

R&D Policy in Israel: An Overview and Reassessment

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Introduction

The High-Tech sector in Israel has turned in the course of the last decade into a striking economic success story, both by local and by international standards. In fact, Israel stands as one of the most prolific innovating economies, and as one of the few “Silicon Valley” types of technology centers in the world. There is no doubt that Government policy was key to the emergence and success of the sector, a policy embedded for the most part in the programs and budgetary resources of the Office of the Chief Scientist (OCS) at the Ministry of Industry and Trade. However, the very success of the sector and its relentless dynamism call for the periodic revision and reexamination of those policies. Moreover, the current budget impasse in this area (due to tight government funding at a time of growing demand for R&D grants) brought to the surface basic tensions that were built into the policies, and that could no longer be ignored.

Interest in R&D Policy as an area of research has experienced recently a marked upsurge within mainstream economics (see for example Klette, Moan and Griliches, 1999, David and Hall, 2000, Jones and Williams, 1998, etc.). This probably reflects the perception that technical advances in Information Technologies (IT) and related areas have had a noticeable and sustained impact on productivity growth in recent years (contrary to the previous uneasiness in that respect vividly articulated in “Solow’s Paradox”). Since R&D is driving the relentless flow of innovations that fuel IT and the “New Economy”, policies that affect R&D have thus become an attractive field of inquiry. Moreover, advanced economies other than the US, and in particular European countries, see it as a major goal to partake in the processes associated with the current wave of innovations, and therefore their interest in R&D Policy is immediate and pragmatic. So it is for Israel, where early recognition that its comparative advantage resides in its highly skilled labor and world-class academic resources (contrasted to its relatively poor endowment in natural resources) led the Government to actively promote commercial R&D for the past three decades.

The main goal of this paper is to provide the basic ingredients for the understanding of R&D policy in Israel, and suggest possible changes to it. It consists of a descriptive first part, whereby the various programs of the OCS are laid out in some detail, and a second chapter where we examine the outstanding policy issues and put forward suggestions for reform. Following a brief account of the functioning and history of the OCS, we review in section I.2 the OCS main programs, including their mission, mode of operation, budget and composition. Section I.2.1 describes the standard R&D Grants Program, followed by the “Magnet” Program, and the Incubators Program; section I.2.4 touches on International Cooperation, including the BIRD Program. Section I.3 presents quantitative indicators of OCS activities over time, including budgets and projects by size of firms, followed in section I.4 by a review of econometric studies on the contribution of the OCS, and an overview of the rise of the High-Tech sector in Israel with the aid patent data.

Part II opens with a discussion of allocation schemes for the regular OCS Grants Program in view of a rigid budget constraint, followed by an examination of possible ways of departing from the principle of “neutrality”. Section II.2 deals with a host of related issues, such as the payback system, the conditionality of production in Israel, and the need for ongoing economic assessment of the various programs. Section II.3 attempts to assess the “Magnet” program for the support of consortia engaged in generic R&D, and raises the question of the desirability of supporting it versus the regular commercial R&D projects. Lastly, we tackle the issue of how much should the Israeli economy invest in R&D, and what does such a target imply in terms of Government support.

It should be emphasized once again that this paper is meant to be first and foremost a *descriptive account* of ongoing R&D government programs in Israel, with the goal of providing a suitable framework for a much needed discussion on outstanding policy issues. Hopefully, these issues are of relevance not just for Israel but for any economy contemplating active government involvement in R&D.

Part I

Government Support for Industrial R&D in Israel: An Overview¹

I.1 Background

The beginning of government support for industrial (civilian) R&D in Israel dates back to 1968: a government commission, headed by Prof. Kachalsky, recommended the creation of the Office of the Chief Scientist (OCS) at the Ministry of Industry and Commerce, with the mandate to subsidize commercial R&D projects undertaken by private firms. Support was confined until then to National R&D Labs, and to academic R&D, in addition to the weighty resources that were devoted to defense-related R&D and to agricultural research. And indeed, industrial R&D rose rapidly following the establishment of the OCS. Between 1969 and 1987 industrial R&D expenditures grew at 14% per year, and High-Tech exports grew from a mere \$422 million in 1969 (in 1987 dollars), to \$3,316 million in 1987 (Toren, 1990).

The next key development was the passing of the “Law for the Encouragement of Industrial R&D” in 1985 (it has been revised several times since). This is the main piece of legislation that has defined the parameters of government policy towards industrial R&D ever since. The stated goals of the legislation, to be implemented by the OCS, are to develop science-based, export-oriented industries, which will promote employment and improve the balance of payments. In order to do this, the legislation was supposed to provide the means to expand and exploit the country’s technological and scientific infrastructure, and leverage its high-skilled human resources. The 1985 Law may soon undergo a significant revision, in view of the changes undergone by the High-Tech sector in the course of the last decade, and the recent budgetary restraint that has resulted in excess demand for R&D grants under the present system.

¹ As the title indicates, we confine ourselves to *civilian, industrial* R&D. Both defense R&D and academic R&D have played all along a pivotal role in Israel’s overall research enterprise, and fueled to some extent the growth of High Tech via a variety of spillovers, but these are beyond the scope of this paper.

At the heart of the law is a program of financial incentives. Companies – whether big corporations or small startups – which meet certain eligibility criteria, are entitled to receive matching funds for the development of innovative, export-targeted products. The OCS funds up to 50 percent of R&D expenses in established companies, and up to 66 percent for start-ups. The OCS supports and administers a wide range of additional programs, the main ones being: (i) “Magnet”, a program to encourage pre-competitive generic research conducted by consortia; (ii) a program of technological incubators; (iii) various programs involving bilateral and multilateral international R&D collaboration. We review these programs here in some detail. Other, relatively minor programs aimed at specific stages along the innovation cycle or at particular segments in the progression from an innovative idea to a full-fledged commercial enterprise are described in Appendix 1. In section I.3 we present quantitative indicators of the various programs.

I.2 A Review of OCS Programs²

I.2.1 Support for Standard R&D Programs

This is by far the largest program, and administering it constitutes the main activity of the OCS. The way it works is as follows. Qualifying firms submit grant applications for specific R&D projects, these are reviewed by a Research Committee, and if approved (about 70% are) the applicants receive a grant of up to 50% of the stated R&D budget for the project. Successful projects (i.e. those leading to sales) are required to repay the grant, by paying back to the OCS “royalties” of 3% of annual sales,³ up to the dollar-linked amount of the grant. Recipients of the R&D grants have to abide by the following conditions: (1) the R&D project must be executed by the applicant firm itself; (2) the product(s) that emerge from the R&D project must be manufactured in Israel; (3) know-how acquired in the course of the R&D may not be transferred to third parties.⁴

² We draw for this section from a variety of material from the `` (see Israel Ministry of Industry and Trade, 1994, 1999a, 1999b and 1999c), as well as from personal involvement with the OCS, in particular with the Magnet Program.

³ Actually the original payback schedule was as follows: 3 % of revenues from sales of the products developed for the first 3 years; 4% in the next three years, and 5% from the seventh year onwards. This schedule has been revised a few times, and the Treasury is pressuring the OCS to increase these percentages, and even impose interest payments.

⁴ The Research Committee may grant exemptions to requirements (2) and (3), but as far as I have been able to establish, this has rarely happened.

The Research Committee, chaired by the Chief Scientist, is responsible for defining the conditions for granting aid (within the confines of the 1985 Law), and for reviewing the applications and selecting the recipients. The committee is staffed both by qualified government officials and by public representatives, but it relies on (outside) professional referees and advisers to review the applications. Decisions of the Research Committee can be appealed before an Appeals Committee.

Grants of (up to) 50% of the total R&D costs are given to projects that “lead to know-how, processes or systems for manufacturing a new product/process or substantially improving existing ones.”⁵ Grants covering 30% of R&D costs are available for projects leading to *improvements* in existing civilian products, and 20% for improvements of military products. Start-up companies qualify for grants of up to 2/3 of R&D costs, with a ceiling of \$250,000 a year for two years. Products aimed at the military (export) market qualify for grants of up to 30%.

Israel has a long-standing policy of encouraging the development of an industrial base in peripheral areas (away from the main urban centers), which is reflected also in the R&D support programs. Thus, R&D projects performed in the preferential peripheral areas (“Grade A Development Areas”) are entitled to additional 10% grants: for civilian projects that means grants of up to 60% (rather than 50% for the others), and military projects are entitled to grants of up to 40% (rather than 30% for the others).

I.2.2 The “Magnet” Program

Notwithstanding the rapid growth of the High-Tech sector in Israel from the late 1960’s onwards, it became clear by the early 1990s that the industrial landscape in Israel was too fragmented, and Israeli industrial companies were too small to be able to shoulder the escalating costs of developing new technologies in cutting edge fields. Moreover, Israel boasted world-class research universities, but they operated largely in

⁵ In the early 1990’s the 1985 Law was amended so as to place the software industry on an equal footing with other industrial sectors, so that software development projects qualify for the same type of aid.

isolation from surrounding industrial developments and needs, and hence the vast economic potential embedded both in the highly qualified academic manpower and in university research remained largely untapped.⁶

Against this background the OCS established in 1993 the “Magnet” Program⁷, to support the formation of consortia made of industrial firms and academic institutions in order to develop *generic, pre-competitive* technologies.⁸ These consortia are entitled to multi-year R&D support (usually 3 to 5 years), consisting of grants of 66% of the total approved R&D budget, with no recoupment requirement. The consortia must be comprised of the widest possible group of industrial members operating in the field,⁹ together with Israeli academic institutions doing research in scientific areas relevant to the technological goals of the consortia.

Mindful of possible conflict with anti-trust provisions, consortia members must pledge to make the products or services resulting from the joint project available to any interested local party, at prices that do not reflect the exercise of monopoly power. Keeping with the mandate to encourage pre-competitive technologies, support to the consortia ceases once the equivalent of the “pilot plant stage” is reached. That is, the additional R&D required for the actual commercialization of the products is not supported by Magnet, but the member companies may then apply for regular grants from the OCS. Contrary to the regular OCS support to industrial R&D projects, the Magnet program operates on a competitive basis, that is, it is open to any number of proposals for the formation of new consortia, and it selects only those that merit support on the basis of a ranking system.

By the end of 1999 there were 18 consortia in operation, commanding a budget of about \$60 million, and four additional consortia in various stages of gestation. These

⁶ Israeli universities have proved also to be highly capable of generating innovations having economic potential (as manifested for example in the large number of US patents assigned to them – see Trajtenberg 1999), but once again weak links with industry have prevented the extensive exploitation of such potential.

⁷ “Magnet” is the acronym (in Hebrew) for “Generic, Pre-Competitive Research”.

⁸ Magnet supports also the integration of advanced technologies into industry via users’ associations, but that is a secondary activity.

⁹ Participation is limited to Israeli-based companies, or Israeli subsidiaries of foreign companies.

Table 1
Active Magnet Consortia as of
December 1999

1. Ground Stations for Satellite Communications
2. Digital Wireless Communications
3. Broad-Wide Band Communication (BISDN)
4. Multimedia On-Line Services
5. Diode Pumped Lasers
6. Multi Chip Module (MCM)
7. Magnesium Technologies
8. Hybrid Seeds and Blossom Control
9. Algae Cultivation Biotechnology
10. DNA Markers
11. Drug and Kits Design and Development (“Daa’t”)
12. MMIC/GaAs components
13. 0.25 micron/300 mm devices
14. Ultra Concentrated Solar Energy (“Consular”)
15. Network Management Systems
16. Digital Printing
17. Image Guided Therapy (“Izmel”)
18. Computerized Industrial Processes
<i>User Associations:</i>
1. Users of Advanced Technologies in Electronics
2. Users of Advanced Technologies in Metal

consortia span a wide range of technologies, primarily in communications, micro-electronics, biotechnology, and energy. Table 1 shows the complete list.

I.2.3 The Incubators Program¹⁰

Technological incubators are support organizations that give fledgling entrepreneurs an opportunity to develop their innovative technological ideas and set up new businesses in order to commercialize them. The program was introduced in the early 1990s, when immigration from the former Soviet Union had reached its peak. Many of these immigrants were scientists and skilled professionals that came to Israel with highly valuable human capital as well as with plenty of ideas for innovative products. However, they were lacking in virtually all other dimensions required for commercial success, from knowledge of the relevant languages (e.g. Hebrew and English) and of commercial practices in western economies, to managerial skills and access to capital. Even though it targeted new immigrants, the program is open to all.

