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Leveraging ICT for Development

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Israel: Factors in the Emergence of an ICT Powerhouse

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Introduction¹

It has been the Israeli government's explicit goal to position their country at the center of the knowledge economy, but the process has been neither fully planned nor completely organic. There has been close collaboration between government and business, with government involvement focused and limited, ready to withdraw as soon as the private sector was able to continue on its own.

This case study highlights the important role of the government in the emergence of Israel as a high-tech power, encouraging and supporting the capacity of the private sector to compete in international markets. Significant components of government action have taken the form of a) heavy investment in education, reinforced by large-scale immigration to provide the necessary human capital, b) effective investment incentives favoring foreign investors to build industrial momentum, c) investment in R&D in a proportion of GDP (4.6 percent) higher than that of any other industrialized country, and d) incubator and venture capital programs to convert research into cutting edge businesses.

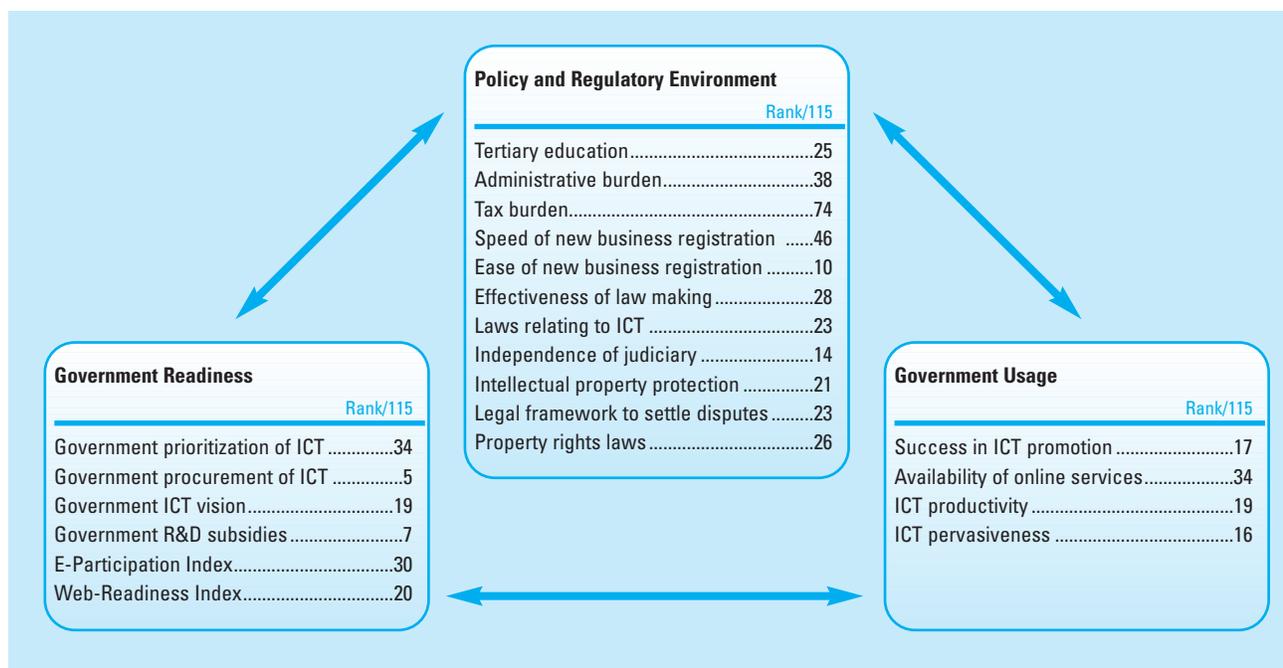
Alongside these helpful interventions, providing a backdrop for the development of information and communication technologies, Israel has also made important strides in laying the foundation for macroeconomic stability. Not only has inflation fallen sharply from the runaway levels seen in the mid 1980s, but wide-ranging reforms have been put in place aimed at reducing the scale of the public sector and the role of the state in the allocation of resources, and, more generally, at supporting the modernization of the economy.

This paper will outline the role of the Israeli government in supporting ICT development, and the influence of education, culture, immigration, and security issues on Israel's achievements. This is followed by a detailed discussion of the role of government in investment and R&D, and the relationship between the ICT sector and Israel's overall economy.

The role of government

Recent Israeli economic history is an excellent showcase of the key contribution efficient government intervention can make to the overall innovation potential and ICT readiness of a nation. In this respect, there is broad agreement on the major role played by the Israeli government in the emergence and development of today's vibrant high-tech sector. Indeed public policies have been instrumental in fostering and complementing private sector initiatives, by laying the basis for an environment conducive to innovation, by means of both an appropriate regulatory framework, as well as infrastructure and ancillary services, such as education and financing. Furthermore, the government has been at the forefront of ICT readiness, adoption,

Figure 1: Government role in networked readiness in Israel



Source: World Economic Forum, 2006.

and use. This is evident in the remarkably high positions Israel occupies in the 2005–2006 Networked Readiness Index (NRI) for variables capturing government readiness and use, such as government procurement of ICT (5th), government R&D subsidies (7th), government ICT vision (19th), success in ICT promotion (17th), ICT productivity (19th), and the pervasiveness of ICT use (16th). Figure 1 gives a more general overview of the many government-related variables comprising the NRI, as well as of the respective rankings for Israel in 2005–2006.

Government intervention has been remarkable for the market-friendly spirit in which it has been conducted from the outset. Until very recently,² the guiding principle has been neutrality toward the private sector, with the focus placed on remedying the market failures intrinsic in the generation of optimal levels of investment in innovation,³ rather than on “winner-picking” practices. The case of the Incubator Program, analyzed in detail later, is an excellent illustration of such an approach, since it has provided, and still provides, financing and support to ventures in the early, pre-seed, stage, when the funding gap could prevent many of them from moving from the idea phase to projects attractive to private investors (see Figure 2).

The market-friendly nature of government intervention in Israel has resulted in considerable flexibility and dynamism, permitting specific policies and instruments to evolve over the years, and adapt to what were perceived as the most pressing needs of the time. An example is the

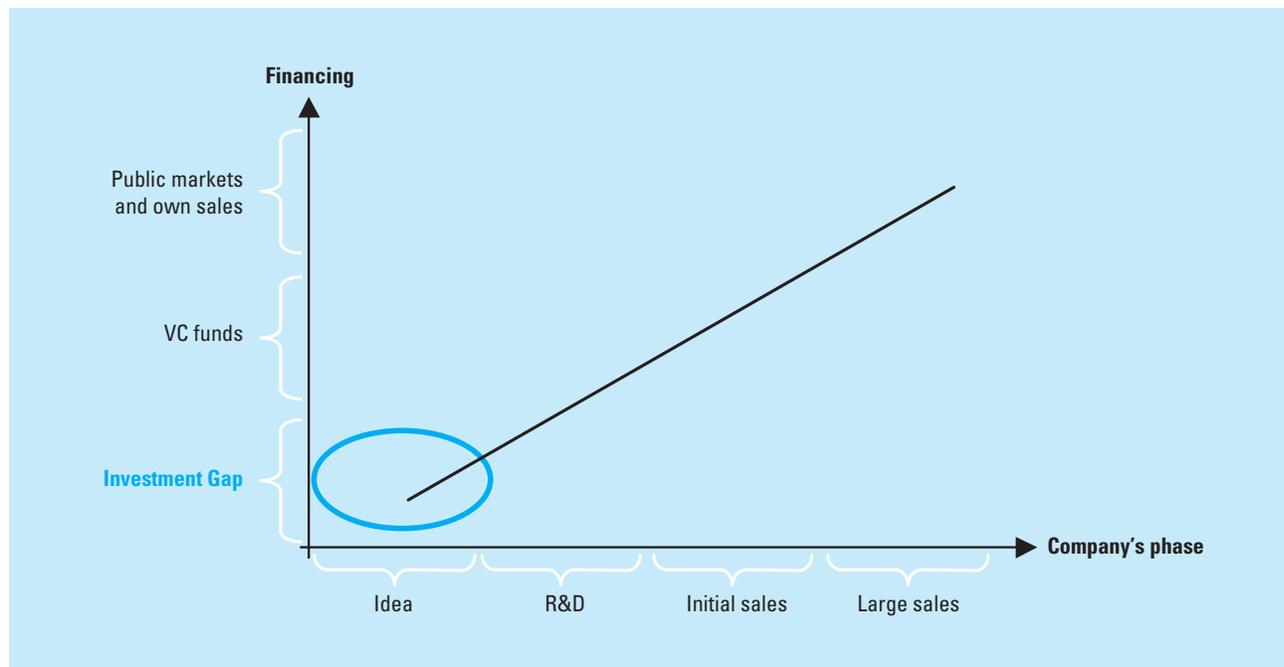
array of programs put in place by the government to encourage R&D at different points over the past two decades.

