checkpoint.com/products/downloads/applicationintelligence_whitepaper.pdf, p.12

[26] Check Point. Annual Report (2007), p. 48, http://www.checkpoint.com/corporate/ir/docs/2008Form20F.pdf

market, including the doubling of storage capacity of a basic semiconductor memory cell and simpler cell architecture that allowed for the reduction of manufacturing costs.

Saifun's founder, Mr. Boaz Eitan[27], completed his masters degree and doctorate in applied physics at the Hebrew University. In 1981 he emigrated to the United States with his family to work for Intel's development group in Santa Clara. During his employment in Intel and subsequently in WaferScale Integration Inc (WSI) Mr. Eitan focused on the development of technological improvements to the NVM storage capacity of memory chips, and was the co-inventor of several of the patents that were owned by WSI. In 1993 Eitan returned to Israel with his family and established the local branch of WSI. Mr. Eitan's wife, Ms. Tali Eitan, was trained as an attorney in the United States, specializing in ICT IPRs. She has played an instrumental part in protecting and managing Saifun's intellectual property assets to date.

After WSI decided not to pursue NROM technology Eitan, decided to develop his invention independently. In 1996 Eitan applied for a patent for the technology (US. patent number 5,768,192, granted in June 1998).

3.4.2 **Foundation of the Company, Strategy and Business Model**

After conducting feasibility tests for the new NROM technology Eitan founded Saifun in 1998. The company received seed money from Tower Semi-Conductors (an Israeli company) as well as from two local VCs. In March 2005 Saifun went public (at NASDAQ).

Saifun's strategy was explicitly focused on the creation of intellectual property assets in the NVM market/area for licensing (and provision of solutions) to other companies that who sell their own products in that market.

By February 2008 Saifun owned more than 91 U.S. patents, including two co-owned patents, and 12 non-U.S. patents. The company had more than 92 pending U.S. patent applications and more than 79 pending non-U.S. patent applications. – all intended to protect a variety of key aspects of NROM technology.

3.4.3 **Litigation**

Saifun successfully sued two multinational giants - Advanced Micro Devices Inc. (AMD) and Fujitsu Ltd – for the infringement of its patents and trade secrets. It argued that both companies had unlawfully used Saifun's technology after the latter had attempted to negotiate a licensing agreement with them back in 1998. Given the solid legal position of Saifun in this dispute, AMD and Fujitsu agreed to settle their dispute with Saifun out of court. The two companies agreed to pay Saifun US$ 25 million (each) for the license to use its technology. Both companies would also invest in Saifun and receive a 4.5% ownership share.

[27]Ginsburg, A. An Extraordinary Tale, Haaretz (30 December 2005)

3.4.4 **Sale of the Company**

Despite its many patents and solid legal base, after a decade of activity Saifun did not manage to generate enough value in terms of its business performance. One reason was that a joint venture with the German company Infineon Technologies (formed in 2001), aimed at manufacturing flash memory devices based on Saifun's technology, ended in failure in 2007. Another was the fact that traditional flash memory technology was good enough.

As a result Saifun was sold in 2007 to Spansion (a spin off company co-owned by AMD and Fujitsu), which currently is the world's largest provider of Flash memory solutions. The deal effectively focused on the acquisition of Saifun's intellectual property assets. In March 2008, Saifun became a wholly-owned subsidiary of Spansion, and "serves as the licensing arm of Spansion Semiconductors Inc."

3.5 Mirabilis

3.5.1 **The Product**

ICQ is a type of instant messaging (IM) first developed in 1996 by the Israeli start-up company Mirabilis. It was the first program to allow internet users to identify who else is online at the same time and subsequently to instantaneously connect and communicate with one another.

Mirabilis pioneered the field of instant messaging (IM) over the internet. IM programs did exist before ICQ. However IM services were rather limited since they were only usable by non-graphic operating systems. The developers of ICQ identified a technological gap in the market – the fact that users of these operating systems did not have the built-in ability to directly and instantly identify each other and to communicate with another while surfing the internet.

3.5.2 **The Company and its Business Model**

Mirabilis was founded in 1996 by 5 individuals, four of whom were young software developers in their early 20s who were responsible for the development of the technology. The four developers had tried without success to interest potential investors in their innovation. It was only after one of the developers sought the help and involvement of his father, Dr. Yossi Vardi, that Mirabilis was created and that ICQ started to gain momentum. At the time, Dr. Vardi, was a successful businessman and a faculty member of Israel Institute of Technology (the Technion). He was well versed in technical and commercial matters having established one of Israel's first generation software companies ("Techen") in 1969 and having served in a series of high level public and private positions.