The goal of the incubators is thus to support novice entrepreneurs at the *earliest* stage of technological entrepreneurship, and help them implement their ideas and form new business ventures. The premise is that the technological incubator would significantly enhance the entrepreneur's prospects of raising further capital, finding strategic partners, and emerging from the incubator with businesses that can stand on their own. Of course, this initial stage is the riskiest, and certainly in the early 1990s there were virtually no other sources of finance in Israel for such ventures. Since the mid-1990s there has been a growing influx of venture capital, and hence it may well be that the purely risk-sharing function undertaken by this program may be less critical at present than what it was at its inception.

Each incubator is structured so as to handle 10 – 15 projects simultaneously, and provides assistance in the following areas: determining the technological and marketing applicability of the idea, drawing up an R&D plan and organizing the R&D team, raising

¹⁰ In addition to the sources already mentioned, we drew material for this section from the internet site of the program, www.incubators.org.il

capital and preparing for marketing, provision of secretarial and administrative services, maintenance, procurements, accounting, and legal advice.¹¹

To qualify, projects must be aimed at developing an innovative idea with export potential. The R&D team is to be made of 3-6 workers, and the stay at the incubator is of up to two years. The expectation is that by the end of the period there would be a prototype and an orderly business plan, and the project should be ready for further commercial investment and/or the involvement of a strategic partner. The budget for each project is of about \$150,000 per year, for two years at most.¹² As with the regular OCS program, the ensuing products have to be manufactured in Israel, and if successful the entrepreneur has to eventually repay the grant through “royalties” on sales.

Since its inception in 1991 and up to end of 1998, the incubators have managed close to 700 projects, of which about 200 were still running as of December 1998 in 27 incubators across the country. Current projects employ about 900 professionals, 70% of them recent immigrants, all with academic training and many with high degrees. Of the 500 “graduating” projects, the success rate was about 50%, i.e. half managed to continue on their own, the remaining half were discontinued. About 200 projects (out of the successful half) managed to attract additional investment, ranging from a mere \$50K, to several \$ million. There are no pre-determined technological areas for the submission of projects. The actual distribution of projects by fields has been as follows: Electronics 27%, Software 20%, Medical instrumentation 17%, Chemistry 27%, Miscellaneous 9%.

I.2.4 International Cooperation

The relative advantage of Israel’s High-Tech sector manifests itself primarily in its technological prowess in the R&D stages. However, Israeli High-Tech companies

¹¹ Each incubator is an autonomous not-for-profit organization. Day to day operations are run by a professional (salaried) manager, and next to her operates a projects committee that selects and monitors the projects. These committees are composed of professionals from industry and academia, e.g. corporate executives, R&D managers, professors, etc. Committee members volunteer their time and expertise and do not receive any financial compensation.

¹² The budget for the incubator’s administration is of \$175,000 per year. This includes the incubator manager's salary, administrative expenses, outlays for sorting and studying of ideas, and organizational expenses for project commercialization and marketing.

suffer from serious difficulties in marketing abroad, primarily because of geographic distance from the target markets, and their relatively small size. Thus, cooperation with foreign companies active in the target markets is likely to increase the ability of Israeli technology and products to penetrate global markets. In that spirit, the Israeli government has signed in recent years a number of bilateral R&D cooperation agreements with foreign governments. These are meant to encourage contacts between Israeli and foreign companies leading to joint R&D, manufacturing and marketing. Foreign companies are expected to benefit by gaining access to advanced Israeli technology, and they are also likely to derive commercial advantages from Israel's simultaneous free trade agreements with the U.S. and the European Union (few countries enjoy both).

Joint ventures between Israeli and foreign companies, authorized by the relevant authorities in the respective countries, are entitled to aid from both governments according to the regulations prevailing in each. Bilateral agreements exist already with a number of countries, including the U.S., Canada, France, Holland and Spain; their implementation is the responsibility of the Chief Scientist, assisted by "MATIMOP" – The Israeli Industry Center for R&D.

The BIRD Program

The Israel-U.S. Binational Industrial Research and Development Foundation was founded in the early 1980s under a convention signed by both governments. Its objective was to "promote and support joint, non-defense, industrial research and development activities of mutual benefit to the (private sectors of the) two countries." The Foundation has an independent legal status and its main office is in Israel. Its Board of Governors is comprised of representatives of the U.S. and Israeli governments.

BIRD participates in the funding of joint R&D via "conditional grants" amounting to 50 percent of the project costs, up to a maximum of \$1.5 million per project. If a project succeeds, BIRD receives royalties – a pre-tax expense to the payer – up to a maximum of 150 percent of the conditional grant. Only in cases where a project fails and there are no sales are the companies exempted from repaying the grants. BIRD also helps

Israeli or American companies identify partners in order to enable them to submit joint R&D programs for funding by the Foundation.

I.3 Quantitative Indicators of OCS Support Programs

Systematic data on the OCS are hard to obtain, and in fact there are virtually no “official” statistics on the activities and budgets of the OCS since its creation in 1969. The lack of data has been detrimental to the functioning of the OCS and has surely impaired the formulation of R&D policy at all levels. The OCS is well aware of the problem, and efforts are currently being made to remedy it in a fundamental way. The data presented here are based on reports supplied to us by the OCS in January 2000,¹³ but there still remain question marks regarding some of the figures, and hence these should be seen as tentative data, that require further scrutiny.

The dollar figures in coming tables are all in *current* \$ - in order to transform them to *constant* \$ one would have to construct an appropriate R&D deflator, of which the main component should be of course the dollar cost of R&D personnel, such as wages of engineers and technicians. We do not have at present such deflator, and hence we opted to leave the figures in current \$, rather than resort to arbitrary (and potentially deceiving) deflation procedures.¹⁴ Thus, all statements henceforth based on or implying comparisons of dollar figures across time need to be qualified, in that dollar figures of different years are not strictly comparable.

Table 2 shows the OCS budget since 1988, as well as paybacks, and the amounts allocated to the Magnet and Incubators program. Total R&D grants administered by the OCS increased steeply since 1988 and up to the mid 1990s, then increased slightly until 1997, and have changed little since. Paybacks have risen very fast throughout the whole period,¹⁵ and in fact their weight in the OCS budget has increased dramatically from a mere 7% in 1988 to 32% by now. What this means is that about 1/3 of the present OCS

¹³ The data comes from the office of Lidia Lazens of the OCS, and was supplied by Shai Goldberg.

¹⁴ A common practice is to deflate just by the rate of inflation in the US, but such deflator is in fact irrelevant for the case at hand.

¹⁵ The projections for 2000 indicate that paybacks may have stabilized by now.

budget just constitutes “*recycling*” of funds within the *High-Tech sector, and not Government subsidy to R&D*. The net subsidy is given in column 4 under “Net Grants”: these peaked in 1995, and have since declined slightly (certainly more so in real terms). Furthermore, if we subtract the funds allocated to the Magnet and the Incubators programs, we can see that the *net* subsidy to the *regular* OCS Grants program has declined very substantially since 1995 (by about 25% in nominal terms up to 1999).

Table 3 shows the number of firms applying to the OCS for grants, total as well as first timers. Both peaked in 1994 and have declined substantially since. The decline includes, quite surprisingly, also start-ups that applied for the first time.¹⁶ Given the rapid growth in the overall number of startups throughout the economy,¹⁷ the decline in the number of first-time startup applicants may well reflect a change in their funding strategy, that is, more of them may prefer to rely on venture capital funds rather than on the OCS (without “strings attached” in terms of production in Israel or the eventual sale of the firm to foreign corporations).¹⁸ It is worth noting that in the course of the 1990s a total of 2,380 firms applied for support from the OCS for the first time. This is a large number by any standard, and offers further indication of the prominent role that the OCS has played in fostering the High-Tech sector.

Tables 4 (a) – (c) show the distribution of projects and grants by size of firms.^{19,20} The annual number of projects supported averaged 1,300 for the past 5 years, declining from a high of 1,500 in 1995 to 1,200 in 1999.²¹ On the other hand the average \$ amount per project increased from \$227,000 in 1995 to \$368,000 in 1999 (in nominal terms).

¹⁶ Start-ups are defined by the OCS as firms of up to 3 years of age.

¹⁷ Once again, there are no official figures in that respect, but all indications are that startups have mushroomed in Israel since the mid 1990s. In fact, a recent newspaper report based on the number of startups that hired the services of accounting firms claimed that in 1999 alone 1,500 new startups were formed.

¹⁸ This might also reflect a change in the technology mix of the newcomers, with more of them in Internet applications that represent novel business models rather than novel technology, and hence that may not qualify for support from the OCS.

¹⁹ “Large firms” are defined by the OCS as those with over \$100 million in sales; startups refer to firms of up to 3 years of age.

²⁰ In table 4 some dollar series are aggregated into 5-year totals: these sums obviously don’t mean much since the figures are in *nominal* \$, but may still be useful as ballparks to compare across firms of different sizes.

²¹ This figure refers to projects *approved*. In fact, the average number of projects applied for is about 1,800.

Table 2
The OCS Budget 1988 – 2000
(in current \$ million)

	(1)	(2)	(3)	(4)	(5)	(6)
Year	R&D Grants	Paybacks	Paybacks/ Grants	Net Grants *	Magnet	Incubators
1988	120	8	0.07	112	-	-
1989	125	10	0.08	115	-	-
1990	136	14	0.10	122	-	-
1991	179	20	0.11	159	0.3	3.6
1992	199	25	0.13	174	3.7	16
1993	231	33	0.14	198	4.6	23
1994	316	42	0.13	274	10	28
1995	346	56	0.16	290	15	31
1996	348	79	0.23	269	36	30
1997	397	102	0.26	295	53	30
1998	400	117	0.29	283	61	30
1999	428	139	0.32	289	60	30
2000**	395	128	0.32	267	70	30

* R&D Grants minus Paybacks.

** Estimates

Table 3
No. of Firms Applying for R&D Grants

Year	No. of Firms Applying	First-Time Applicants	
		Total	Start-Ups
1990	451	216	34
1991	576	264	109
1992	626	241	165
1993	661	245	179
1994	777	291	218
1995	715	236	146
1996	705	257	200
1997	643	200	170
1998	629	222	165
1999	598	208	138
<i>total</i>		2380	1524

Table 4 (a)
No. of Projects Approved
by size of firms

Year	Large	Small & Medium	<i>of which Startups*</i>	Total
1995	219	1303	357	1522
1996	212	1170	314	1382
1997	207	1045	270	1252
1998	266	1009	285	1275
1999	202	960	245	1162
Total	1106	5487	1471	6593

Table 4 (b)
Grants (in current \$M)
by size of firms

Year	Large	Small & Medium	<i>of which Startups*</i>	Total
1995	144	202	62	346
1996	149	199	66	348
1997	161	236	67	397
1998	157	243	60	400
1999	99	329	68	428
total	710	1209	323	1919

Table 4 (c)
Average Grant/Project (in \$thousands)
by size of firms

Year	Large	Small & Medium	<i>of which Startups*</i>	Overall mean
1995	658	322	174	227
1996	703	366	210	252
1997	778	466	248	317
1998	590	463	211	314
1999	490	643	278	368
mean	642	440	220	291

*not including incubator projects

Notice though that the average size of projects for *large* firms declined quite steeply, whereas that of small and medium firms increased a great deal. Large firms commanded about 40% of grants (in \$ terms) for most of the period, but their share of the budget declined steeply in 1999, to 23%.^{22,23}

I.4 The OCS and the Rise of the High-Tech Sector

So far we have described the structure and programs of the OCS, and presented quantitative indicators of its activities over time. The natural questions that one would like to pose now are those related to the *impact* of the OCS, e.g. to what extent has the OCS fulfilled the goals envisioned by the 1985 Law? What effect have the various OCS programs had on the High-Tech sector and on the economy at large? And so forth. We review first existing econometric studies, we then discuss some economic indicators contrasting R&D-intensive sectors to traditional ones, and lastly we present an overview of the rise of the High-Tech sector in Israel with the aid patent data.