It was also market considerations which led Israeli policymakers to concentrate on innovation and R&D. The government realized very soon that Israeli comparative advantage resided in its qualified human capital rather than in its relatively scarce natural resources and land. The national market was too limited to sustain national industries and the political situation precluded selling to neighbouring countries. Thus, the target inevitably had to be international, requiring a focus on innovative products which could be sold on international markets. These unfavorable structural parameters—market size and the adverse political geography—served as catalysts to spur the development of an industry which ultimately would not depend for its success on these two factors. Thus, Israel may well be an illustration, in reverse, of the “natural resource curse,” a concept popularized by Sachs and Warner (1995). Unable to tap into a plentiful extractable commodity, Israel has been forced to trade globally on its human capital endowment.

Education

As a small country with limited natural resources, the government has long recognized the importance of investing in human capital for its development. Building on a strong

Figure 2: The investment gap: The role of the Incubators



Source: LabOne, 2005.

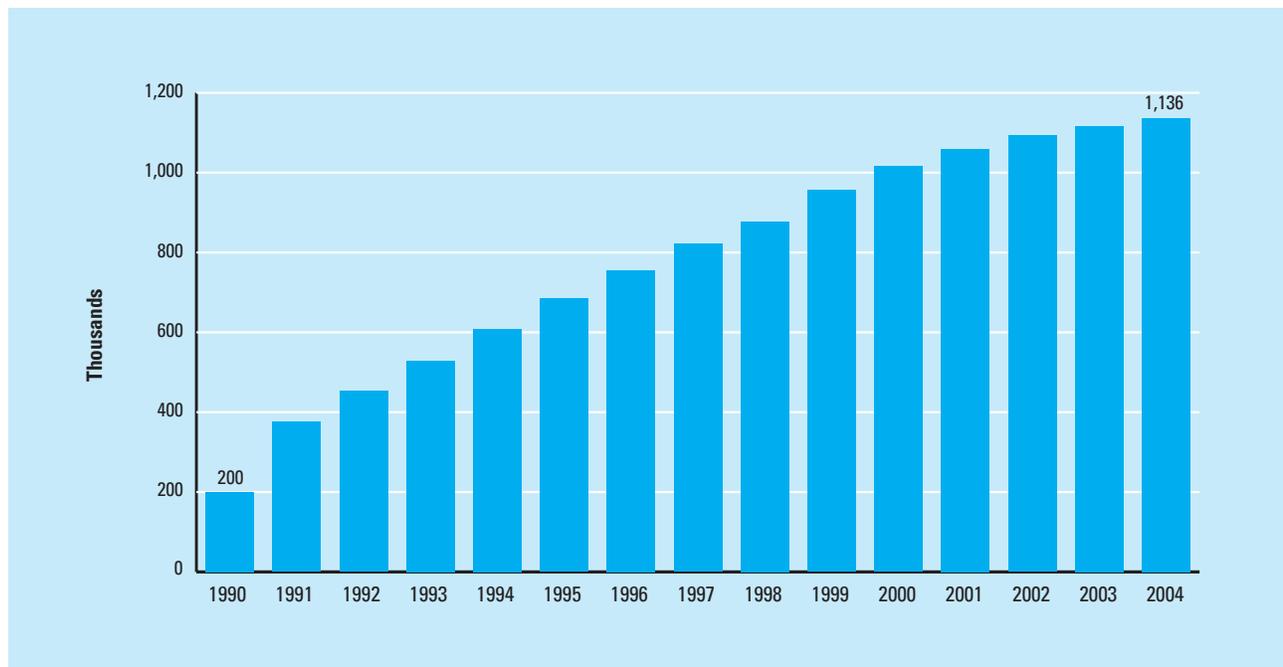
cultural heritage stressing excellence in education, universities began to be established in the 1920s. With the founding of the state of Israel in 1948, the government focused its attention and resources on the development of a first class educational and scientific research establishment. By the early 1970s, there were half a dozen university-level centers of teaching and research: the Technion in Haifa, the Weizman Institute in Rehovot, Hebrew University in Jerusalem, Ben Gurion University in Beer Sheba, and the Universities of Haifa and Tel Aviv.

While traditional universities have not changed greatly, with about 30 percent of students receiving degrees in sciences and engineering, the growing demand for higher education over the last 30 years has been met by liberalizing higher education to allow private colleges, foreign competition, and by recognizing degrees granted by technical schools accredited by the Ministry of Education. Between 1980 and 2000, the percentage of the population with at least 13 years of education rose from 21 to 41 percent for Jewish citizens, and from 7 to 21 percent for non-Jewish citizens. By 2000, degrees from non-traditional colleges responding to market demand for business and technical training represented 32 percent of the total (Khavul, 2005). This process provided the trained managers and workers needed by a rapidly expanding industry. Furthermore, attempts have been made from time to time to reprioritize various professional streams within Israel's system of higher education. For instance, in the early

1990s, industry leaders saw the need to retrain many of the graduates from the top universities in electronics and computer science. Task forces were created and a major boost was given by the universities to these particular areas. In other words, there have been fairly successful attempts to shift the priorities of career workstreams within the public university system to reflect the most pressing needs of industry, particularly the high-tech sector, because of its perceived growth potential.

The informality of much human interaction, coupled with the educational and cultural emphasis on initiative and risk-taking, may also have contributed to a more entrepreneurial culture. As with other world technology centers, the symbiosis between top research universities and dynamic industries has been so significant that Israel, despite its small size, has been ranked by the Global Creativity Index—a measure of technology, talent, and tolerance—as the 14th most creative country in the world.⁴

One unique feature of the educational process in Israel is the significant catalytic role played by the military. With compulsory military service for both sexes, the military can select and train the brightest young people in elite computing units, giving engineers considerable responsibility for project management at a young age. While Israel has not explicitly sought to commercialize military information technologies directly, the skills developed in young programmers have produced innovative networks when they return to civilian life, creating strong

Figure 3: Immigration to Israel, 1990–2004 (cumulated yearly values, thousands)

Source: Central Bureau of Statistics, 2005.

links between research teams in the military and in industry. In addition, the Computer and Data Communications Network Center of the army continues to train software developers when they return to the unit for reserve duty every year, while these experienced reservists teach their skills to new conscripts and other reservists. Nevertheless, there are not that many examples of innovations in the military with clearly successful commercial applications—firewall development by Check Point being the most notable exception. Perhaps because of this, the majority of Israeli high-tech companies see themselves as innovating for the global market. The research capabilities of the Israeli Defence Forces have been boosted by the existence of rolling five-year budgets which facilitate product development and encourage them to take on substantial projects with a high-technological component.

Immigration

Immigration, welcomed and supported by the government, has always been a central feature of the development of the State of Israel, as Jews from many countries returned to their historic homeland, bringing diverse talents and capacities, combined with the motivation and creativity of a pioneering movement. The fortuitous coincidence of the collapse of the Soviet Union, combined with the explosion of information and communications technologies in the late 1980s gave the Israeli ICT industry a major boost.

As shown in Figure 3, almost one million refugees from Eastern Europe arrived in Israel in the decade between 1989 and 1999, many with advanced degrees, technical training, and often bringing with them ambition, innovative approaches to problem solving, and a strong scholastic tradition. This increased the population by a fifth and reinforced its general educational level.