Dr. Vardi recognized ICQ's significant market potential and created Mirabilis with a business model, which involved developing proprietary technology with the aim of undertaking an "Exit" by selling it or the company or both to a multinational company or investor. Initially the company was financed by local investments of about $US 3 million.

Having developed the technology and software and ensured protection of it IPRs, Mirabilis's next step was rather revolutionary: It handed out the **permission to use it's software for free** – and initated and intensive word of mouth campaign to push the software to users. Less than two years after it was introduced to the market, ICQ had a subscriber database of more than 12 million users.

3.5.3 **Sale of the Company**

The growing popularity of ICQ and the fact that the software and technology were protected by IPRs allowed Mirabilis to enter into negotiations with big multinational companies such as AT&T, Microsoft, Yahoo and AOL. Very early Vardi identified AOL as a potential buyer. The company based its business plan on the then popular concept of "eyeballs' – an assumption that the commercial returns of an internet platform can be derived from the number of people viewing an internet site. Following intense negotiations between AOL and Mirablis, the company was sold to AOL in 1998 – for the total sum of $US 407 million

3.5.4 **IP Protection and its Significance**

Mirabilis *copyrighted* its ICQ software and related components. It also uses *trademarks* in order to protect its brand and the key visual features that are associated with the software. Moreover during its early stage of operations, Mirabilis also sought to protect its technology via a *patent*, an action that, at the time, was considered innovative and uncommon for a software company. Here it should be noted that not only did Mirabilis apply for patent protection in the US (as mentioned, in Jan. 1997) but also in other markets, including Israel, where it first applied in October 1996 (using the so called PCT track).[28]

IP Protection enabled Mirabilis to enter into negotiations with foreign multinational partners with a non-insignificant assurance that the knowledge and its intellectual assets would be protected. It seems that at least during part of the negotiations Dr. Vardi feared that the technology might spill over to the multinational with whom he was negotiating sale of the company (this relates to Arrow's Paradox of Disclosure, see Arrow 1962 and Gans and Stern 2002).

It should also be noted that the patents that were granted to Mirabilis and which were later assigned to AOL as part of the acquisition, allowed the latter in the early 2000s to gain an important legal advantage in the IM market as a whole, particularly against Microsoft and Yahoo its main rivals in the IM field. However, this is a clear case of a company (AOL) **not** enforcing its patent rights, even though it could.

3.6 Conclusions

3.6.1 **The Concept of Catch-up**

Our case studies (section 3) suggest the need to significantly modify what could be considered a classical view of catch-up in relation to industrializing economies. The

28. ICQ's US Patent No. 6449344 was filed in January 1997, by Mirabilis and was granted to AOL as the new owner of ICQ in 2002. On 30 September 1997 Mirabilis also applied for an international patent.

modifications suggested refer to *the firm as a repository of catch- up related capabilities; to the degree of specificity of the product; and to the sources of catch-up-related value added.*

Specific national firms need not always be the repositories of catch-up capabilities since these firms may be acquired by foreign multinationals (in four out of five of our cases). Still some of these national firms like Elscint and M-Systems could have operated at the technological frontier for one or two decades and even been a technological and possibly a global market leader (or among the leaders) before being acquired. In these cases it would be reasonable to assume that a (*relatively) sustainable firm level catch-up has been achieved.* This is even more so in relation to Check Point who has remained and independent company. While sustainable firm level catch-up might not have characterized the remaining two companies (Saifun and Mirabilis), it could be argued that these companies still contributed to *overall ICT sector/cluster catch-up.*
We would like to propose that *catch-up could be embedded in the ICT sector/cluster* rather than (or in addition to) the individual firm; and that this inevitably involves a *dynamic product heterogeneity perspective.* Product heterogeneity is inherent in high-tech where frequently new products both substitute old products and cater to previously unsatisfied need or wants. This leads to a constant change in the cluster product mix and to a segment of relatively short lived and 'failed' products and correspondingly of firms with fleeting existences. While any one of these firms might not have achieved sustainable catch-up, *the revolving set could have contributed to overall cluster catch-up.*