I.4.1 Review of Econometric Studies

The consensual view in Israel is that the OCS played indeed a key role in the emergence and development of the High-Tech sector, a role that went beyond the mere administration of grants. There have been various studies in Israel examining inter alia the impact of R&D expenditures on productivity at the firm level (Bregman, Fuss and Regev, 1991, Griliches and Regev, 1995, Bregman and Merom, 1998). They all find that the returns to R&D have been high, and in particular significantly higher than investments in physical capital. However, these studies do not address the effect of government support per se.

If one could assume that OCS grants brought about higher *total* R&D outlays (this is commonly referred to as “additionality”), then the findings of high returns to R&D would imply also positive returns to government support. Capital markets were extremely

²² This was a conscious policy decision by the OCS, meant to cope with the excess demand for support in view of the budget cap imposed by the Treasury.

²³ A report prepared for the OCS in 1999 claimed that large firms commanded 56% of the OCS budget during the period 1985-94. If so there is a declining trend, beyond the one-time policy shift in 1999. However, the figures are not strictly comparable, and hence we cannot assert this with certainty.

limited in Israel during the early stages of development of the High Tech sector in Israel (i.e. in the 1970s and 1980s), and hence it is very unlikely that R&D grants supplied by the OCS would have crowded out private R&D funds back then. Later on though internal reform as well as international openness greatly increased the availability of funds to industry, and hence the issue of additionality remains open (at least for the 1990s), and with it the effect of government support through that channel.

Taking a different track, Griliches and Regev (1999) examine whether the source of R&D funds per se (private vs. OCS grants) makes a difference on productivity (once again in a panel of firms), regardless of additionality. They find that it does: government-funded R&D appears to be significantly more productive than privately- financed R&D, by a surprisingly large margin. The reason may be rooted in the ability of the OCS to “pick winners”, and/or in the fact that the very process of applying for grants may compel firms to self-select projects, use more structured pre-assessment and planning techniques, etc. Finally, an unpublished study commissioned by the OCS itself examined the contribution of OCS grants to sales, exports, and the like, relying on detailed data from the OCS and on an extensive survey of firms (Michloll, 1999). The study finds very high “multipliers” per dollar of OCS support, higher for small firms than for large ones; however, the study is careful to point out to its limitations, particularly given the lack of a suitable control group.

The evidence thus far available from these studies provide then econometric support, albeit limited, to the presumption that OCS grants have had a positive and significant impact on productivity in R&D-intensive sectors, and through them on the economy as a whole. Still, there is a long way to go in that respect, if only because a major ingredient of the rationale for government support to R&D, namely spillovers, has not been investigated at all. Beyond the aforementioned studies, we present now some evidence on the development of the High-Tech sector itself, with the implicit understanding that the OCS was one of the main drivers behind the raise of this sector. We do that in two ways: first, we briefly recount reports from the Bank of Israel on the performance of technological advanced sectors vis a vis traditional ones; second, we

present an overall view of innovation in Israel, relying on comprehensive and highly detailed information on Israeli patenting in the US.

I.4.2 Aggregate Sectorial Indicators²⁴

Responding to the rapid changes in the composition of industry, and in particular the raise of the High-Tech sector, the Research Department of the Bank of Israel introduced in the mid 1990s a new classification of the manufacturing sector: it was divided into “advanced”, “traditional” and “mixed” sectors, according to the quality and composition of the labor force (e.g. the percentage of scientists and engineers), the quality of the capital stock, and the relative size of the R&D stock.²⁵ Table 5 presents selected indicators according to this classification.

The advanced sectors outperformed the two other categories in virtually all dimensions during the reported period (1995 – 98). The differences between them increased substantially in 1997 and 1998, a period characterized by a rather severe recession. During those years the advanced sectors grew at a rate of 6% per year, whereas the others remained stagnant or declined. Similarly, exports from advanced sectors grew at a stunning 18.5% per year, whereas the mixed sectors exhibited an anemic 3% growth, and the traditional sectors *declined* 1.4%. Thus, it is clear that Israeli manufacturing is shifting away from traditional industries and into technological advanced, export oriented sectors.

²⁴ See also Israel CBS (1999a) for further detailed statistics on “advanced” versus traditional sectors.

²⁵ Thus the advanced sectors include for example electronics and electrical, the mixed sectors construction-related industries, and the traditional ones textiles and apparel.

Table 5
Performance Indicators by Type of Sector
 Annualized rates of change, 1995 - 98

Indicator	Period	Sector		
		Advanced	Mixed	Traditional
<i>Production</i>	1995-96	8.0	6.3	5.9
	1997-98	6.0	0.3	-1.8
<i>Labor Productivity</i>	1995-96	3.5	2.4	4.2
	1997-98	4.5	0.6	2.2
<i>Capital Stock</i>	1995-96	10.7	6.4	9.7
	1997-98	10.0	6.1	6.8
<i>Exports</i>	1995-96	9.0	10.5	2.7
	1997-98	18.5	3.0	-1.4
Source: Bank of Israel, Annual Report for 1998, table B 10 (page 56).				

I.4.3 Innovation in Israel: Patent Indicators²⁶

Patent-based statistics are often used as indicators of innovative activity. Indeed, their very wide coverage, long time series and richness of detail make them a unique and compelling data source for the study of Technical Change. There are also limitations: not all innovations are patented, both because of failure to meet patenting requirements, and because of strategic considerations. We present in this section an overview of innovation in Israel based on all patents awarded to Israeli inventors in the US, during the period 1968 - 97 (over 7,000 patents), as well as patents of comparison countries. Given that the High-Tech sector in Israel is overwhelmingly export-oriented, and that the US is a prime destination for those exports, there is reason to believe that Israeli patents issued in the US are representative of the main technological trends and patterns in Israel.

Figure 1 shows the number of successful Israeli patent applications in the US over time, starting in 1968. The growth in the annual number of patents has been very impressive, starting from about 50 in the late sixties, to over 600 in the late 1990's. However, the process was not smooth, but rather it was characterized by big swings in growth rates. Particularly striking are the two big jumps that occurred in the second half of the period: from 1983 to 1987 the number of patents doubled, and then they doubled again from 1991 to 1995.²⁷ Figure 2 shows industrial R&D expenditures (in constant 1990 \$) along with patents.²⁸ There is clearly a (lagged) co-movement of the two series, as manifested for example in the following simple Pearson correlations:²⁹

²⁶ This section consists of excerpts from Trajtenberg (1999).

²⁷ The in-between “flat” period of 1987-91 (which represents R&D activity done *circa* 1985-89) presumably reflects the big macro adjustment and micro restructuring that followed the stabilization program of 1985.

²⁸ The R&D figures are from Griliches and Regev (1999), table 1. Since these refer to *industrial* R&D, it may be more appropriate to relate them to Israeli *corporate* patents than to total patents. In practice the two patent series move pretty much in tandem, and hence the correlations with R&D of either series are virtually the same.

²⁹ Patent applications reflect (successful) R&D conducted *prior* to the filing date, with lags varying by sector. Thus, the number of patents in a particular year should be attributed to investments in R&D carried out in the previous 1-2 years at least, and in some sectors further back.

Figure 1
Israeli Patents in the US - 1968-97
by Application Year

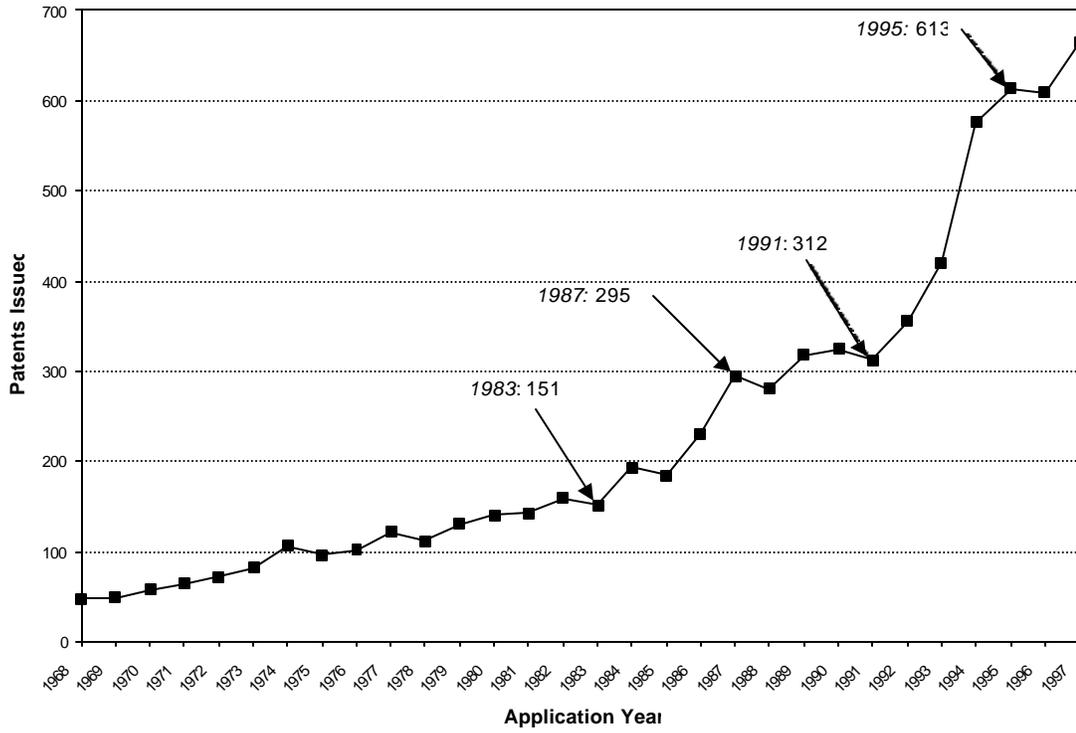
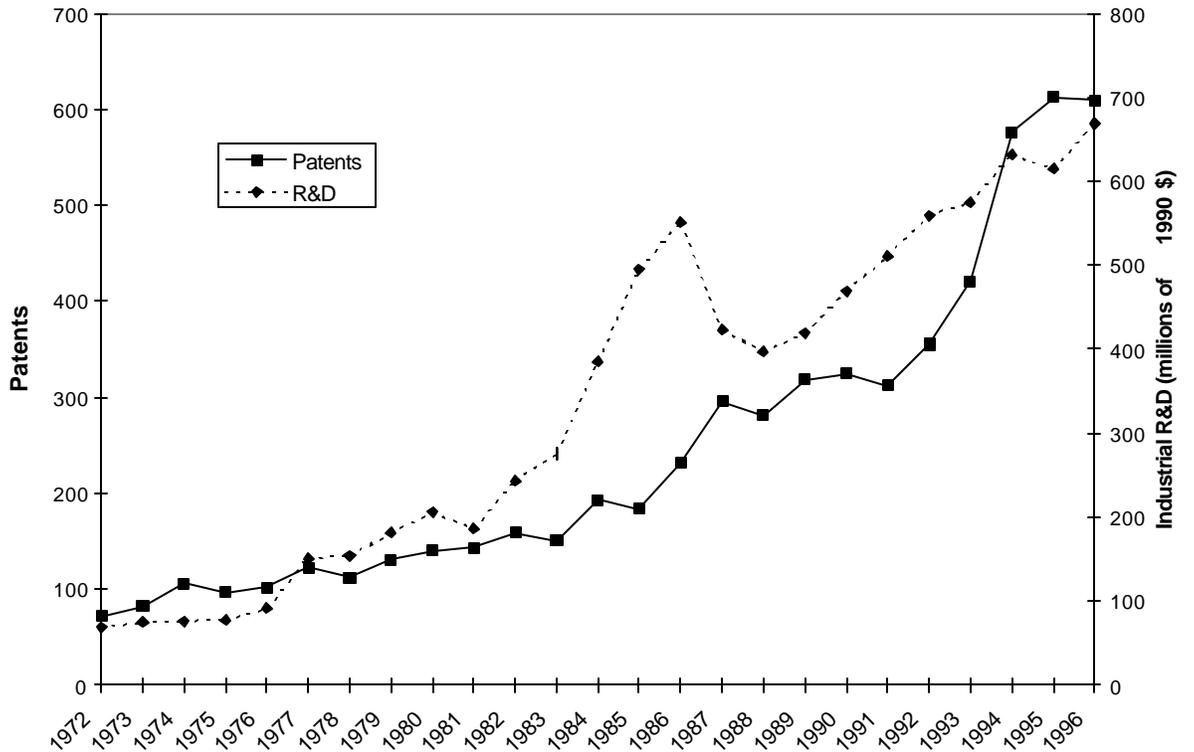


Figure 2
Israeli Patents and Industrial R&D



	R&D	R&D(-1)	R&D(-2)	R&D(-3)
Patents	0.850	0.877	0.884	0.883
Log(patents) with Log(R&D)	0.890	0.901	0.922	0.928

Thus, patents lead R&D by 2-3 years, and the correlation is stronger in rates (i.e. when using logs) than in levels. Looking in more detail, there is a striking run up in R&D from 1981 to 1986 (in particular, R&D expenditures more than doubled between 1980/81 and 1984/85), followed by the doubling of patents between 1983 and 1987. This is the period that saw the emergence of the High-Tech sector, and that is well reflected in both series. In 1986-88 we see a decline in the level of R&D spending, and the concomitant flattening of patenting in 1987-91, and then again a sustained increase through the early-mid nineties that anticipates the second big jump in patenting.