These immigrants included more than 100,000 scientists and engineers, giving Israel by far the highest number of engineers per capita in the world—140 per 10,000 employees, more than twice the level of the United States and Japan, the second and third ranking countries in the list.⁵ This massive influx of manpower ensured the development of the ICT industry until near the end of that crucial decade. However, it did create a major challenge to absorb so many people, and the government set up retraining and business development programs to facilitate the process. With the rapid expansion of the industry, skilled immigrants were quickly integrated. This expansion also attracted highly trained and experienced Israeli engineers, many of whom had previously emigrated to the US and Europe, but who now saw the opportunity to set up research centers for their foreign employers or startups of their own in Israel. There are clear parallels in this area between the experiences of Israel and Taiwan, as noted elsewhere in this *Report*.

Culture

In a globalizing world, international networking becomes a key competitive advantage. For over a century, Israel has benefited from the influx of Jews from the diaspora, characterized by well-established social networks, a strong sense of social responsibility, and the drive to establish themselves and succeed in their new homeland. More recently, this trend has been reinforced by the immigration of significant elements of the diaspora into Israel, bringing skills and connections to international industries and networks.

For centuries, in the vast majority of European countries, Jews were systematically denied the opportunity to enjoy secular education, to enter the professions, or to own land. This, no doubt, contributed to their ability to remain self-sufficient even in extremely inhospitable conditions. Their new-found freedom in Israel, coupled with the long tradition of frank and forceful Biblical argumentation—one of the most highly valued “occupations” open to Jews in the past—has given rise to a remarkably

egalitarian culture of openness, risk-taking and individualism, which places a high value on one’s capacity to speak out, think freely, and constantly question. Unlike Asian countries,⁶ where attempts to foster innovation are sometimes constrained by rigid, hierarchical structures which place a premium on obedience, rather than on challenging authority, human interactions in Israel are much more relaxed (Harel, 2005). Indeed, senior managers in top Israeli companies in the high-tech sector will often refer to their strong preference for original thinkers, who will not hesitate to tell their bosses how wrong they are, and why a particular alternative approach will be better. Conformity with and awe of one’s supervisors is neither encouraged, nor in keeping with the culture of independent thinking and active intellectual dissent.

Another interesting feature of the Israeli high-tech scene is the acceptance of risk-taking. There is a relatively large number of serial entrepreneurs, people who start up new high-technology ventures, develop them, take them to the market, and then sell them, before starting the same

Box 1: Peace dividend

The hoped-for peace process with Syria and the Palestinians, intended to establish credible and lasting security arrangements with these neighbors, would likely have a positive influence on Israel’s long-term economic outlook and its ability to sustain high growth rates. The following might be considered some of the most obvious benefits of peace in the Middle East:

- The scope it would provide for a medium-term restructuring of budgetary expenditures, diminishing over time the burden of defense and the maintenance of the associated military establishment. Annual defense expenditures have amounted to some 9–10 percent of GDP in recent years (down from 25 percent of GDP in the early 1980s), compared to 2.5 percent in the EU and some 3 percent in the United States. Peace would permit further spending cuts over the next several years, releasing resources which could be allocated in other ways, particularly in the area of infrastructure, where Israel suffers from a number of shortcomings, in comparison with EU members with similar levels of per capita income.
- The coming on stream of a number of potentially large infrastructure projects (water works, electricity generation, and railroads) in the border areas with Syria and Lebanon could have potentially lasting effects on investment demand. Beyond this, peace would also be expected to boost intra-regional trade in the Middle East and cross-border direct investment.
- The further expansion of the vast potential of the tourism sector, where activity has tended to closely reflect the underlying security situation, as illustrated by the large losses in the sector as a result of terrorist attacks and the second intifada. Israel received some 2 million tourists in 2005, a 26 percent rise over the previous year, but still small when compared to 65 million in Spain and 15 million in Portugal. Making generous allowances for population size and other factors of scale, and with appropriate investments and upgrading in the facilities supporting the sector, there is no reason why the numbers of tourists could not double within a few years, with beneficial effects on growth and the balance of payments.
- With its highly educated labor force, its close trade links with the EU and the United States and the remarkable expansion of high-tech industries seen in recent years, Israel is singularly well positioned to become a leading center for a broad range of multinational corporations, intent on expanding their activities in a post-peace settlement environment.
- Last but not least, peace with Israel’s neighbors would be a permanent boost to the confidence of foreign investors, as economic agents would be able to view decision making in a medium- to long-term perspective, characterized by less uncertainty about the political environment and greater faith in the stability of the country’s policies and institutions.

cycle again with a fresh idea. Others have failed in the early stages but, driven by a philosophy that “failure is not disgraceful if you fail honestly,” have started over again, sometimes more than once.

It is worth asking if there may be a cultural dimension to the difficulty Israeli companies have in commanding a world presence in terms of market capitalization. Possibly, the atmosphere of a small, innovative or congenial community, in which human relationships and independent thinking are important, may outweigh the advantages of large-scale institutionalization. At the same time, it may well be that the emphasis on individual initiative and improvisation makes management less of a strength. As important as the subject may be, it is outside the scope of this study to explore in greater detail the role of culture in the development of a spirit of entrepreneurship and technological innovation.

Investment incentives and capital market reforms

One major area of government intervention has been in the policies and measures encouraging domestic and foreign capital investment in Israel. The investment incentive package had its origins in the *Law for the Encouragement of Capital Investment* (LECI), adopted in 1959 to attract private investment—especially in the most remote and least developed areas of the country⁷—and to foster business initiatives, employment, and exports.

The law, revised on a number of occasions to take into account new technological and economic developments,⁸ did not explicitly favor the high-tech or any specific industrial sector,⁹ but, rather, ventures with high value-added and marketing capabilities in local and international markets. The importance given to both new and existing projects varied according to the specific zone, whereas the contribution to exports had to be more substantial for the central areas, zones C and B, than for the peripheral one, zone A, for which the contribution to local employment was valued more. Those enterprises, both Israeli and foreign-owned, which were deemed eligible by the Israeli Investment Centre—a department of the Ministry of Industry, Trade and Labor in charge of the law’s administration—gained the status of “Approved Enterprises” or “Beneficiary Enterprises.” They were thus in a position to benefit from government grants—up to 24 percent of tangible fixed assets—and/or tax benefits in various forms, depending on the geographical location and the percentage of foreign ownership.

Beyond the stated goal of LECI to promote private initiative and internationally competitive products, the market-friendly character of the law can be seen in its attempt to provide institutional underpinnings to the initiatives of private investors, and to share with them the higher risk associated with the development or expansion

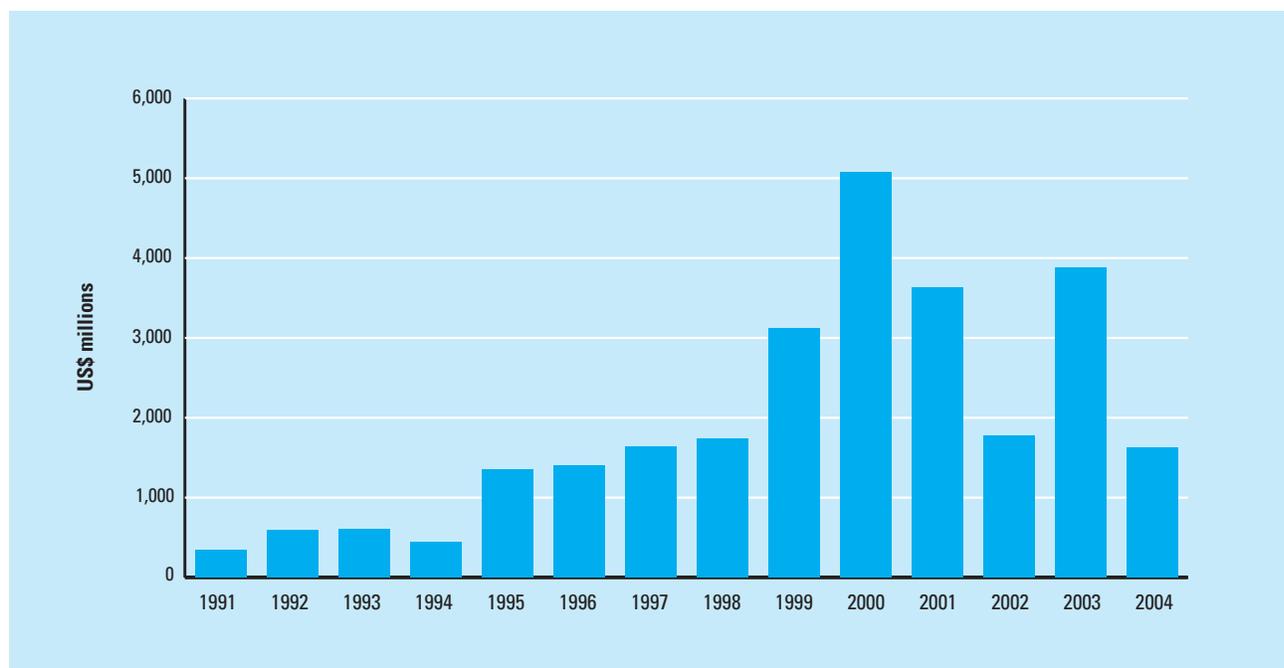
of a venture, addressing in this way the market failures inherent in the preliminary stages of investment.