The above conclusion is reinforced by the fact such firms may have generated externalities to other firms and indirectly to the cluster as a whole. That there are many sources for such (and many types of) externalities, is suggested by the fact that any firm operates in three types of markets: goods/services, knowledge and company shares. Thus a firm which is acquired by a foreign multinational after two (Mirabilis) or eight years (Saifun) could have been successful in knowledge markets (Saifun's case) and in capital markets (both Mirabilis and Saifun). These sources of value added or cluster 'outputs' should be added to the value added from new product commercialization when ascertaining the existence or non-existence of ICT cluster catch-up

3.6.2 **Role of IPR in Export Markets**

Our case studies show that IPRs (in their different expressions and forms) have provided three major functions with regard to the Catch-UP process. First, the confidence and incentive (a sort of 'insurance') required to develop new software and hardware related products including stimulating outside investment in R&D firms even at the early stages.[29] This includes the *patent wall* created by Elscint in the medical imaging areas like nuclear medicine and CT. Secondly, the legal protection of IPRs allowed these companies to engage in independent commercial activities in the market as with Elscint, M-Systems and Check-Point. Finally IPR's also enables companies to interact and reach complex agreements of various kinds (alliances, strategic partnerships, joint ventures, joint development agreements and cross

[29] This was emphasized by U. Galil, founder of the Elron group (the first high-tech industrial group group of the country) when referring to the whole period considered in this paper including the early years of Israeli high-tech during the 1960s and 1970s (Interview August 8, 2008).

licensing agreements) with larger and more established multinational enterprises. Indeed it was the protection of IPRs that has allowed companies such as Mirabilis to be successfully sold to AOL, who sought to buy its main internet platform (ICQ), or to Saifun to enter into strategic alliances with Advanced Micro Devices Inc. (AMD) and Fujitsu, after being able to successfully enforce its IPRs using legal proceedings against these companies. Moreover without such IPR's as a *quid pro quo,* M-systems could not have outsourced production at Samsung and Toshiba under favourable terms as it did in the second half of the 1990s.
In only one case did foreign held IPRs in the US market *somewhat constrain* the innovative efforts of a leading Israeli ICT company (Elscint). However, overall it seems that the combination of growing domestic capabilities and continued ICT revolution created ample opportunities for innovation by Israeli firms that did not violate existing patents granted in those countries (and even more so in the Software areas where copyright, a less strong form of protection, prevailed). Success in this respect required a well managed IPR regime in those countries (principally the US but also in some countries in Europe) where Israeli high-tech firms exported goods and, no less important, knowledge assets (IP) or company shares. Success in using this institutional arrangement, however, depended on companies being very aware of the importance of IP protection; and being strategic about the use of IPRs, even in the 1970s.

We conclude that our analysis strongly suggests that IPRs granted in the main export market of Israeli firms (particularly the US), had a very positive and important role in the Catch-Up process of ICT companies in Israel and of the high-tech, ICT cluster. In the concluding section we will argue that a capacity to successfully exploit a strong IP regime abroad depended critically on a consistently strong domestic IP regime within Israel.

SECTION 4: THE IP ENVIRONMENT IN ISRAEL AND THE PHARMACEUTICAL INDUSTRY

4.1 Overview

Over the decades, Israel has chosen to create an IP environment supportive of its local generic pharmaceutical industry. Before the 1990s, this orientation was aimed at *self-sufficiency*. Its motivation was somewhat different from that of e.g Brazil, Chile, India and S. Korea since it was linked with Israel's national security interests and to the fact that foreign companies including pharmaceutical companies, were unable and even unwilling to operate in Israel. It was during this period that generic companies, such as Teva, were becoming highly productive and successful.

In 1967 Israel modified its Patent Act to allow local generic companies to copy patent-protected drugs **if** the owners of these products did not market them in Israel (the so called *requirement for local use*). This allowed local generic companies such as Teva to copy the original pharmaceutical patented product without being considered to be violating the patent. While the changes introduced by the amendments were primarily aimed for local use their implications were also arguably international insofar as they allowed Teva, as well as other

companies, to acquire expertise in the development and manufacture of generic versions to original brands (developed by US and EU-based MNEs). Indeed, the former CEO of Teva and current Chairman of the Board Mr. E. Hurvitz argued that this change in legislation allowed Teva to gain the necessary expertise to become a world leader in the manufacturing of generics: "I used to say that we should thank God for bringing us the Arab boycott…Without it our company wouldn't exist."[30]

Parallel to this, generic companies like Teva also entered into agreements with foreign companies to distribute and market innovative products patented in the Israeli market (some still have such agreements today).