Although we do not have “official” figures for R&D grants from the OCS prior to 1988, available figures indicate that the behavior of the time series for grants move very closely to that of total R&D industrial spending (see for example Griliches and Regev, 1999, table 6). In particular, from 1981 through 1986 OCS grants also doubled, they flattened during 1986-88, and they grew fast again up to the mid 1990s (see Table 2 for the latter). It is clear then that industrial R&D expenditures are closely linked (with a reasonable lag) to patents, and so are R&D grants awarded by the OCS. Further research is needed to unravel the joint dynamics.

International Comparisons

We resort to international comparisons in order to put in perspective the overall level and trend over time in Israeli patenting. We do that with respect to 3 different groups of countries: (1) The G7: Canada, France, Germany, Italy, Japan, UK and USA;

(2) a “Reference Group”: Finland, Ireland, New Zealand and Spain;³⁰ and (3) the “Asian Tigers”: Hong Kong, Singapore, South Korea and Taiwan.

Figures 3-5 show the time patterns of patents per capita for Israel versus each of the above groups of countries. We normalize the number of patents by population, simply because this is a widely available and accurate statistic that provides a consistent scale factor.³¹ Figure 3 reveals that Israel started virtually at the bottom of the G7 (together with Italy), but by 1987 it had climbed ahead of Italy, UK, and France and was in par with Canada. In the early-mid nineties it moved ahead of Canada and (the unified) Germany, thus becoming 3d after the USA and Japan. Using civilian R&D as deflator for these countries show a similar result. Thus, there is no question that Israel had surged forward and placed itself in the forefront of technological advanced countries, at least in terms of (normalized) numbers of patents.

The comparison with the Reference Group reveals that the only country that is “game” is Finland, which has followed a pattern virtually identical to Israel. The other 3 countries are well behind, and have remained at the bottom without any significant changes over time. As to the Asian Tigers, we can see immediately that Taiwan has grown extremely rapidly since the early eighties, actually surpassing Israel as of 1997. And indeed, Taiwan is widely regarded today as a High-Tech powerhouse, after being associated with low-tech, imitative behavior for a long time. South Korea seems to be embarked on a similar path. By contrast, Hong Kong and Singapore remain well behind.

Comparisons based on *normalized* patent counts notwithstanding, many aspects of the innovation process require a “critical mass”, and for those purposes it is the *absolute* size of the innovative sector that counts, as proxied here by the (absolute) number of patents. Israel has still a long way to go in those terms: it stands well below all

³⁰ The Reference Group was chosen according to their GDP per capita in the early 1990’s, that is, we chose the 4 countries that had at that time a level of GDP per capita closest to that of Israel (in ppp terms). Notice that, except for Spain, the other 3 countries in this group are very similar to Israel also in terms of population.

³¹ Another normalization of interest would be R&D expenditures, but except for the G7, the figures for the other countries are far from satisfactory

Figure 3
Patents per Capita: Israel vs. the G 7

(patents per 100,000 population)

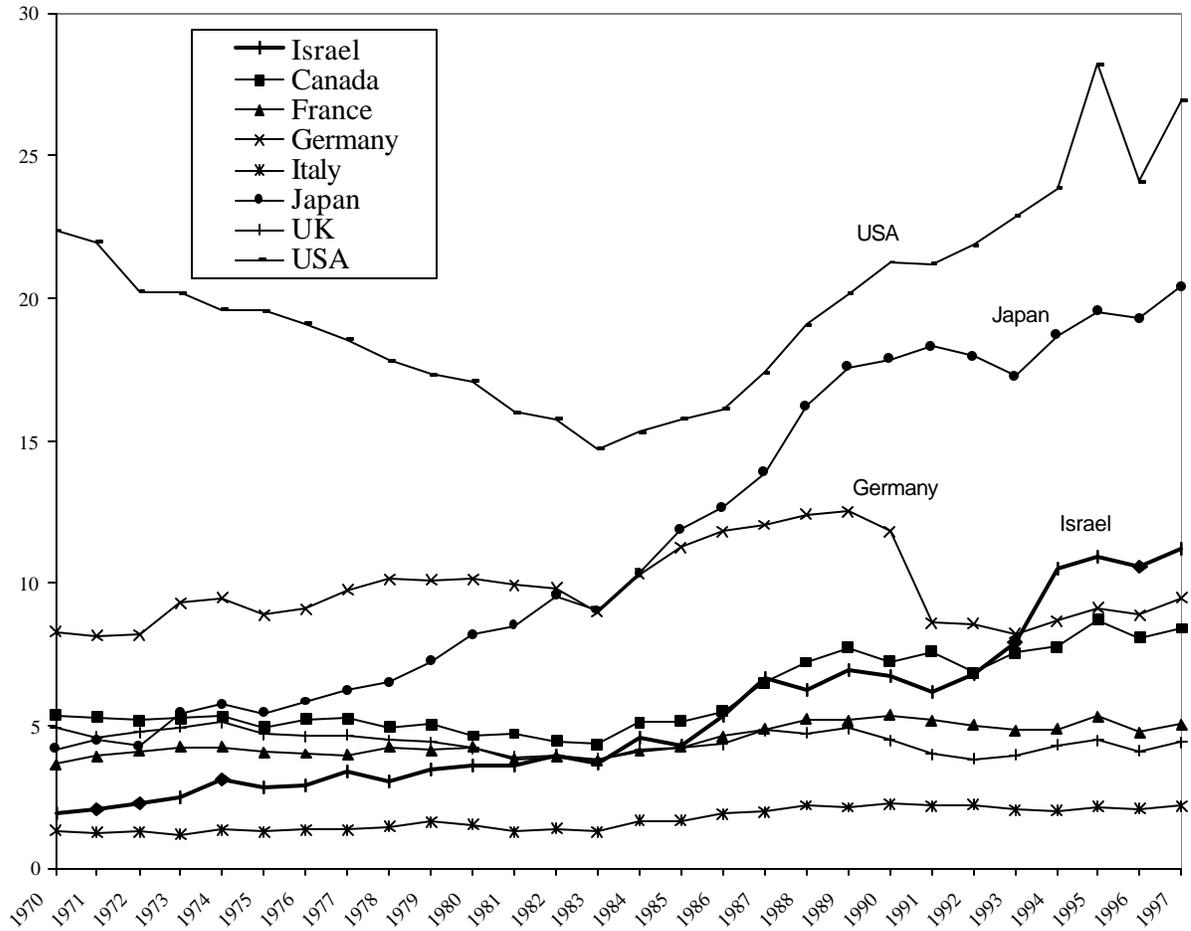


Figure 4
Patents Per Capita: Israel vs. the Reference Group

(patents per 100,000 population)

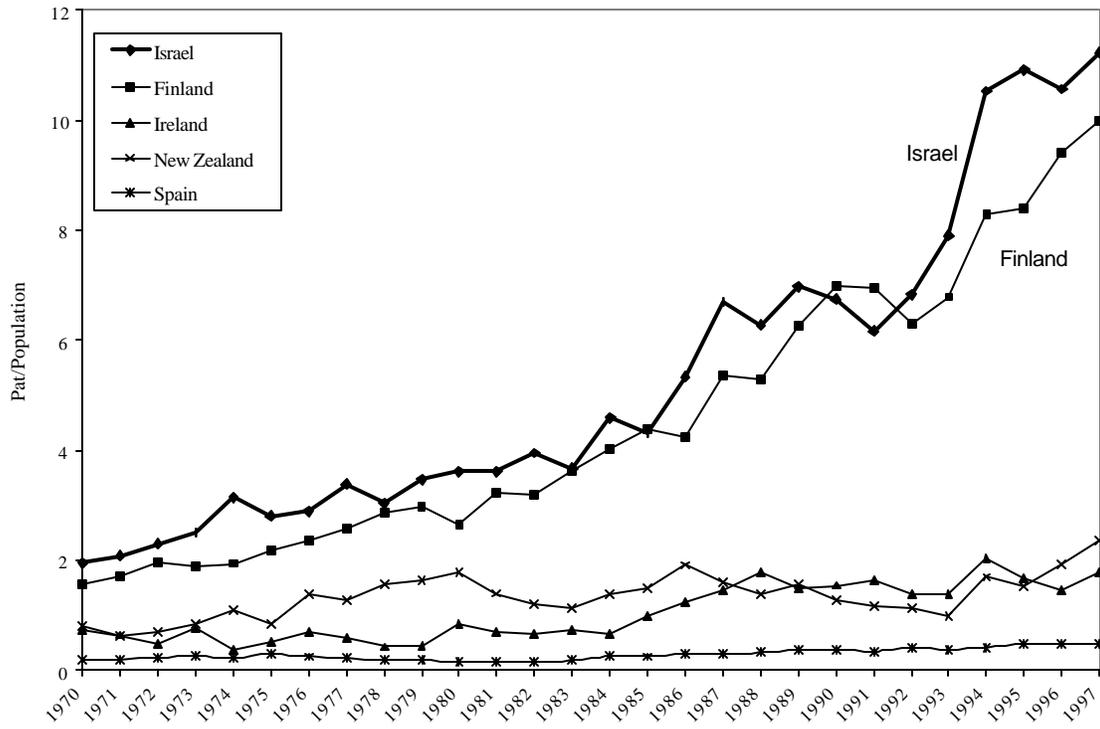
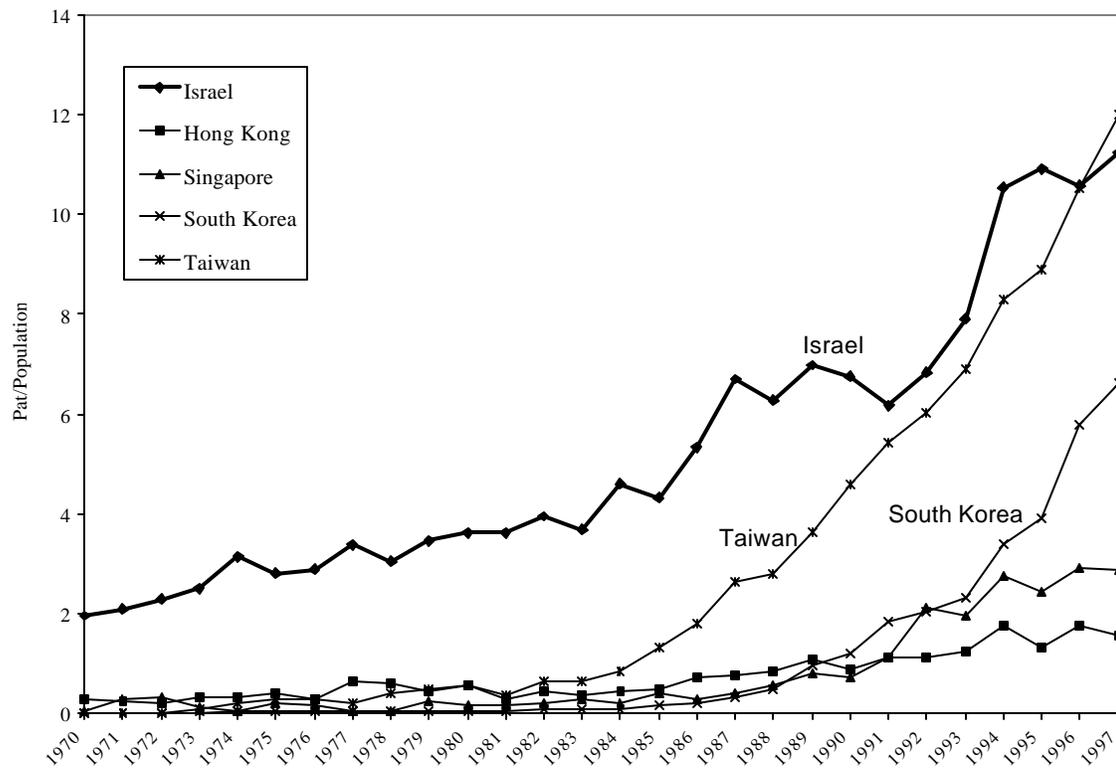