LECI deliberately introduced a bias in favor of foreign investors, which took the form of preferential tax treatment with respect to national investors. It was thought that a favorable tax regime and the relative abundance of well-trained engineers and scientists would strengthen the attractiveness of Israel as a location for multinationals. The policy was based on a specific rationale: multinationals would not only create employment in Israel, but they would also bring with them the technology, know-how, operating procedures, managerial skills and exporting channels that the nascent Israeli industry needed. In other words, the idea was to leverage the spillovers deriving from the operations of the multinationals in Israel for the development of the local high tech industry.

The government’s strategy worked well: international investors flocked to Israel during the 1960s and 1970s, including high-tech giants such as IBM, Motorola, and Intel, and were followed by many others. Figure 4 shows the evolution of FDI over the 1991–2005 period.

This process has been facilitated by a number of reforms in the capital markets which have considerably improved the efficiency of, and competition within, Israel’s financial system. These have mainly involved deregulation and the elimination of a host of administrative restrictions and interventions, and the welcome reform of the capital market which centered on the separation of the various funds from the banks. Reserve requirements, which had ranged well over 30 percent in the late 1980s, had fallen to an average of 4 percent by the end of the 1990s. This, in turn, contributed to a marked narrowing of interest rate spreads. Undue segmentation of the credit markets was sharply reduced; for instance, the share of mortgage credit allocated by the government fell from 70 percent in the mid 1980s to less than 25 percent by the end of the 1990s. Even sharper drops took place with respect to other forms of credit.

The reforms also saw a sharp reduction in the share of obligatory investments in government bonds by pension and provident funds. Provident funds, the largest institutional investor in the Israeli economy, were allowed to invest a much larger share of their holdings in equities and other financial assets. Alongside these efforts aimed at deregulation, there was also significant streamlining and modernization of the stock market, which emerged as one of the most technologically advanced in the world, with continuous trading and short clearing periods, against a background of fairly sound securities legislation. There are ongoing efforts to broaden the range of financial instruments offered to the public, to ensure equal tax treatment of different classes of investors and/or savings instruments, and to encourage more long-term savings. The modernization of the financial sector is thought to have played a strong

Figure 4: Foreign Direct Investment in Israel, 1991–2004 (inflows, US\$ millions)

Source: UNCTAD, 2006.

supportive role in the development of the ICT industry. To the extent that these reforms were driven by a desire to improve market efficiency, they made it easier for emerging companies to obtain funding under more favorable circumstances. Parallel progress in bringing inflation levels down to international levels also contributed to the creation of a more stable macroeconomic environment, conducive to private sector activity in a more predictable climate.

Foreign investors in the ICT sector have typically used one of two options to establish a presence in Israel: they have either set up operations directly, or adopted a strategy of mergers with, or friendly take-overs of, small local companies. As shown in Table 1, as regards operations carried out in Israel, foreign investors have placed the emphasis on the installation of research and development facilities,¹⁰ taking advantage of Israel's ample supply of highly skilled engineers, and its solid track record for innovation and problem solving. In this regard, some have argued that the above competitive advantages have been a mixed blessing for the Israeli economy, in that research facilities do not generally make the same contribution to job creation and exports as do manufacturing plants. They also act as a drain on limited Israeli brain power,¹¹ which could otherwise be used by local firms.

The above considerations notwithstanding, the contribution made by multinationals to the development of the Israeli high-tech industry is generally viewed as

Table 1: Multinational companies with R&D centers in Israel (partial list)

Alcatel	Kollmorgen Servotronics
Analog Devices	Marvell Semiconductor
AMCC	Microsoft
Avaya	Motorola
BMC Software	National Semiconductor
Boston Scientific	Oracle
Broadcom	Organics
Computer Associates	Paramic Technology
CEVA	Pfizer
Cisco	Phillips
Conexant	QUALCOMM
Freescale Semiconductor	Samsung
GE Medical Systems	SAP
HP (including HP Labs)	Siemens
IBM	Silicon Graphics
Infineon	Sun Microsystems
Intel	SunGard
Interpharm	Texas Instruments
KLA-Tencor	Veritas Software

Source: Israel Venture Association, 2005.

positive, given the many spillovers to the local economy, such as easier access to the international financial and business markets, improved export channels, and the transfer of know-how and managing/marketing skills from the personnel of multinationals to local companies.

In addition to creating state-of-the-art R&D centers, companies such as Intel and Motorola established manufacturing facilities, which rapidly became some of the largest private employers in Israel. At last count, Intel was employing more than 6,000 workers at several plants scattered around the country (Haifa, Jerusalem, Kiryat Gat, Petach Tikva, and Yakum), and has developed into one of the top Israeli exporters, with a volume of US\$1.6 billion in 2003, equivalent to 13 percent of total Israeli electronic exports. The linkages between Intel and Israel are particularly strong, as evidenced by a rapid ramping up of multi-billion dollar investments, mainly to expand capacity at existing plants, some of which have become world leaders of research and innovation.

Government support for R&D

As a coherent body of policies and programs, government support of R&D began somewhat later than the policy of incentives to private investors. By then, the economy and the flow of immigrants had slowed, after two decades of strong growth. The need to define a new development strategy was seen as a priority. Building on considerations similar to those which had motivated the policy on investment incentives—notably, the abundance of a highly skilled labor force, a culture of technological and scientific excellence, and the scarcity of natural resources—the government decided to actively promote the development of a science-based sector by subsidizing private-sector R&D projects.

A first step in this direction was the creation, in the late 1960s, of the Office of the Chief Scientist (OCS), at the Ministry of Industry, Trade and Labor. The OCS administers and grants government funds for R&D, and, in the words of Dr. Eli Oppen, the current Chief Scientist, “operates on the premise that the business sector alone is incapable of carrying on an optimal level of R&D for market growth...and that under such conditions government involvement through support of industrial R&D is warranted.”¹²

Another milestone was the adoption of the *Law for the Encouragement of Industrial R&D* (LEIRD) in 1984, which still represents the fundamental legal framework for government support to private industrial R&D. This law is not fundamentally different in spirit from the LECI (which focuses on fostering capital investment) and calls for the development of a science-intensive, export-oriented industry, able to accommodate the expansion of the

national labor force, improve the balance of payments, and provide grants, loans, and other incentives.

The OCS together with the LEIRD, which it administers, constitute the two main instruments for implementation and administration of government policy in R&D, and have shown a remarkable degree of flexibility over the years, and the capacity to adapt and expand their scope in response to changing technological and economic priorities. As shown in Figure 5, the programs and interventions of the OCS take in the whole spectrum of the innovation process, trying to make up for market failures, when it appears necessary to overcome potential bottlenecks in private initiative/funding.

Figure 6 gives a general overview of several programs which are currently conducted by the OCS, together with their respective budgets. As shown in the figure, the OCS programs can be either national or international, and they cover pre-seed activities as well as generic and competitive R&D. It is worth mentioning that the evolution of OCS programs shows how dynamically the law has been applied.