As a result the interests, including IP interests, of generic-based companies became embedded (even to date) in Israel's governmental or quasi-governmental structures e.g. the chemical and pharmaceutical division of the *Manufacturers Associations of Israel* (MAI) and the Ministries of Industry and Finance.

Between 1967 and the early 1990s there were no major changes in Israel's patent regimes regarding pharmaceuticals. As of the mid 1990s the Israeli market has become increasingly linked with, and dependent upon, international markets. In 1995 Israel became a member of World Trade Organization (WTO) and a signatory to the agreement on trade related aspects of intellectual property rights (TRIPS). By signing this agreement Israel recognized the importance of intellectual property to knowledge-based economies and also committed itself to respect and to protect the intellectual property rights of research-based pharmaceutical companies. Under the auspices of the WTO, Israel was categorized as a developing country and, as such, was expected to fully implement the TRIPS agreement by January 1st 2000.

From the perspective of pharmaceutical multinationals, Israel's TRIPS commitments, combined with positive changes in the geopolitical environment, were expected to create new business opportunities. With the understanding that Israel's domestic IP regime was about to improve significantly, research-based multinational pharmaceutical companies decided to increase their involvement in the Israeli economy and aspired to build upon the potential of Israel's capabilities in the field of Biomedicine. Thus between 1995-2000, leading research based pharmaceutical companies, such as Merck, Pfizer, Glaxo Welcome, SmithKline Beecham, Bristol-Myers Squibb, Roche, Novo Nordisk and Eli Lilly opened subsidiaries in Israel. These subsidiaries *focused (and are still focusing) on marketing and distribution activities and on clinical trials.* Though at the time some of the local subsidiaries did aim to invest in more extensive R&D activities, the nature of the activities of these companies did not change dramatically and to date, not one multinational company has established more extensive R&D operations in Israel. This is in dramatic contrast with the R&D facilities that have been established in Israel in the ICT sector by companies such as Intel, IBM, Microsoft and Motorola, some of them more than 30 years ago.

[30]Haaretz, (1 November 2004) (Translated from Hebrew)

Contemporaneously, local generic-based pharmaceutical companies became much more active internationally. Companies, such as Teva, Agis, and Taro operate today in many international markets.

Paradoxically, the combined effect of rapid entry of pharmaceutical multinationals and the international expansion of local generic-based pharmaceutical companies did not lead Israel to strengthen its IP protection. There were three major arguments against this and the subsequent expected entry of MNEs seeking to protect their IPRs.

i. It would be highly damaging to the business operations of local generic companies focusing on the domestic market (companies such as "Unifarm") e.g., delaying the entry of new generic products to the local market.

ii. It would weaken the ability of local generic companies to compete in international markets, by delaying the launch of new generic drugs.

iii. The *Sick Funds* (Israel' biggest health providers and purchasing bodies), argued that increased protection of pharmaceutical IPRs would automatically raise the prices of drugs.

4.2 The case of Teva Pharmaceuticals

Teva Pharmaceuticals --- considered to be the world's biggest multinational generic company --- is probably the most successful Israeli company to date. With roots in 1901, first plants in the 1930's, Teva has become one of the country's leading pharmaceutical companies. During the 1960s and 1970s it grew locally via a series of merger and acquisitions. In 1982 Teva was granted FDA approval for its Kfar Saba (Ikapharm) manufacturing plant. Over the course of the 90s Teva became a major player in the global generic market by adopting an aggressive Megers and Aquisitions strategy in the in the US and Europe. In the year 2000, Teva's acquisition of Novopharm in Canada, together with its Hungarian subsidiary, made Teva the largest generic pharmaceutical company in North America. Between 2004 and 2008, Teva further expanded its global outreach via a series of acquisitions, such as that of Sicor in 2004 and Ivax Corporation (another major player in the US generic market) in 2006.[31] Recently (2008) Teva has also completed the acquisition of Barr Pharmaceuticals, one of the strongest generic companies in the US.