Figure 5
Patents Per Capita: Israel vs. the NI



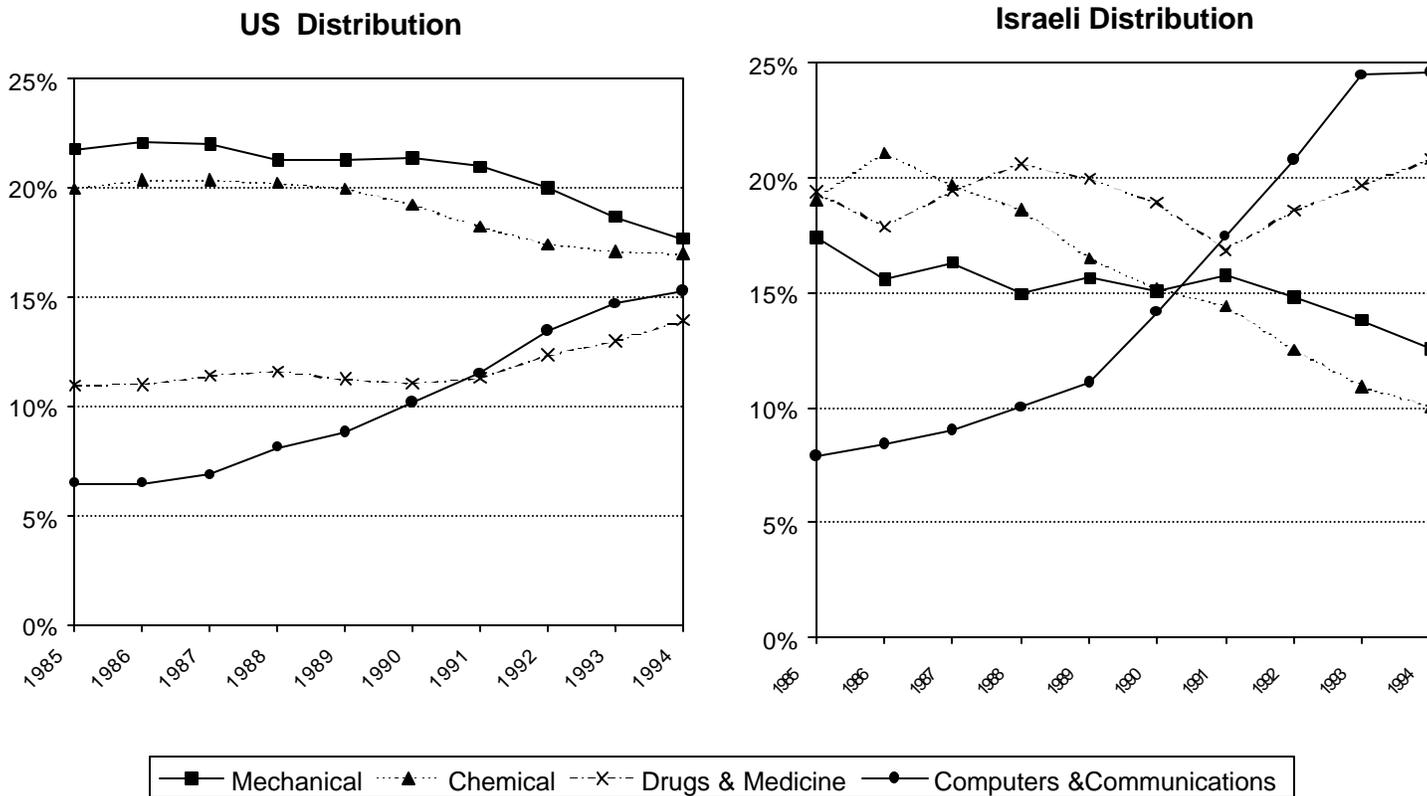
of the G7 countries, and is about ¼ the size of Taiwan and South Korea. The question is whether there are forces in the Israeli economy capable of keeping the momentum going for the High-Tech sector, bringing it up to the size required and ensuring its long-term viability. The stagnant budgets awarded in recent years to the OCS are not a good omen in that respect.

The Technological Composition of Israeli Patented Innovations

The US Patent Office has developed over the years an elaborate classification system by which it assigns patents to some 400 main patent classes, and over 150,000 patent subclasses. We have developed recently a new classification scheme, aggregating these 400 patent classes into 6 main categories: Computers and Communications, Electrical and Electronics, Drugs and Medicine, Chemical, Mechanical and Other. Figure 6 shows the shares of these categories over the decade 1985-94, for Israel and for the US. Up until the early 1980s the picture was quite stable in the US: the shares of Mechanical and Other were highest (over 25% each), whereas Drugs and Medicine and Computers and Communications accounted just for a tiny fraction, up to 5% each. Starting in the early 1980s this static picture starts to change: the 3 top fields decline, whereas the bottom two surge forward, with Computers and Communications accounting by 1994 for over 15% of all patents.

The pattern for Israel is similar, except that the changes are more abrupt. The most striking development is the surge of Computers and Communications from about 5% in the 1970's (as in the US), to a full 25% by 1994 and beyond. Likewise, Drugs and Medicine doubles its share from 10% to 20%. The flip side is the much more pronounced decline in the traditional categories, with Chemicals exhibiting by far the sharpest drop, from 40% at the beginning of the period, to less than 10% by 1996. The composition of innovations has thus changed dramatically in Israel, and seemingly in a healthy way, in the sense that they are in tandem with worldwide changes in technology, except that Israel is experiencing them at an accelerated rate.

Figure 6
US vs. Israel Tech Categories - 1985-94



Who owns, and who benefits from israeli patented innovations?

The patent-based indicators mentioned so far suggest that Israel's innovative performance has been quite impressive. However, the question arises as to whether the Israeli economy can take full advantage of the innovations generated by Israeli inventors, in view of the composition of the patent assignees, i.e. of the owners of the intellectual property rights to those innovations. In fact, just about half of all Israeli patents granted in the last 30 years are owned by Israeli assignees (corporations, universities or government): the rest belongs to private inventors ("unassigned" patents) or to foreign assignees. This percentage is lower than most of the comparison countries, certainly much lower than the corresponding figure for the G7 countries except Canada (local assignees made 74% of patents in the US, 96% in Japan). The presumption is that (local) economic gains from innovation are correlated with this figure, and furthermore, that they are correlated with the percentage of patents owned by local *corporations* (just 35% in Israel). The trend is encouraging though: the percentage of patents that belong to Israeli corporations has been raising steadily, and stands now at close to 50%.

The overall picture that emerges from these patent indicators is thus mixed: on the one hand Israel exhibits a rapidly growing and vibrant innovative sector, that has achieved an impressive international standing. On the other hand, the Israeli economy has still a way to go in order to achieve "critical mass" and to realize the economic benefits embedded in those innovations.

Part II

R&D Policy in Israel - A Reassessment³²

After having described the programs and basic ingredients of R&D policy in Israel towards the industrial sector, we now undertake to examine the contents of such policy. Unfortunately, the lack of rigorous empirical research in this area hampers the formulation of sound, long term and well-grounded policies. Nevertheless, we shall suggest changes to the policy currently in place and to the implementation mechanisms, which seem imperative in light of current developments. Needless to say, this should be seen just as a tentative beginning, aimed primarily at fostering public debate in this area (see also Teubal, 1999, who lays out a detailed proposal for an R&D Strategy for Israel).

The examination will consist of four parts. First, we look at the present system by which grants are allocated: with the recent imposition of a rigid budget constraint on the OCS, the present system is basically untenable, and hence we examine various alternatives that will incorporate this new reality. Second, we examine a series of policy issues that go beyond the allocation of funds: the payback system, the conditionality on production in Israel, etc. Third, we look in detail into the Magnet program, and the rationale for supporting it versus the regular OCS grants. Lastly, we tackle the issue of how much R&D Israel should do, and what that implies in terms of overall government support.

II.1 Rethinking the Rules of the Game in View of a Rigid Budget Constraint

II.1.1 Background

The R&D Law in Israel does not address the thorny issue of how to allocate a (rigid) budget for R&D support if the demand for such support exceeds the budget provision. That is, the OCS support program was not meant to be competitive, and in principle it should provide with R&D subsidies to *all* projects that pass the eligibility

³² As mentioned in the Introduction, a great deal of research on R&D policy has been done recently. Aside from the references mentioned there, see also David et al (1999), Hunt and Tybout (1998), Klette and Moen 1998a and 1998b.

criteria. The latter are based on technological and commercial feasibility, and other procedural considerations. Projects are judged one by one, and there is no attempt to rank them or establish otherwise a funding priority. The paramount principle of “neutrality” that has been a cornerstone of R&D Policy in Israel since the late 1960s precludes also picking projects according to fields or any other such consideration.

In 1997 the projected demand for R&D support greatly exceeded the budget provision (by about 50%, i.e. some \$200 million), and the Treasury refused to consider any substantial increase to the OCS budget to accommodate such demand.³³ An impasse ensued, bringing a great deal of uncertainty to the working of the OCS and to the High-Tech sector as a whole. A committee was formed to try to find a way out of the crisis. After months of deliberations the committee could not reconcile the conflicting forces at play: on the one hand the imperatives of the existing law, the expectations of the High-Tech sector based on it, and the perceived need to expand the R&D support budget in order to accommodate and foster the success of the High-Tech sector; and on the other hand the sudden imposition of a rigid budget constraint, that did not allow for any growth of demand.

The result has been ad hoc tinkering both with the OCS budget and its way of operation, in order to keep the system running without solving the underlying issues. More importantly, this protracted crisis made it clear that the R&D law as is, and the implementation mechanisms in place, are in need of extensive revision in view of the explosive growth of the High-Tech sector (as well as the rapid changes that took place within the sector), and the pressure that puts on the R&D support budget in an era of fiscal restraint.³⁴ Following is a discussion of the set of policy issues that lie at the core of this conundrum. The basic premise underlying the discussion is that, if current procedures

³³ Apparently this was the first time in the history of the OCS that demand exceeded the budget provision by a substantial amount.

³⁴ Indeed, in January 2000 the Government initiated a move aimed at revising the R&D Law, in view of this fundamental conflict, as well as of the dramatic changes that have taken place in the High-Tech sector.

are left unchanged, demand for R&D support will exceed present level budgets by wide margins,³⁵ and hence there is an urgent need to design a suitable allocation mechanism.

There are essentially two ways to go about allocating a fixed budget to projects that request support in excess of available resources. The first is to depart from the principle of neutrality in some dimension, the second to design an allocation mechanism that would do the job. Of course, the two are not mutually exclusive, and one could have a combination of both. We consider each in turn, starting from the latter.

II.1.2 Allocation schemes for the regular OCS program of R&D grants

Until now the system has been such whereby all eligible projects are supposed to be supported, and in principle the support should be equal across projects (in percentage terms). The eligibility criteria entail checks of technological and commercial feasibility (or “viability”), the good standing of the applicants, and other administrative criteria. There are three main options to move away from such system: (i) to adjust every time the support rates or the eligibility criteria so as to meet the budget constraint; (ii) to implement a competitive/ranking system; (iii) randomization.