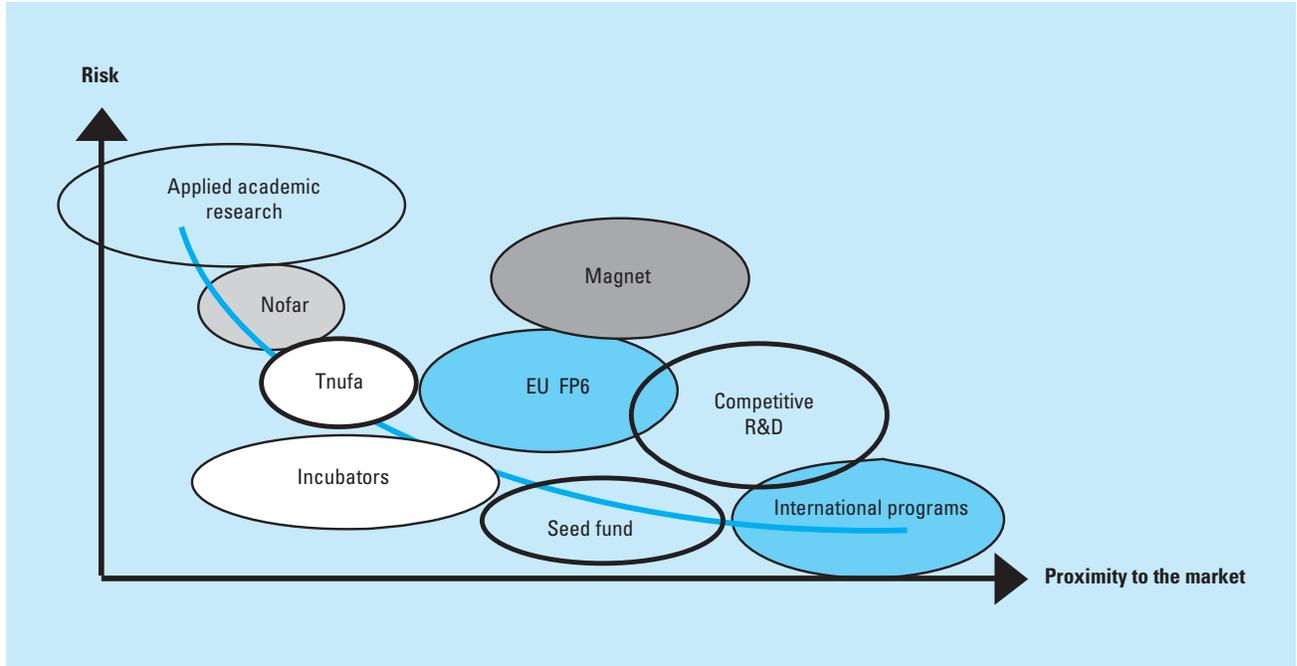
Indeed, the strategy has responded well to signals coming from the market and to political priorities, adapting and/or adopting new programs where appropriate.

Looking at the composition of national programs, support for industrial R&D is by far the most important, in terms of budgetary allocations: US\$300 million per year. Priority is generally given to those projects which result in know-how and technology, and which can lead either to new products and processes, or to substantial improvements of existing ones. Under the program, qualifying companies can apply for government grants, which normally cover 20 to 50 percent¹³ of the approved R&D expenditure budget. A Research Committee, chaired by the Chief Scientist, is in charge of administering the program, notably by evaluating the eligibility of projects, and defining the conditions for approving the grants according to the general terms set out in the 1984 law. In this respect, eligible projects should be executed by the applying company itself, and although the provisions on the non-transferability abroad of both know-how and manufacturing rights resulting from the R&D projects have recently been relaxed, transferability is still subject to clearly defined costs and conditions.

If the products and processes resulting from the government-sponsored project are commercially successful, the company must pay the government back royalties, which correspond to a defined percentage of the total annual product sales. The annual budget for industrial R&D research covers an average of 1,000 projects, implemented by 500 companies.

Another important program is called Magnet, put in place in 1993 to strengthen the linkages between industry—a fragmented landscape whose entities seemed to

Figure 5: OCS support for programs in the innovation process



Source: MATIMOP, 2005.

Figure 6: Programs and activities of the Office of the Chief Scientist (US\$ millions)

	Pre-Seed	Generic R&D	Competitive R&D
National	Technological incubators30.0 Tnufa.....3.0 Nofar.....2.2	Magnet.....40.0 Magneton5.5	Industrial R&D projects....300.0 Seed fund.....1.0*
International		ISERD (European 6th Framework Programme).....4,000.0	MATIMOP Eureka16.0 Bi-national funds.....>23.0** Bi-national agreements

* Over two years.

** Total sum available for the five bi-national R&D funds.

Source: State of Israel, 2005.

struggle to sustain the cost of developing cutting-edge technology—and the largely untapped first-class research capabilities of Israeli universities. Under the Magnet program, consortia of industrial firms and at least one academic institution are entitled to multi-year grants of three to five years, for up to 66 percent of the total approved R&D budget (with no royalty payment) to develop pre-competitive generic technologies. The consortium commits to making the resulting technologies available to any local interested party at a moderate price. In 2005, there were 31 consortia.

On the other hand, the international program of the OCS responds to a different set of considerations. The relative strength of the Israeli high-tech sector lies in the R&D phase. Its weaknesses, however, stem from lack of expertise and skills in international marketing, due to the country's geographical remoteness,¹⁴ and the small size of its companies. These two factors suggest the importance of establishing links and formal mechanisms for cooperation with companies in the target markets. In that spirit, the fostering of contacts between national and foreign companies leading to joint R&D, manufacturing, and marketing has been an important focus of government R&D policy. Many supporting programs have been established to promote this goal, among which the most notable are bi-national funds (such as the Israel-US BIRD Foundation), parallel funding agreements, and participation in the European agreements offering partnering services (EUREKA and the Sixth Framework Program for R&D, known as FP6). The OCS is assisted in the implementation and administration of these agreements by MATIMOP, which was created to serve as the national hub for encouraging the participation of Israeli enterprises in bilateral/multilateral programs for industrial R&D.

Innovation: Technology incubators

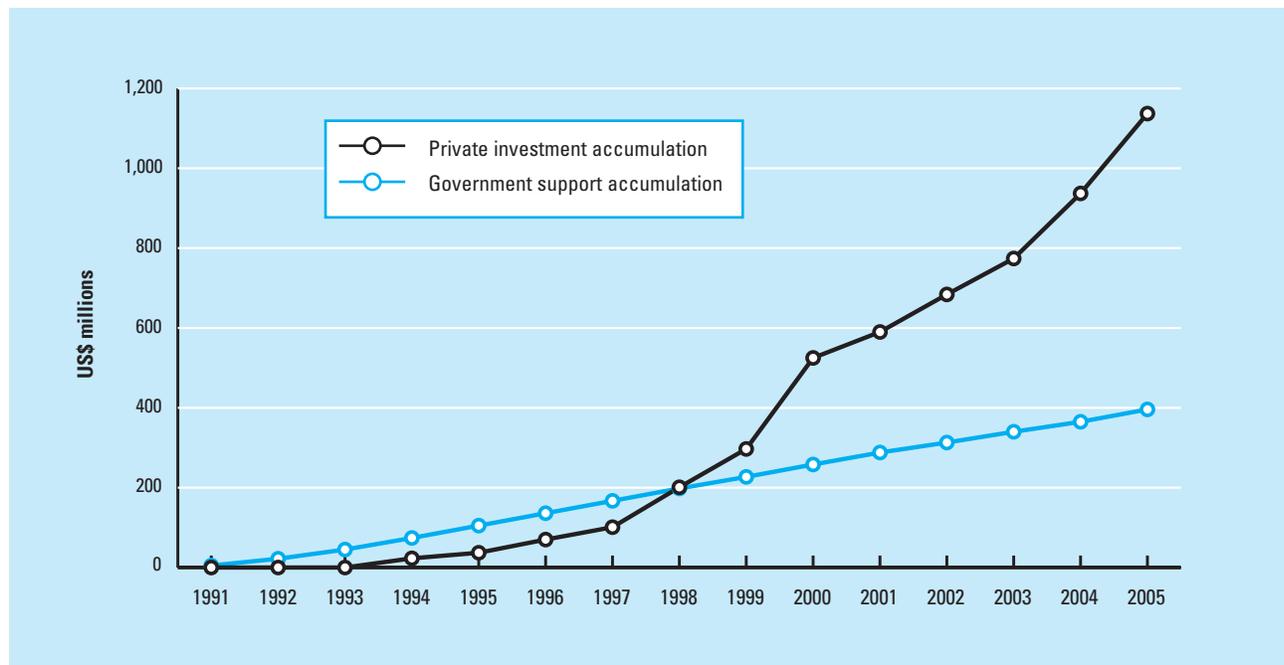
Successful innovation in technology requires two fundamental steps, the intellectual and the financial. In Israel, the generation of ideas has always been prolific. However, the traditionally high level of research in the universities and institutes has resulted in discoveries, which, in general, were not rapidly transmitted to industry through mechanisms for the commercialization of university inventions. Indeed, it was the Magnet program, which later sought to strengthen the avenues of collaboration between industry and the academic community. This was paralleled by the importance of the military, particularly the army's Computer and Data Communications Network Centre, which has been an incubator of computer and software development for decades. The rapid return of its staff to civilian life after military service facilitates the transfer of their innovative approaches to software design to the private sector. The government also created incentives for