Today, Teva is the world's largest multinational generic company. 91% of its sales, (which totaled US$9.4 billion in 2007), are in North America and Europe. Teva has approximately 28,000 employees worldwide and production facilities in Israel, North America, Europe and Mexico.[32]

www.tevapharm.com[31]Teva. *The History of Teva*. Teva Pharmaceuticals website (2008)
www.tevapharm.com[32].Teva. *Company Overview*. Teva Pharmaceuticals website (2008)

Teva is also considered to be the most significant R&D investor in Israel's pharmaceutical and biomedical markets. It invests in biotech incubators (e.g Bioline RX) and start-up companies and has strategic partnerships with hospitals and universities. In 2001 the company launched its first innovative drug – Copaxone. Used in treating multiple sclerosis, Copaxone is the product of collaboration between Teva and the Weitzman Institute of Israel.

4.3 The Development of Israel's Pharmaceutical IP Environment after 1995

Israel's level of IP protection was already quite developed and in most cases above the level of TRIPS when it signed that agreement.(for example Israel did allow patenting of pharmaceutical products and extended 20 years of patent protection). Therefore our focus on post 1995 legislation is not whether it is TRIPS consistent or not; rather it compares such developments with the pharmaceutical IP developments that took place in developed countries (such as in the US, the EU and Japan) over the last 15 years. The major legislative changes that took place after Israel signed the 1995 TRIPS agreement are shown below.

1998 - Israel amended the Patent Act (Patent Act, paragraph 54a) to permit testing of patented pharmaceutical products in Israel for commercial purposes without being accused of violating the patent (so-called Bolar amendment, which was approved in the US in 1984).[33]

1999 - Israel amended the Pharmacists' Ordinance (Medicinal Preparations) to allow parallel importation of pharmaceutical products protected by patents both abroad and in Israel (Article 47C). Such activity refers mostly to the importation of patented pharmaceutical products from low-price countries into Israel, through channels other than those authorized by the local patentee or licensee (mostly via the local Sick Funds who would then gain greater negotiating power vis-à-vis multinational pharmaceuticals companies). For this to be legal, countries must adopt the *principle of international exhaustion*, according to which once patentees have sold their product in one country, they have exhausted their rights to prevent the resale of that product to other countries. While Parallel Imports are essentially permitted under TRIPS (article 6), a fact confirmed by Israel's Supreme Court of Justice in August 2001, technically this post-TRIPS amendment weakened Israel's existing pharmaceutical IP regime.

January 2000 - TRIPS Article 39.3 obligates the governments of WTO members to protect the registration files of innovative pharmaceutical companies against unfair commercial use. This protection is known as *"data exclusivity*". However, at that time, Israel did not provide any kind of legislation or regulatory protection of data exclusivity.

Between 2002 and 2005 - Israel examined and discussed the issue of data exclusivity in various governmental and parliamentary committees. This led to new legislation aimed at amending the Pharmacists Ordinance (Article 47) to provide *marketing exclusivity* in Israel that is linked to the registration of new pharmaceutical products.

[33] For an overview of why this bill is referred to as the "Teva-Bill" see: Knesset Protocols, Meeting no. 140 of the Knesset no 14 (17 February 1998), http://www.knesset.gov.il/Tql//mark01/h0012237.html#TQL

However for a number of reasons the new marketing exclusivity legislation, in its current form, seems to fall short of the accepted data exclusivity models in the US and the EU e.g. *de facto* it provides for less than five years of protection[34].

4.4 Summary

Between the late 1960s and the mid 1990s, Israel reformed its Patent Act to allow for generic companies to safely copy patented pharmaceutical products without being accused of violating the patent. These changes reflect the contemporary need for self sufficiency (not least given the Arab boycott) and the fact that the local industry was focusing mostly on the Israeli market.

During the *mid 1980s* and thereafter, Israeli generic companies began to expand internationally and lead in the exportation of generic drugs. Their IP needs changed accordingly towards a *weakening* of domestic pharmaceutical IP in order to be "first in the market" not only in Israel but internationally as well. On the other hand during the 1990s multinational pharmaceutical companies showed an increased interest in the Israeli market which resulted in the opening of new subsidiaries and affiliates and also in demands (contrary to the demands of generic companies) to *strengthen* Israel's pharmaceutical IP environment.

Once Israel became a member of the WTO it changed its patent Act to close the "loopholes" that were created in the 1960s (e.g. the permission to copy the patented medicine if it was not marketed in Israel). However simultaneously it ensured that the core interests of its local generic companies would not be harmed. This was achieved through a multitude of amendments to existing legislation and new enactments (such as those regarding patent extension terms and data exclusivity) that aimed to ensure that exporting generic companies would still be able to be the "first in the market" in the leading markets (US, EU). These changes are not necessarily contrary to TRIPS; and it could persuasively be argued that they were aligned with the national interest.