The first option entails adjusting the support *rates* or the eligibility criteria with every new budget so as to meet the budget constraint. The major drawback is of course the uncertainty that such a policy shift will introduce, greatly impairing the ability of firms to plan ahead (certainly long term). In addition, this would make the whole support system vulnerable to political manipulation.

The second option simply means that projects would have to compete against each other for scarce support funds (as happens with the “Magnet” program). There will be a ranking system, and the funds will be allocated from the top down until the budget is exhausted. A serious issue that will almost certainly arise in such context is whether or not such system is compatible with neutrality, in view of the fact that any ranking system will be extremely hard to implement *across* fields, and the ranking would have to be done

³⁵ Some projections indicate that would be true even if the budget was increased substantially.

primarily *within* fields.³⁶ However, it may be that in any case the system will have to move away from neutrality (see below).

The last option is some sort of randomization, that is, to chose at random from the set of projects that pass some eligibility threshold (as in the present system), up to the point where the budget constraint is met. We shall not analyze this option in any detail, simply because it would seem that it is (at least at present) politically unfeasible.³⁷ Thus, it seems that the only viable alternative at this point is to implement some sort of ranking/competitive system, as suggested above, and tie it with a conscious departure from neutrality.

II.1.3 Departures from Neutrality

As already mentioned, one of the hallmarks and basic premises of the OCS support programs has been all along *neutrality*, that is, the OCS does not select projects according to preferred fields or any such criteria, but responds to demand that arises spontaneously from industry. It is fair to say that such policy has been eminently successful, since it basically reinforced existing competencies and emerging comparative advantage. Moreover, it avoided one of the main potential dangers of any industrial policy, namely, the “picking of winners” by government officials.

However, the fiscal constraint on the overall support budget implies that the OCS may have to depart from neutrality in any case, in which case it is certainly better to do it explicitly as a result of serious analysis, and not by default. There are at least two dimensions along which the OCS could opt for non-neutral allocation policies: according to fields, and according to type (or rather size) of firms.³⁸ As already suggested, such

³⁶ It is quite likely that the present system in actuality is not neutral either, but the lack of neutrality is disguised. In a ranking system the issue raises to the surface and will have to be addressed head on.

³⁷ It is interesting to note that there is a great deal of interest in this policy both in the US and in Europe, and it would seem that at some point some version of randomization will be implemented. One of the great advantages (in the long run) of such a policy is that it allows for methodologically sound assessment studies of the efficacy of government support (since the “control sample” is built in).

³⁸ In fact, it would seem that, while formally neutral, actual support policies favored particular technological areas, primarily electronics, and until the mid 1990s large firms over smaller ones (see below).

departures could be made part of a revamped allocation scheme (e.g. adopting a ranking / competitive system).

Departing from neutrality in terms technological fields is always dangerous, since it implies outguessing future technological and/or market developments, and deciding “by committee” what is better left to the market. Thus, one should avoid it except if there are some glaring market failures that need to be remedied. There is room to believe that may be the case at present in Israel with the field of biotechnology. Israel has a very talented and plentiful scientific workforce in Life Sciences. Yet, this pool of human capital in one of the most dynamic technological areas at present, and potentially one of the most important *future* growth areas, has yet to make a mark on industry (i.e. in biotech). Thus, there is room to consider taking a more active and entrepreneurial attitude towards this sector (not necessarily by channeling more funds to it) but that requires further study.

The second possible departure from neutrality is differential support to firms of different sizes. We discuss this option now in more detail.

II.1.4 Departing from neutrality: Large vs. small firms

In principle, the support policies of the OCS do not make any distinction among types of firms in terms of eligibility for the existing flat rate of support (50% of the approved R&D budget).³⁹ In practice though and as described in Part I, the support for large firms during the past two years has been reduced, reversing the previous trend whereby a handful of very large firms (large by Israeli standards) accounted for a large proportion of the total support dispensed. However, this *de facto* change has been essentially an ad hoc response to budgetary pressures (and hence is likely to be temporary), and not a well formulated policy reassessment. Thus, we still have to examine whether the principle of equal support to all firms regardless of size is a reasonable policy. In other words, the question is whether the rationale for R&D support (in terms of market failures etc.) holds equally for small and large firms. A brief review of the basic economic rationale for support to R&D reveals that indeed there is room to

³⁹ Except for the incubators program, as described in Part I.

(re)consider the prevailing policy, and reduce the rate of support to large firms versus smaller ones.

First, the larger is the firm, the more able it is to internalize the spillovers that it generates, and hence the smaller would be the divergence between the social and the private rate of return on the R&D that it performs. One of the main goals of government support to private R&D is precisely to bridge the gap between the two rates of return: absent that support firms will do too little R&D (relative to the *socially* desirable level), and hence the support is meant to encourage them to increase that amount, pass what is profitable according to the *private* rate of return on it. However, the more a firm manages to capture the spillovers that stem from its R&D projects, the less there is room to subsidize it on that basis. Size matters in that respect: small firms are hardly able to capture the externalities that they generate, but that ability increases as they grow larger.

A further rationale for government support of R&D has to do with risk and risk taking. First, the degree of risk of an R&D project from an economy-wide point of view may be lower than that perceived by private firms; or, closely related, the risk premium demanded by private investors may be higher than “warranted” because of asymmetric information. Second, the degree of risk aversion by private investors may be higher than the social rate. As a result, the market may provide for too little risk taking in R&D, and hence government support would encourage firms to move in the socially desirable direction.

The point in the present context is that there might be substantial differences in this respect between small and large firms. First, problems of asymmetric information are usually more acute for younger/smaller firms, and hence the risk premium that smaller firms are required to pay is often much higher. Second, R&D projects undertaken by small firms are, *ceteris paribus*, riskier than if done by larger firms, even if they are exactly the same in terms of technological goals. This is so because younger/smaller firms are disadvantaged relative to large firms in terms of a wide range of competencies and experience that are *complementary* to R&D, be it in marketing, pure management,

access to complementary know how, etc. Thus, there is more room to subsidize risk taking by small firms than by larger ones.

Lastly, imperfections in capital markets usually affect small firms more than large firms. First, the availability of internal financing, which has been shown to be important in the context of R&D, is normally less constraining for older/larger firms than for smaller ones. Second, access to global capital markets is easier/cheaper for larger firms. Thus, government support to R&D meant to bridge over those imperfections ought to be channeled more towards small firms than to larger ones.

These considerations suggest that the rate of support to small firms should be larger than that given to larger firms. One could envision the following support structure: Going start-ups (up to 5 M\$ sales):⁴⁰ 66%; small to medium-sized firms (5 – 100 M \$ sales): 50% (as at present); large firms (over 100 M \$): 33%. This is of course just an example – a serious proposal would have to pay a great deal of thought to the cut-off levels, the implications for the budget, etc.

II.2 Further Policy Issues

II.2.1 The payback scheme (“Recoupment”)

At present the policy is that successful projects (i.e. projects that eventually lead to sales) are required to pay back to the OCS the amount of support received, but the payback cannot account for more than a small percentage of annual sales.⁴¹ The idea is that this way the OCS shares the risk of the R&D projects (effectively lowering the risk premium that private firms have to pay), and overcomes possible imperfections in capital markets by offering easily accessible finance. Moreover, it subsidizes R&D both in that it demands zero interest on the conditional loan, and in the sense already mentioned of lowering the risk premium. There are, however, serious drawbacks to such a system:

⁴⁰ By start-ups we mean young, small ongoing firms, not those that are still in the “incubator” phase.

⁴¹ The percentage was set at 3%, but there have been several attempts by the Treasury to raise it further (to 4.5%), and even to charge interest on the principal. In fact, the Treasury has been promoting the idea that the grants should turn into a conditional loan, that will serve as a way of overcoming financial constraints by R&D firms, but not as a straight R&D subsidy.

- Since the payback obligation applies to sales that stem directly from the projects supported, this immediately creates moral hazard problems in terms of how projects are defined, and all sort of pernicious incentives as to how to relate products/sales to projects.
- The previous issue implies that the OCS and the firms supported find themselves engaged in an antagonistic/confrontational situation, that is detrimental to the efficient functioning of both.
- As we have seen in Part I, the weight of payback funds in the overall OCS budget is growing steeply over time, and there is a real danger of “political opportunism” in this respect, namely, that the commitment to R&D support may diminish but in the short run that could be disguised by the increased reliance on payback funds in order to support new projects.

Beyond those issues, we oppose the payback scheme because it blurs the real intent of the R&D law, obscuring the true extent of the support budget, and hence the commitment of the government to R&D. The support is warranted for good and sound economic reasons, that call indeed for a *subsidy* to R&D. Contrary to some widely held perceptions, the intent and rationale of the R&D law is *not* for the Government to assume *just* a financing role, in view of imperfections in existing financial markets in Israel. The intent is to bridge the gap between the social and the private rate of return to R&D, and that calls for a straight subsidy. The recent availability of venture capital, and the opening of the Israeli economy to foreign capital markets may reduce the effective cost of capital and perhaps also the risk premiums to Israeli High-Tech firms. However, that has nothing to do with the fact that these same firms generate spillovers to the Israeli economy that they can only partially appropriate, a fact that calls for subsidizing R&D. Once the above is understood, it is then clear why we support the phasing out of the payback scheme: that way the OCS support would become strictly what it should be (and be seen accordingly), namely, a straight subsidy.

II.2.2 The conditionality of production in Israel

At present the R&D Law stipulates that if the OCS extends support to an R&D project, the innovation resulting from it should be produced in Israel. In fact, the Law states as one of its goals to increase employment in such a way. It should be clear that such conditionality might lead to grave allocational inefficiencies. Denote by c_I the costs of producing in Israel, by c_A the costs of producing abroad, and by S the R&D subsidy. It is trivial to show that the firm will choose to take the R&D subsidy, execute the project in Israel and produce here even though production in Israel is more costly, if $c_I - c_A < S$. If the inequality is reversed then the project will be carried out abroad. Denote the cost disadvantage by $S' = c_I - c_A$. In the case where $c_I - c_A < S$, we can see that the R&D subsidy is in fact composed of two parts: $S = S' + (S - S')$. The first part, S' , is then a subsidy to *production*, not to R&D, and only the second part is a true R&D subsidy. The larger is the gap between production costs in Israel versus those abroad, the more we are perverting the character of the subsidy, i.e. the more we are subsidizing inefficient production that should not be located here according to the elementary principle of comparative advantage.

Thus, we suggest that this provision of the law should be annulled: there is no economic rationale for it, and it leads as said to production inefficiencies. Israel presumably has a comparative advantage in R&D, not in the assembly of “boxes” containing the sophisticated innovations that we produce. It should be clear also that if this conditionality is repealed, then the *effective* R&D subsidy could be increased without increasing the actual amount of funds disbursed. Denote by S_N the new subsidy, then one could have $(S - S') < S_N < S$. Of course, the Government can legitimately try to encourage local employment, and see the R&D Law as one of the means to do so. In that case though it should be clear that part of the grants constitute in fact an *employment subsidy*, and should not be counted as R&D support.

II.2.3 Policy changes and support to large firms

We suggested above that the rate of support to large firms should be lower than that to smaller firms. However, we envision the implementation of these policy changes

as a comprehensive package. In that case, while lowering the rate of “nominal” support to large firms, the effective rate may actually increase, both because of the phasing out of recoupment, and of the conditionality to produce in Israel. This latter provision is likely to affect larger firms more than smaller ones, since for larger firms the options and opportunities to produce abroad are much more extensive. As to the payback scheme, it is also likely that the percentage of successful R&D is higher for them, and hence that the payback burden is also disproportionately higher for larger firms. On both accounts then larger firms stand to gain from the repeal of these provisions, thus compensating for the lower support rate.