returning Israelis who had succeeded in Silicon Valley and other technology centers, enticing them either to set up R&D centers for the companies they worked for, or to establish their own high-tech startups. As a result, in 2004, Israel ranked sixth after the United States, Japan, Taiwan, Switzerland, and Finland in the number of US patents granted per capita. It is noteworthy that a much higher proportion of international patents originating in Israel are held by individuals and universities rather than corporations, as is the case in other countries, such as the United States (Khavul, 2005).

In 1991, to promote business startups, and particularly to assist the new wave of immigrants from the former Soviet Union of the early 1990s, the OCS initiated the incubator program to enable first time entrepreneurs with innovative ideas to develop them into a business. Although the program was initially targeted at the many engineers and scientists coming from the former Soviet Union, many of whom had remarkable skills and research potential, but who lacked the know-how required for commercial success—knowledge of Hebrew and English, of methods to access funding, and familiarity with market economy practices—it was, and still is, open to all. The basic rationale of these two programs is to “polish the diamond,” that is, to take selected entrepreneurs with innovative ideas with export potential through to first round investments in product development, to the point where they can stand on their own, find strategic partners, and raise venture capital on the market.

The incubator initiatives have enabled the government to bridge the funding gap present at the early, risky stage of the realization of promising ideas. With a budget of US\$30 million, a total of 24 technology incubators have been set up throughout the country, each conducting an average of about 10 projects, with an average life time of two to three years. The average budget of each project is approximately US\$450,000 per year. Some 85 percent of the funds are provided by the government in the form of grants and soft loans, with the remainder provided by a venture capital firm, the incubator, or the entrepreneur, in exchange for a share of equity in the company. The incubator's investment and support allow the new venture to develop and prove its technology, to file patents, undertake market validation, develop a business model, attract the first customers, add key personnel to the management team, prepare professionally for the approach to venture capital firms, and gain credibility by being supported by a reputable VC. Figure 7 shows how initial government support acts as a stepping stone for private investment.

Beginning in 2001, 13 incubators have been privatized, taking advantage of the growing influx of venture capital into the country since the mid 1990s, such as LabOne in Tel Aviv, now jointly owned by a venture capital fund and the Tel Aviv Economic Development Authority.

Figure 7: Government vs. private sector investment in the incubator program (US\$ millions)

Source: Office of the Chief Scientist, 2005.

There are no plans at present to expand the number of incubators. The authorities feel that the scope of the present program is appropriate, given the number of promising ideas which can reasonably be expected to appear at any given time. Instead, they have sought to monitor the program to ensure strict quality control and high standards of excellence. The incubator program has become the number one producer of startups in Israel. In 2000, there were 2,000 startups, five times the number a decade earlier. Today Israel has the world's highest density of high-tech startups, nearly 2,500 in a country of only 6 million people (Harel, 2005). Moreover, the success rate of incubator startups is 50 percent, measured as the ability to raise private funding to allow the company to operate for at least two years. This figure compares with only 10 percent for startups in the United States and for Israeli dot.com startups (Trajtenberg, 2001).

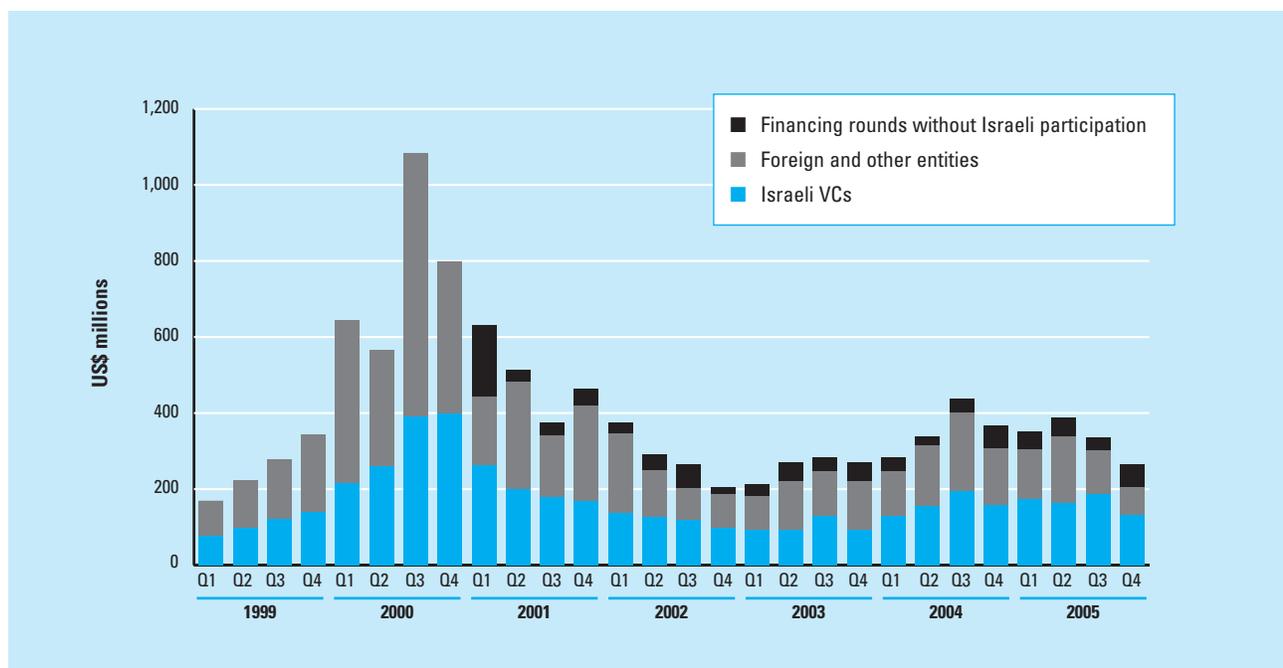
Venture capital

Technological creativity can only lead to successful business development if there is an adequate flow of venture capital, and in this area Israel has achieved enviable momentum. Not only does the country have the highest concentration of high-tech companies in the world after Silicon Valley, but it is a world leader in startups, which contribute a higher share to GDP than in any other

country (Dar, 2005). Startups require venture capital to help them through the product development phase.

In order to address one of the most pressing market failures for many years in the Israeli financial system, the Israeli government played a direct role in creating a remarkably market-friendly venture capital industry. The lack of a well-developed national capital market was one of the most serious hindrances to the proper functioning and expansion of Israeli industry, a deficiency which government grants could only partially make up for.

In 1990, Israel had two venture capital funds, managing US\$59 million. In 1992, the OCS established the Yozma program, to trigger the creation of a venture capital market in the country. The government provided US\$100 million to encourage international venture capital to enter Israel, invest in Israeli high-tech firms, and mentor local venture capital talent. To match the government investment, ten funds were established by international venture capital and industrial firms, headed by Israeli managers. Private investors participating in the funds were offered the option to buy back Yozma's shares at a predetermined price within five years. In this way the government attracted eminent international investors and, together with their funds, their much-needed expertise. Yozma was created in a market-friendly spirit, with a fixed duration of seven years, at the end of which it was privatized, with the government selling out its interest to the private sector. By 2000 there were over 50 venture capital

Figure 8: Capital raised by Israeli high-tech companies, 1999–2005 (US\$ millions)

Source: IVC Research Centre, 2005.

firms that raised US\$9.4 billion. In that year, Israel raised US\$600 per capita in venture capital, compared with US\$30 per capita in Europe, making it the most attractive technology market outside the United States. The level of Israeli domestic venture capital as a percentage of GDP was the highest in the world. In addition, Israel ranked fifth in informal investment (Khavul, 2005). Much of this financing was for relatively small investments in startups.