SECTION 5: SUMMARY, CONCLUSIONS AND AFTERTHOUGHTS

An ICT-oriented, high-tech (henceforth *high-tech)* Catching Up process took place in Israel during the 1990s with the emergence of both a high impact domestic Venture Capital industry/market and an ICT-oriented Entrepreneurial High-tech Cluster with a large number of high-tech start up companies. The result of a three phase, 25 year process of evolution of Commercial Innovation and of the underlying Science, Technology, Higher Education infrastructure with which it co-evolved, the phenomenon is also consistent with the sharp absolute and relative growth of Israeli patenting in the US. The outputs of the cluster include value added from sales/exports of goods (around 13 Billion $ towards 2000), from sales of knowledge and technology assets, and from sales of company shares typically through IPOs in NASDAQ (around 10.7 Billion $ during the 1990s) or acquisitions of relatively small domestic companies and Start Ups by foreign MNEs (approx. 18 Billion $ during the 1990s).

[34]Pugatch, M.P. A Transatlantic Divide? *The US and EU's Approach to the International Regulation of Intellectual Property Trade-Related Agreements* (European Centre of International Political Economy: Brussels, April 2007).

A central point to recognize is that the *initial conditions* during the 1948-69/70 period (and, prior to 1948, the existence of three very good institutions of higher learning and research and a strong IP regime established already in the 1920s during the British Mandate) were very favorable for the subsequent evolution and emergence of a world class ICT-oriented high-tech cluster. Also of importance were the composition of the population that existed by the time the State was created in 1948, subsequent educational and immigrant absorption policies and subsequent reinforcement of the Science, Technology and Higher Education infrastructure. During the late 1960s, the institutional underpinnings for Innovation Policy were established. Thus while (Commercial) Innovation and related social technologies and institutions (Nelson 2007) such as management capabilities and organizational forms like Venture Capital and Start Up companies were as yet absent a number of important background factors and institutional underpinnings for a high-tech catching up process, including strong IPR protection domestically, were already in place.

5.1 The Importance of Strong IPR in Israel

It could be maintained that the IPR regime which was relevant for Israeli high-tech Catch-up was that prevailing in Israel's export markets particularly that of the US, and not necessarily the IPR regime prevailing in Israel. We argue that this is too simplistic a position and essentially wrong. We submit that it is inconceivable that Israeli firms could exploit the US market (or any other foreign market with a strong IPR regime) without Israel's long standing strong domestic IPR regime, which was essentially inherited from the time of the British Mandate (see 2.4 above).

Our argument is as follows: Israel's well established and relatively strong *domestic IPR regime* led to a strong *IPR infrastructure* of experienced patent attorneys and to *strong learning effects* by Israeli firms concerning their IP management and strategy. Mastery of these *social technologies* (Nelson 2007) enabled firms to effectively exploit the strong IP regime existing abroad e.g. to effectively apply for timely patent protection abroad; to protect the rights thus acquired.

Strong *domestic* expertise was required due to the inherently complex process of applying and being granted a patent (or a trademark). Wherever a firm wants to patent its invention it has to determine whether the subject matter of the application (the so called "claims") are indeed patentable on the basis of the examination carried out by the patent office of that country. Even today, when submission of an application for a patent can take place on a global scale (using for example the PCT-see 2.4 above) there is still a need to apply for a patent in each country in which the inventor wants to obtain and uphold that patent. This also holds for copyrights since --- despite the ease of obtaining the right --- the ability to enforce these rights (the fight against counterfeiting, illegal downloading etc) is much more complex given that action could be taken against many many users.

Concerning Software there are two *reasons* why strong domestic IP protection was important for Catch-up: as with patent protection, the social technologies that emerged in response to a strong domestic IP regime were critical to make effective upholding of copyrights and other

software IP rights in export markets; and the importance of the domestic market for new software products.[35]

We conclude that a strong IPR regime was an essential institution for high-tech Catch-up. It involved a set of institutions and social technologies of critical importance for articulating and applying the historically strong STE capabilities to the areas of commercial innovation, a process which started almost 40 years ago. This, despite the absence of a clear and systematic, co-evolutionary process between IP protection and Commercial Innovation (and, indirectly, high-tech Catch-up, see section 2.4).