II.2.4 Ongoing economic assessment and policy making

The drawing of sound economic policies towards R&D, innovation and the High-Tech sector is of paramount importance for the Israeli economy. At present though there is no body in charge of setting such policies, and hence things happen in a rather haphazard way, in response to point-wise pressures and developments. What is needed is an economic policy unit, probably at the OCS, with the following mandate: (1) to collect and organize in a comprehensive and coherent way the data needed for policy making; (2) to set procedures for the ongoing evaluation of the effectiveness of the OCS policies; (3) to evaluate, research and discuss long term policies. It is interesting to note that the Advanced Technology Program in the US, which is the closest to the OCS in terms of intent, has such a unit as integral part of its mission and mandate.

II.3 The Magnet Program versus the Regular OCS Fund

As already mentioned, the Magnet program supports consortia of industrial firms and academia, aimed at developing “generic, pre-competitive technologies” common to the members of the consortia. Magnet finances 2/3 of the R&D budget of the consortia with straight grants, and there is no payback obligation. Contrary to the regular program of the OCS, Magnet selects consortia on a *competitive* basis, and allocates in this manner a budget of about 60 million \$/year to the winning consortia.

One of the phenomena that underlies the need for the Magnet program is the fact that R&D efforts in the Israeli High-Tech sector have been rather fragmented. That is, this sector is characterized by the existence of a very large number of small to medium firms, a handful of large ones (but none with sales of over 1 billion \$), and a great deal of turnover.⁴² There is no question that the vitality, daring and some spectacular successes of the sector owes in no small measure to these features, that provide favorable conditions for an accelerated Darwinian process. On the other hand, these same features call into question the ability of the sector, and of the Israeli economy as a whole, to reap the long term economic benefits from its own success. The recent sales of a series of highly successful Israeli companies to foreign corporations is just one of the manifestations of this syndrome.

Fragmentation was perhaps unavoidable, certainly in the initial stages of development of the High-Tech sector, since the overwhelming majority of High-Tech firms grow out of start-ups established by single technological entrepreneurs. Moreover, most of them aim (at least initially) at narrowly defined market niches. As the sector moves on though size matters: in order to tackle larger markets and contemplate accordingly longer term projects, there is need for larger entities, and that in turn calls for various forms of cooperation, joint ventures, mergers and acquisitions. However, for reasons that we do not profess to understand, too little seems to be happening in that respect *internally* (i.e. within Israel). In fact, we witness time and again not only failures of cooperation, but even serious informational failures, in the sense that potential partners are unaware of the existence of each other, and/or of the potential for mutually beneficial cooperation.⁴³

⁴² Consider that the OCS have dealt with R&D projects of about 3,000 firms in the past 15 years, and keep in mind that, as said before, the whole industrial R&D of Israel amounts to that done by the number 28th R&D spender in the US, 3M (see Table 6).

⁴³ I am a member of the Board of Directors of Magnet, and in that capacity I have witnessed many times this sort of “failures”, not only between firms but also between firms and academia. One of the most striking was the case of the digital printing consortium: the main players involved were unaware until the formation of the consortium of crucial research on properties of ink that was being conducted at some academic institutions in Israel (virtually “next doors”).

Given this background, the importance of Magnet may lie not so much in its formally stated mission (i.e. supporting *generic* R&D), but in the fact that it fosters cooperation, it facilitates the creation of larger (sometimes “virtual”) entities, it disseminates information about possibilities for joint ventures, and it encourages individual firms to seek such information. Contrary to deeply-rooted belief, one cannot just *assume* that if there are profitable opportunities for cooperation they will necessarily be realized - the institutional framework definitely has an impact in that sense.

There is no question that the economic rationale for government support to R&D is strongest for a program such as Magnet, both because of the aforementioned reasons, and because of the more traditional (but equally important) motives, namely, that it deals with “generic” projects and strongly emphasizes the sharing and dissemination of information. Thus, we see a need to further promote Magnet as a policy instrument, and probably to increase the funds that it administers. An important issue (that we shall leave open at this point) is thus the split of the overall R&D support budget between the regular OCS program and Magnet. A reassessment of the relative weight of each is called for, and as suggested we favor in principle a shift away from the regular program thus channeling relatively more funds to Magnet. There are a host of specific issues having to do with the way the Magnet Program is implemented, but we leave that as well for further discussion.

II.4 How Much (Total) R&D?

II.4.1 In search for prompt answers

One of the key policy issues in the context of Science and Technology Policy is of course, how much resources should a country (in this case Israel) allocate to R&D? Once a target has been set, the next question is how to get there, i.e. what sort of government policy will bring the Israeli economy to the desired level (and mix) of R&D spending. In principle, the target R&D level should be derived from a growth target for the economy as a whole, and a thorough understanding of the mechanisms by which R&D impacts growth, versus other forms of investment. This is certainly a worthy topic of research that should be pursued in order to arrive at sound policy making. However, we do not have at

present a good empirical model that could provide us with the necessary ingredients to answer the question as posed. On the other hand, policy making can hardly wait: there is a virtual consensus that the Israeli High-Tech sector is key to growth, and yet government policy towards it for the past few years has been quite erratic, particularly in terms of the budget allocated to R&D support.

This policy vacuum quite likely had already a detrimental effect on the High-Tech sector, and hence prompt action is required. Thus, short of providing full, rigorous answers, we shall put forward here a proposal based on a schematic analysis of R&D spending in Israel, and on international comparisons. We intend it primarily as a starting point for a much-needed debate, that will help focus attention on the main issues.

II.4.2 Background: the basic facts⁴⁴

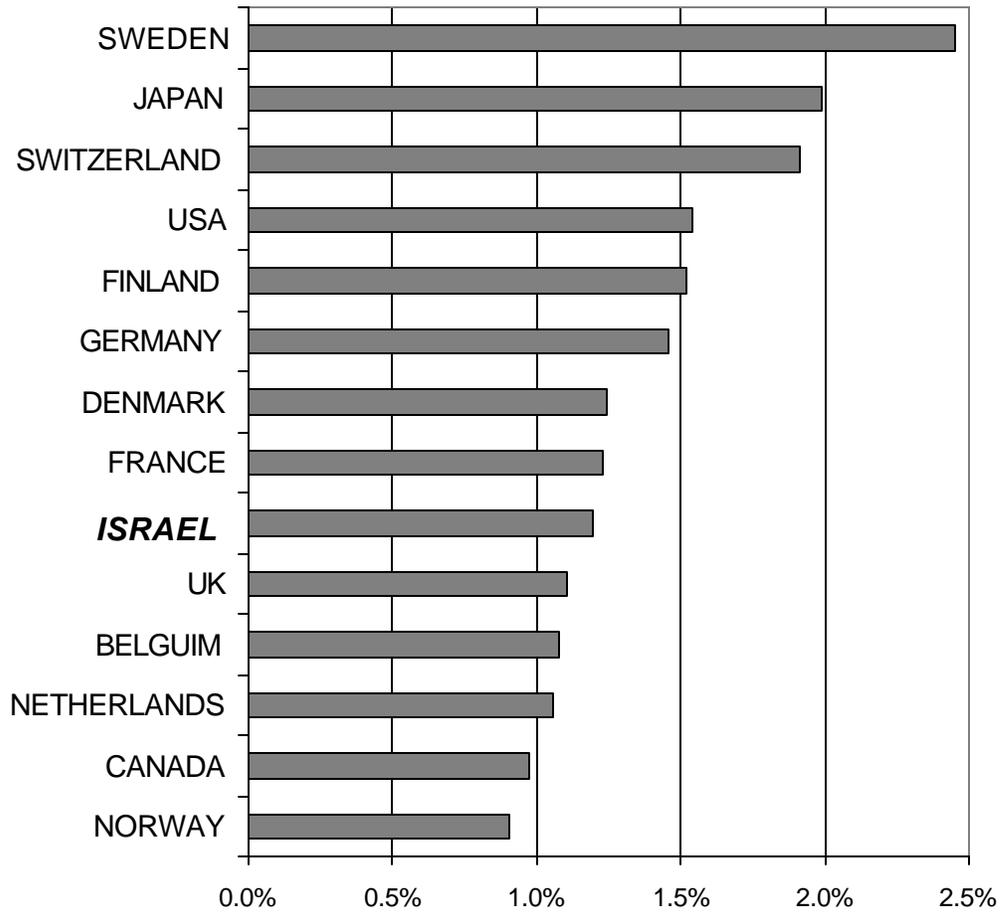
Israel spent on *civilian* R&D about 7.7 billion NIS in 1997 (about 2.2 billion dollars), which accounted for 2.3% of GDP (see CBS, 1998). Where does Israel stand relative to other countries and, in particular, relative to the OECD? In terms of R&D/GDP ratio, Israel ranked in 1996 lower than Sweden, Japan, Switzerland, on par with Finland, and higher than the other OECD countries (see CBS, 1999). In terms of Business Sector R&D (BSRD) though, Israel stood much lower (9th place), below the aforementioned countries, and also below the US, Finland, Germany, Denmark and France (see Figure 7). In terms of R&D per capita Israel ranks 10th, and in terms of BSRD per capita 13th. Thus, in terms of these ratios and relative to OECD countries, Israel's allocation of resources to R&D can be characterized as "average minus".⁴⁵ However, are these ratios a good benchmark? Do they provide a reasonable standard against which to gauge Israel's allocation to R&D?

We would like to argue that these ratios should be considered with great caution as yardsticks for policy, for two reasons: the importance of "critical mass" in the R&D

⁴⁴ The figures in this section are based on CBS, 1998. Since I have written it CBS 1999(b) appeared with updated figures, but I have not yet redone the calculations. In essence the latest (and revised) figures show movement in the right direction, i.e. the R&D/GDP ratio has increased to 2.6%, and the ratio of BSRD to civilian R&D has grown to 52%. However, the essence of the computations here remains the same.

⁴⁵ Once again, these comparisons refer to 1996, the last year for which they are available.

Figure 7
Business Sector R&D / GDP



context, and the extent to which the growth strategy of a country depends on R&D. Contrary to other areas where the *relative* amount of resources may be a meaningful yardstick (such as in health or education), what determines the impact of R&D on the economic performance of the economy is often times the *absolute* and not the relative amount invested. That is so basically because there are substantial indivisibilities in R&D both at the micro and macro levels. At the level of individual projects and/or firms, a wide range of technological areas require the commitment of relatively large amounts of R&D in order to make these projects at all feasible (in other words, the MES – Minimum Efficient Scale – of projects in such areas is large). Thus, the development of communication satellites requires R&D budgets of hundreds of millions of dollars, and so do new ethical drugs.⁴⁶

At the economy-wide level, the conduct of R&D requires a vast array of supporting infrastructure and services, the availability of adequate manpower (not only scientists and engineers but also supporting personnel of various sorts), and of financial institutions and markets. All of these would come into being only if “enough” R&D (“critical mass”) is being carried out to justify the emergence of the required infrastructure, venture capital institutions, training of personnel, etc. Moreover, the ability of firms conducting R&D to capture the spillovers generated by others in the same region/country depend as well on the existence of a sufficiently large nearby R&D sector. This latter factor can be critical for the chances of the high sector in the country to become a “Silicon Valley”. It appears that one of the distinguishing features of Silicon Valley vis a vis clusters of High-Tech firms in other regions/countries is precisely the fact that firms there are better able to internalize spillovers, hence feeding an endogenous growth process.

Second, the extent to which comparisons of R&D *ratios* are informative (and potentially telling from a normative point of view) depend of course upon the characteristics of the countries being compared, and the growth strategy that they have

⁴⁶ The latter including of course the costs of getting approval from the FDA.

chosen. Israel has embarked long ago in a growth path that relies heavily upon the promotion of High-Tech, export-oriented sectors, reflecting its perceived comparative advantage in high-skilled labor. By contrast, countries such as Spain or New Zealand, while comparable to Israel in terms of current GDP per capita, have chosen a very different path (recall Part I, and Figure 4). Thus, while a R&D/GDP ratio of about 1% for Spain might be adequate given *its* growth strategy, Israel's 23% may quite likely be well below mark. Furthermore, a recent study (Jones and Williams, 1998) shows that even the US may devote far too little resources to R&D: they find that the *optimal* R&D/GDP ratio may be **2 to 4 times higher** than the actual one.