Over and above government policy and funding, multinational corporations have also played a significant role through strategic partnerships, which included design centers, marketing channels, eventually buying companies to provide an exit for the venture capital (Oron, 2005).

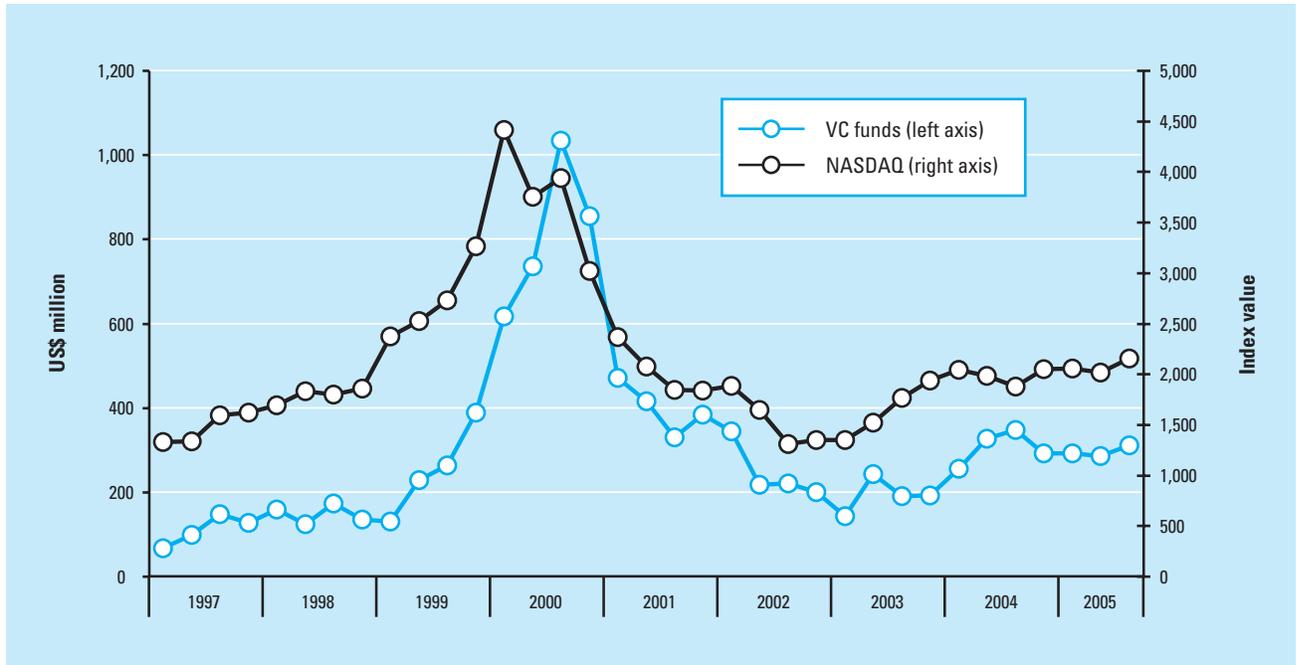
Today, venture capital has become global and most investments are multinational. The Israel Venture Association (IVA) is active throughout the world, publicizing opportunities and raising venture capital for Israeli companies (Harel, 2005). Silicon Valley Bank established branches in England and India in 2004, and in China and Israel in 2005 (Brown, 2004). There are now some 50 Israeli venture capital firms managing over US\$12 billion drawn from the United States, Europe, and the Far East. 133 foreign venture capital firms invested in more than one company in Israel during 2000–2004. As outlined in

Figure 8, in 2004, Israeli high-tech companies raised more capital than any country in Europe (Harel, 2005), with almost US\$1.5 billion invested in startups and the number of venture capital transactions reaching 10 percent of those in the United States. (Dar, 2005).

The leading areas attracting investments are communications and networking, and software, with Israel now a world leader in security technologies and chip design. Figure 9 illustrates Israel's open export-oriented economy in the global ICT marketplace, and how venture capital investments in Israel have placed on the NASDAQ Index. The perspective is clearly on the future, and since 2001, more new companies were established in the life sciences than in any other sector.

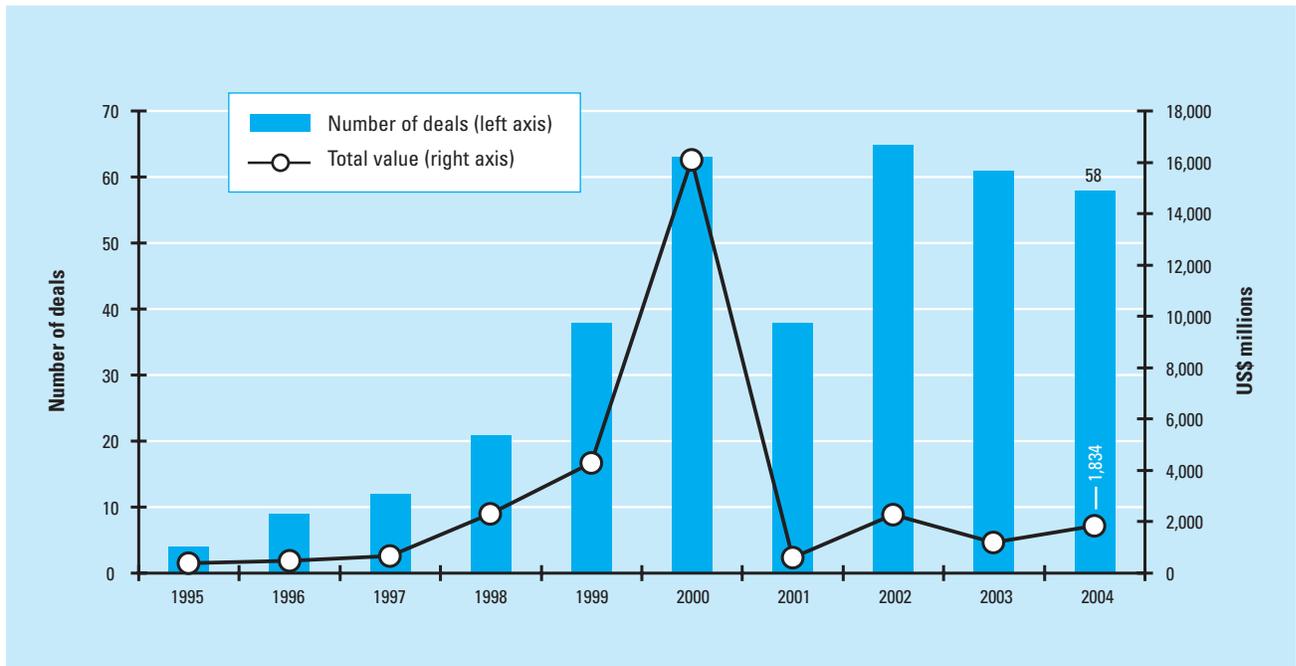
As seen in Figure 10, the success of the venture capital process in Israel is illustrated by the fact that, in the decade 1995–2004, 359 Israeli high-tech companies with a total value of US\$29 billion were acquired or merged (Harel, 2005). Venture capital investments contributed to a 40 percent increase in GDP and 15 percent increase in employment, and accounted for 50 percent of exports and 65 percent of foreign investment over the same period (Harel, 2005).

Figure 9: Investment of VC funds in Israeli startups and the NASDAQ Index, by quarter, 1997–2005



Source: Israel Venture Association, 2005.

Figure 10: Deals in which Israeli high-tech companies were acquired or merged, 1994–2004



Source: Israel Venture Association, 2005.