5.2 Other Policies and Co-evolution

A central conclusion of the paper is that Government Policies were critical for spurring and sustaining the thirty year plus evolutionary process starting in the late 1960s that led to high-tech Catch-up in the 1990s. Critical roles were played by a systematic and increasingly broad scope of *Innovation Policy* whose various programs complemented the continued and expanded support by the Science/Technology infrastructure; and by strong *Intellectual Property Rights (IPR) protection*.

While both Commercial Innovation and IP protection were important, the particular mechanism by which they affected high-tech Catch-up differed considerably. Israel's Innovation Policy was implemented by a specialized agency-the Office of the Chief Scientist of the Ministry of Industry and Trade (OCS). This agency was systematically attentive both to the problems and opportunities resulting from program implementation and from changes in the broader environment to which it rapidly reacted both in terms of fine-tuning and adaptations of existing programs and by implementing new Innovation Policy programs. The outcome was a strong co-evolutionary process between Innovation Policy on the one hand and Commercial Innovation (and high-tech catch-up) on the other.

In contrast, there was no clear co-evolutionary process linking *high-tech* IP protection policies and Commercial Innovation. Israel's IP regime was for historical reasons roughly comparable to that existing in advanced countries and thereby 'strong'. There were relatively few major changes in IP legislation before the onset of high-tech Catch-up during the second half of the 1990s, although some erosion did take place later on due to non-adaptation to changing circumstances. But these, in our judgment, would not have been a central factor in the recovery of the high-tech cluster starting in 2004.

The impotance of an explicit and consistent Innovation Policy focused on extending Grants to R&D at firms is a distinctive feature of Israel's high-tech catch-up. Much of policy research up to the 1990s did not appreciate the potential importance of *Innovation Policy* in the sense used in this paper namely, *direct* support of *Innovation* in firms (for a different view see Teubal 1983, 1997). Moreover little analsys of co-evolution between the two variables or of

[35] Domestic software sales were consistently higher than export sales both during the 1980s and also during 1991-2000 (Breznits 2008, Table 1).

the link of policies through time exists (e.g between Israel's Grants to R&D program initiated in 1969 and theYozma program directed to Venture Capital 24 years later).

The fact that no significant co-evolutionary links seem to have existed between IPR policies and Commercial Innovation (and indirectly with high-tech catch-up), would seem to be, in the light of Ordover's thesis (Ordover 1991), a second distinctive feature of the Israeli case. Rather than co-evolving with innovation capabilities and related social technologies, Israel's strong domestic IPR regime should be regarded as a critical institution providing a *background context* (Nelson 2007, p.8) for the evolution of such capabilities/ social technologies and for the resulting high-tech catch-up process.

5.3 The Case of Generic Drugs

The growth of the generics industry since the creation of the state and in particular of Teva, an Israeli based MNE which is the largest generics Medicines and Drugs company globally, originated in the Arab boycott and in the consequent need to assure domestic self sufficiency. Once Israel became a member of the WTO in 1995 it changed its patent Act to close the "loopholes" that were created in the 1960s (e.g the possibility to copy the patented medicine if it was not marketed in Israel). However simultaneously it ensured that the core interests of its local generic companies would not be harmed. The changes and amendments that followed were not necessarily contrary to TRIPS; and it could persuasively be argued that they were aligned with the national interest.

An implication is that within the same country we have contrasting roles of IP and IP strength on Catch-up depending on industry and historical context: a rather strong ICT-related high-tech IP regime which promoted ICT/high-tech Catch-up; and a weak or weakening Medicines & Drugs-related IP regime which promoted *generic* Medicines & Drugs-Catch-up.

Concerning Medicines and Drugs: it may be the case that while the above relative weakening of IP protection domestically helped achieve *generic drugs/medicines catch-up,* turning Israel into a pharmaceutical R&D hub (parallel the R&D intensive ICT high-tech cluster of the 1990s) --- a possible future national priority --- may require a strengthening of some aspects of existing drugs/medicines IP protection policy.

5.4 The Israeli Model of High-tech Catch-up

The fact that the IP system "worked" for Israel in terms of its economic development can be explained by the fact that Israel enjoyed a rich human capital base and a strong tendency first to Science and Technology and then to Innovation and high-tech entrepreneurship. In other words, one can argue that Israel was "ripe" for a strong IP environment right from the beginning.

This also suggests that certain industrializing countries with similarly 'abundant' skilled human resources could eventually, with the help of policy, undertake high-tech (without this becoming the main focus of their development strategy-see below).