As already mentioned, the absolute amount of resources allocated to civilian R&D in Israel in 1997 was about \$2.2 billion, of which \$990 million was business sector R&D. In order to gain some perspective on what this figure implies, consider Table 6, where we list the leading industrial R&D companies in the US: 28 of them spent in 1996 **over 1 billion \$ each** in R&D, each of them more than Israel's industrial sector as a whole in that year.⁴⁷ To put it differently, **all** of Israeli industrial R&D amounted to the R&D done by **3M**, and was slightly less than the R&D done by Eastman Kodak. These gaps are well reflected also in patent statistics (see Trajtenberg, 1999): Israeli inventors were granted in 1997 a total of 653 patents, of which slightly less than half went to Israeli corporations, i.e. about 320 patents. By contrast, that same year IBM was granted 1,758 patents, Motorola 1,151, Intel 407, Hewlett-Packard 537, General Electric 667, and so forth (we have seen in Part I similar cross-country comparisons).

II.4.3 Setting a target R&D level

Still, R&D ratios have to be taken into account in formulating policy, both because the question of how much resources should be allocated to R&D obviously cannot be divorced from total resources available,⁴⁸ and because political feasibility and expediency often requires such implicit linkages. One way of taking these ratios into account in policy making would be the following. A key difference between Israel and

⁴⁷ See NSF 1998, Appendix table 4-23.

⁴⁸ Expressing it as a ratio of GDP is a convenient way of tying it to total resources and to other (similarly expressed) allocative decisions.

Table 6

The 30 leading industrial R&D companies in the US, ranked by size of R&D expenditures in 1996				
1996 rank	1986 rank	Company	R&D expenditures (millions)	R&D/net sales (%)
1	1	General Motors	8,900.0	5.6
2	3	Ford Motor	6,821.0	4.6
3	2	IBM	3,934.0	5.2
4	9	Hewlett-Packard	2,718.0	7.1
5	20	Motorola	2,394.0	8.6
6	4	Lucent Technologies	2,056.0	13.0
7	66	TRW	1,981.0	20.1
8	18	Johnson & Johnson	1,905.0	8.8
9	46	Intel	1,808.0	8.7
10	31	Pfizer	1,684.0	14.9
11	12	Chrysler	1,600.0	2.7
12	22	Merck	1,487.3	7.5
13	–	Microsoft	1,432.0	16.5
14	47	American Home Products	1,429.1	10.1
15	5	General Electric	1,421.0	1.8
16	35/63	Bristol Myers Squibb	1,276.0	8.5
17	33	Pharmacia & Upjohn	1,266.0	17.4
18	23	Procter & Gamble	1,221.0	3.5
19	38	Abbott Laboratories	1,204.8	10.9
20	11	Boeing	1,200.0	5.3
21	26	Lilly	1,189.5	16.2
22	26	Texas Instruments	1,181.0	11.9
23	8	United Technologies	1,122.0	4.8
24	10	Digital Equipment	1,062.3	7.3
25	13	Xerox	1,044.0	6.0
26	6	Dupont	1,032.0	2.7
27	7	Eastman Kodak	1,028.0	6.4
28	16	3M	947.0	6.7
29	–	Rhone-Poulenc	882.1	16.3
30	21/51	Lockheed Martin	784.0	2.9

Source: Science & Engineering Indicators – 1998

OECD countries in the pattern of R&D spending is that in Israel the business sector carries out just 45% of civilian R&D versus 62% for the median OECD country, whereas academia in Israel accounts for 37% (as opposed to 23% in the OECD).⁴⁹ As argued below, this divergence stems from the fact that the business sector performs too little R&D, and certainly not because of “excessive” academic research.

We shall not attempt to analyze in any detail the allocation of funds to academic research, suffice here to mention the following: First, in Israel basic research is performed almost exclusively in academia, as opposed to the US and some European countries where industry, government labs and other institutions also perform a very prominent role in basic research. Second, academic research both feeds into industrial R&D, and provides the training for the manpower which the High-Tech sector in Israel relies upon. Lastly, the figures for research spending in Israeli universities may be biased upwards vis a vis other countries, given the difficulties in distinguishing between research and teaching. These difficulties are exacerbated by the fact that until not long ago, virtually all the high education teaching was done at research universities, and hence the research figures for the sector as a whole suffered from that problem (the rapid proliferation of colleges in Israel in the last few years has changed that dramatically, but that is not yet fully reflected in the available statistics). By contrast, in the US there is a rather sharp distinction between the vast number of colleges and other teaching institutions and the much fewer research universities. Thus, the problem there is necessarily less severe.

As already mentioned, Israeli’s growth strategy centers on the development of an expanding High-Tech sector, which requires the channeling of additional R&D resources into the business sector. Thus, a reasonable R&D policy goal would be to reach the OECD mark of 62% for the *share* of business sector R&D (BSRD), keeping constant the R&D expenditure *levels* of the other sectors (Government, Academia and Non-for-profit

⁴⁹ These ratios correspond quite closely to the distribution of Israeli patents according to different types of assignees. In fact, the percentage of Israeli patents assigned to Israeli corporations (out of the total number of Israeli patents having Israeli assignees) was 43% over the period 1968-97, and about 48% for 1997, close to the share of business sector R&D (see Trajtenberg 1999, page 17 and also Figure 13).

Institutions).⁵⁰ Given that total R&D spending in 1997 amounted to \$2.2 billion, the target of 62% for BSRD (from 45% at present) would require an increase of BSRD level spending from \$990 million (in 1997) to \$1.97 billion. If that happens, total R&D would increase from 2.2 to \$3.18 billion, which would represent 3.3% of GDP, compared to 2.3% at present. In other words, reaching the target of 62% BSRD without compromising current levels of R&D spending in other sectors would require raising the R&D/GDP ratio by a full one percentage point. In order then to maintain this ratio over time, all components of R&D level expenditures would have to be fully linked to GDP growth.

II.4.4 From target to implementation

How do we get there? Quite clearly it is not politically feasible to do that in one discrete jump. Suppose instead that the policy is to reach those ratios in 4 years, the expected time horizon of a new government in Israel. That would require increasing BSRD by 17% per year, plus the annual rate of growth of GDP. Assuming for the moment that the latter will stand at 5%, we are talking about a yearly increase of 24%. What does that imply in terms of government policy? In order to answer this question we would need to know what is the “additionality factor”, that is, by how much total industrial R&D spending increases with each additional dollar of government support, in the context of a structural model that carefully deals with a host of possible endogeneity problems. At this point we don’t know that, but we can use *as an illustration* (and no more than that!) the results from a simple regression of total industrial R&D on (lagged) government R&D support:

⁵⁰ At a point in time, but obviously these levels would have to be linked to GDP growth – see below.

Dependent Variable: LOG_TOTAL_R&D

Method: Least Squares

Sample(adjusted): 1977 1996

Included observations: 17

Convergence achieved after 7 iterations

Variable	Coefficient	Std. Error	t-Statistic
LOG_GRANT(-1)	0.845397	0.080621	10.48601
C	2.341984	0.335404	6.982582
AR(1)	0.203955	0.209763	0.972311
R-squared	0.936823		
Adjusted R-squared	0.927797		
S.E. of regression	0.143284		
Durbin-Watson stat	2.230653		
Inverted AR Roots	.20		

One has to be very careful in interpreting this regression: the most we can say is that, according to past experience, a $\Delta\%$ increase in total industrial R&D has been accompanied by a $\Delta\%/0.845$ increase in government support. Of course, this is not a statement about causality or additionality, but at best a slightly better “guesstimate” than the benchmark elasticity of industrial R&D to R&D subsidies of 1.⁵¹

In 1997 government support to industrial R&D amounted to \$294 million (about 30% of BSRD).⁵² In order to “induce” a 24% growth per year in BSRD, this amount would have to increase by $24\%/0.845=28.4\%$ per year over the next 4 years, and then stabilize by year 2004 at a level of about \$815 million (linked from then on just to the growth of GDP). Is this a feasible policy goal? A 28.4% increase in government support to R&D from current levels means an additional \$85 million for the first year, which is not a priori utterly implausible. Of course, keeping the pace of yearly increases at that rate over 4 years does necessitate a significant change in government priorities, but not a dramatic one.

The following table presents these calculations in a schematic way (figures are rounded up for convenience; we assume as said a 5% yearly growth rate in GDP):

⁵¹ If the elasticity were one, then obviously in order to increase industrial R&D by a certain factor, R&D subsidies would have to increase by the same percentage.

⁵² This is net of paybacks: the gross amount was \$397 million.

Projected R&D Levels and Ratios According to Suggested Policy

Year	BSRD ^a (billion \$)	Other R&D (billion \$)	Total R&D (billion \$)	BSRD/ Tot. R&D	R&D/ GDP	Gov Support (million \$)
2000	1.00	1.20	2.20	45%	2.3%	300
2001	1.24	1.26	2.50	50%	2.5%	385
2002	1.54	1.32	2.86	54%	2.7%	495
2003	1.91	1.39	3.30	58%	3.0%	635
2004	2.36	1.46	3.82	62%	3.3%	815

^aBSRD: Business Sector R&D.

It is worth noting that the projected level of Government support by year 2002 is approximately what would have been required a year ago to meet the demand for funding by the OCS. Moreover, notice that the percentage of BSRD funded by the Government would barely grow, from 33.3% in the base year to 34.5% in 2004.

This is then just a schematic suggestion, meant to stimulate a much-needed reassessment of existing policies. It is important to note that the issues raised first dealing with the allocation of grants (neutrality, allocation mechanisms, etc.), and the question of how much R&D are not unrelated; to wit, and as already mentioned, current allocation mechanisms are incompatible with the budget constraint imposed. What is needed then is an overall reformulation of R&D policy that would include both.

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Appendix 1

Additional Support Programs of the OCS

Beyond the main programs described above (the “regular” R&D Grants, Magnet, and the Incubator Centers), the OCS offers a variety of additional assistance programs, aimed at specific stages along the innovation cycle or at particular segments in the progression from a innovative idea to a full-fledged commercial enterprise. Although much smaller in terms of budget, these programs may play an important role in making sure that potentially viable projects don’t fall in between the cracks along the hazardous way towards successful commercial implementation. Following is a concise description of some of these programs.

1. Bridging Aid

This program offers support for the transition between R&D and manufacturing and marketing. The intention is to enable companies that have completed the R&D stage to manufacture a number of prototypes for installation on the premises of potential clients, especially abroad. In the case of chemical innovations, the program supports the setting up of a pilot plant, enabling the manufacturer to obtain feedback on the performance of the new product or process.

Companies with sales of up to \$6 million may receive a grant of 50% for these purposes, whereas larger ones (with annual sales of up to \$30 million) are eligible for 30% grants. Total approved spending may not exceed \$600,000 over a 30-month period. Recognized “transition period” expenses generally include:

- ❑ Construction of prototypes;
- ❑ Adaptation to standards in foreign countries;
- ❑ Registration of the product for marketing abroad;
- ❑ Operation of a pilot plant, not including construction costs;
- ❑ Patent registration fees.

2. Aid in Establishing Industrial Incubators

The goal of this program is to encourage *established* companies to develop cooperative start-ups in new technological areas, taking advantage of the companies' existing infrastructure, finance and management. The OCS grants 66% of the approved R&D outlay, up to a ceiling of \$300,000 annually for a maximum of two years. Thereafter the projects would qualify for standard R&D grants. The program is aimed at scientific entrepreneurs (including new immigrants), who are required to create a cooperative framework with an established Israeli industrial company, having previous R&D experience and annual sales of at least \$5 million.

3. Sub-contracting Industrial R&D

This program supports the carrying out of civilian R&D projects for foreign companies, by Israeli enterprises acting as subcontractors. The goal is to initiate joint ventures with foreign partners, so as to help Israeli companies market their technologically advanced products abroad. The OCS grants up to 20 percent of the approved R&D costs. The Israeli subcontractor must be an industrial company with annual sales of up to \$100 million, and the R&D project must be in a new area for the Israeli company.

4. Exploratory Studies for Industrial R&D Projects

This program supports studies of the market potential for new technologies, prior to the investment of large sums in the R&D stage. It is intended primarily for start-up companies, or those with limited R&D experience. However, established companies interested in exploring new subjects not included in their current areas of activity are eligible as well. The program extends grants of 50% of approved costs, up to \$30,000. The studies are to be carried out by experienced, external consulting companies, authorized by the OCS.