Global resources including the Diasporas of these countries in advanced nations will increasingly participate in this process, the effect being a new mechanism of 'valorizing' the human resource potential of such countries. This mechanism was not available previously e.g. during the 1960s for Argentina to leverage its rich human resource base at the time in order to develop high-tech industry. This further illustrates another point raised by Editors of this book namely that the *global context* will determine both the possibility of catch-up and the particular profile it may take. Thus, due to the globalization of NASDAQ and Israel's success in transferring and adopting new institutions and social technologies such as Venture Capital and Start Up companies from the US (Avnimelech and Teubal 2006, 2008b) the global context facing Israel in the 1990s involved many new opportunities not available previously for the creation and sale of high-tech start ups and for the sale of knowledge assets. Therefore, in contrast to the hypothetical Argentinian case three decades earlier, high-tech catch-up in Israel could take the form it did of emergence of an *entrepreneurial* high-tech cluster closely linked from day one to global product and capital markets and to global resources.

Not all countries, however, would benefit from this particular pattern of globalization.. Thus when the level of human capital and technological infrastructure is low, coupled by a low level of economic development, stronger IPRs rather than inducing innovation and catch-up would constrain such processes. It follows that in such circumstances, a TRIPS induced imposition of a strong IP regime could be a limiting factor on innovation-based economic development.

5.5 High-tech and Economic Development[36]

During the heyday of Israeli high-tech success one of us suggested that Israel should adopt a broader R&D strategy than the one existing at the time which was focused on promoting high-tech (Teubal 1999). It was argued that existing R&D support to the business sector was biased and that this bias had been on the increase.

Two alternative Innovation Policy Visions/Strategies for Israel were proposed. In ***Strategy I*** High-tech was considered as a key both to assure successful aggregate growth and as the solution to societal problems. The alternative Vision/Strategy (***Strategy II)*** preferred by the author asserted that while Israel did have a comparative advantage in high-tech it was important to achieve a balance between it and the Mid and Low Tech sectors where most of the country's employment was located. It was also stated that these sectors had a strong growth potential, especially if, through adequate policies, they became *sophisticated users* of new technology.

The priorities suggested for Mid/Low Tech development (Teubal 1999, pp. 371-3) included a focus on learning, training and technology transfer with the aim at generating world class manufacturing capabilities in certain areas; and the strengthening of 'clusters'. A number of specific policies were also suggested, some horizontal and others targeted. These required a shift to *a systems and evolutionary policy perspective* which emphasized --- beyond

[36] Thanks to R. Nelson for having pointed out the relevance of this topic and for his comments on the views of Trajtenberg (see below)

incentives and market failure --- priorities, strategy, learning and institutions (Teubal 1999 p.369).

Some of these issues were later taken up by M. Trajtenberg (e.g. Trajtenberg 1995). He started by pointing out the relative isolation of Israel's high-tech from the rest of the economy where growth was sluggish. His second point was that innovation in developing countries should be understood as involving much more that innovation in high-tech.

Trajtenberg stated that most of the production and marketing of the new products resulting from company R&D in Israel (which accounts for most of the employment generated) was done abroad and not in Israel. To this may be added a further possible argument put forward by Nelson namely that, even when production and marketing do go on in Israeli firms, "there is little in the way of upstream and downstream linkages to other Israeli firms; and the level of economic activity of those progressive firms is not large enough for them to generate a broad multiplier effect".

Concerning the link between innovation and development, we agree with Nelson's statement that "the lion's share of the innovating that goes with successful development *is not going to be in high-tech*, but in economic activities that account for the lion's share of employment: farming, construction, transportation, manufacture of standard consumer products and so on".

We conclude that our analysis of Israel's success in high-tech catch-up does not imply that policies for successful 'innovation-based economic growth' of countries not yet at the frontier should conform to the above- mentioned Strategy I with its extreme focus on high-tech. Rather a broader vision of innovation and development is required, in many cases focusing on innovation in mid/low tech, in others on some variant of Strategy II (examples of Korea and Taiwan). Other aspects of Israel's experience could be relevant e.g. the importance of a long term, coherent policy in support of innovation (broadly defined *a la Schumpeter* and not exclusively R&D-based innovation), one which is broadly applied to the important sectors of industrializing economies; and the opportunities which the dynamics generated by such support could create for subsequent policy targeting of specific product classes, sectors or clusters.

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