Box 2: The role of ICT in boosting the growth of the overall economy

The development of the high-tech sector in Israel has been an impressive success story. The main indicators for the last 15 years speak for themselves: the sector grew at an average annual rate of 16 percent in the 1990s, expanding from 4 percent of GDP in 1990 to 14 percent of GDP in 2000, and accounting for one third of total GDP growth.¹ Software exports skyrocketed from US\$135 million in 1992—roughly equivalent to total citrus exports—to US\$3 billion in 2004 (see Figure 11), some 7 percent of total Israeli merchandise exports. ICT products represented 21 percent of total industrial products in 2004.² Of the ratio of R&D expenditure to GDP—4.6 percent in 2004—close to 80 percent was allocated to ICT R&D,³ among the highest in the world. Beyond these impressive indicators, the significance of the Israeli high-tech sector can be fully appreciated when one considers that some of the most important IT breakthrough innovations of the last years have been developed in Israel, from the latest Intel processors used in laptop and desktop computers, to the disk on key, ICQ, and firewall technologies—all Israeli inventions.

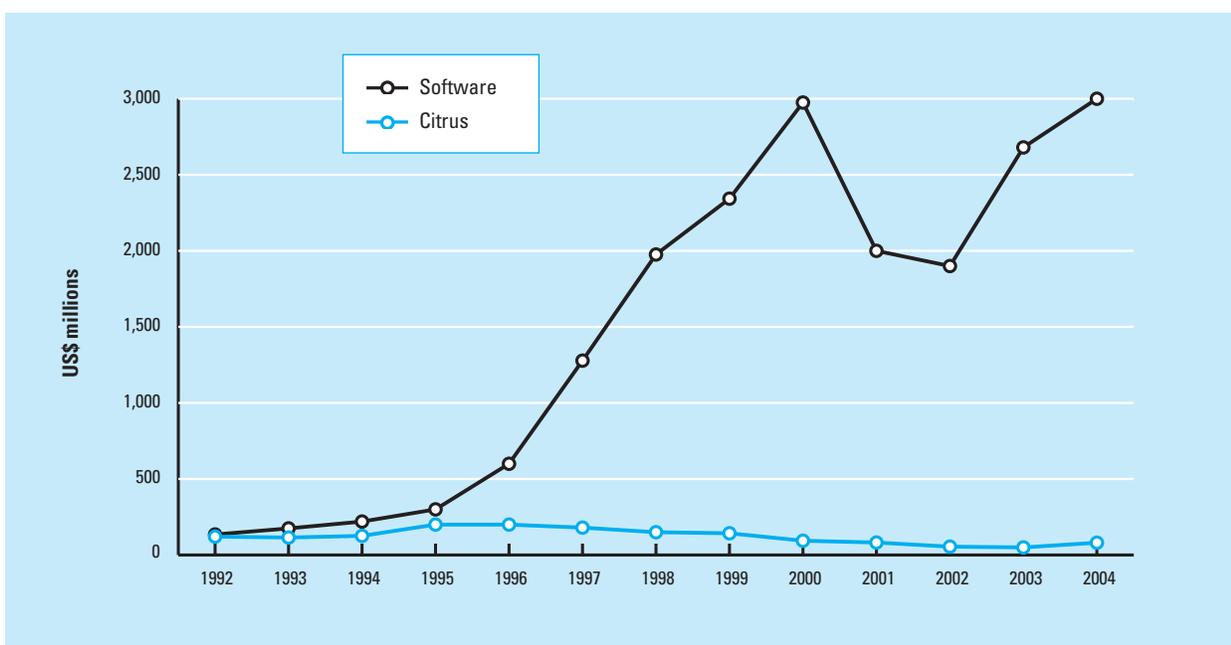
Nevertheless, if one looks at the overall evolution of the Israeli economy, the picture becomes more mixed. Not only did the growth rate of the rest of the economy not match that of the high-tech sector—2.3 percent versus 10.5 percent for the period

1996–2004⁴—but total factor productivity declined for many sectors, such as retailing and business services (–3.3 percent) or the construction sector (–2 percent). Moreover, according to Bank of Israel figures, between 1994 and 2003, the bulk of investment went to the electronics sector, which rose at an annual average growth rate of 20 percent, compared to 5 percent in traditional industries—such as food, textiles and so on—and no growth for the agricultural sector.⁵

Such trends also had a negative impact on the patterns of income distribution in Israel. During the 1990s, the income of the highest decile rose in line with GDP growth, while the income of the middle and lower deciles remained more or less unchanged,⁶ reflecting a large intra-sector wage disparity between the high-tech sector and the rest of the economy. Indeed the average annual salary bill for the high-tech industry in 2002 was higher than the equivalent bill for the mixed high-tech industries, the mixed traditional technological industries and the traditional technological industries.⁷ These observations have led a number of observers to suggest the existence of a “dual economy,” in which the high-tech sector continues to boom while the rest of the economy lags behind.⁸

This, in turn, raises questions about the growth and competitiveness prospects of the Israeli economy over the medium to long term, given that the high-tech

Figure 11: Exports of software and citrus (US\$ millions)



Source: MATIMOP, 2005.

Box 2: The role of ICT in boosting the growth of the overall economy (cont'd.)

sector today represents only 15 percent of the economy, and only around 6 percent of total employment in the business sector.⁹ Therefore, it is important to look at the reasons behind the relatively limited spillover from the high-tech sector to the rest of the economy. Trajtenberg (2005) identifies a number of key factors:

1. Nature of the government R&D programs:

although neutrality has been the stated guiding principle of government policies in R&D, ex-post there may have been a bias in favor of *product* innovation as opposed to *process* innovation, and therefore in favor of the ICT sector, as shown by the very high percentage of R&D expenditure allocated to the high-tech sector. Trajtenberg notes that, whereas in the OECD, on average, 21 percent of R&D spending is allocated to ICT, the share in Israel is closer to 79 percent.

2. Reference market: as noted earlier, the development of the high-tech sector has been export-led. From its inception, the reference market for the sector has been the international market. In that sense, spillovers from the high-tech industry may have been mainly targeted to and benefited external consumers and companies abroad, rather than the local market, such that local intra-sectoral innovation complementarities did not develop to the extent one might have expected.

3. The involvement of multinationals: a large share of R&D in Israel has traditionally been conducted by local R&D centers of multinationals, such as Intel, Cisco, Motorola, and IBM, which mainly serve the needs of the global market and of the parent company, rather than the needs of the local economy. Certainly, there are positive externalities for the overall human resource pool in Israel, in the sense that the local labor force, working for multinationals, can transfer their acquired knowledge and managements skills to local companies, as they move from the former to the latter. At the same time, however, the fact that multinationals draw from the limited highly skilled local labor pool can exacerbate situations of inelastic labor supply, and lead to salary increases which can potentially disadvantage local companies.

4. The massive involvement of VC funds in start up financing: the very nature of VC funds is such that they have a very short time line, usually five to seven years. Thus, they look for an exit after a short time, normally by selling off to a US-based or other

international company, resulting in benefits for markets abroad of the innovation developed in Israel.

What can be done to remedy some of these characteristics of the “dual economy”? How can the rest of the economy take greater advantage from the stellar growth and amazing innovation potential of the high-tech sector? Again Trajtenberg suggests a potential way forward in the promotion of locally oriented innovation, to allow the local economy to absorb maximum spillover. Government R&D policies may have to be realigned, in order not only to maximize knowledge creation, but also to redirect the impact to benefit the local economy. In the case of Israel, it could also be economically and socially beneficial for the government to promote locally oriented innovation and the adoption by the rest of the economy of high-tech innovations in a way that will increase their own productivity. The OCS has recently initiated a program to revitalize the traditional industries by encouraging innovation and R&D. There is also evidence that the extremely important contribution made by ICT to productivity growth in the United States has been linked to the adoption of ICT by sectors (e.g. retailing) which have used ICT to make important changes in business processes, such as procurement, distribution, just-in-time production. Such a strategy in Israel could be a win-win approach, both in terms of reconciling the two parts of the “dual economy” and for export purposes, since domestic demand shares a number of characteristics with a large proportion of world demand, notably that coming from developing countries.¹⁰ Tailoring innovation to address local demand, at least partially, can open a whole new range of export markets, boosting the growth of the local economy at the same time.

Notes

1 Trajtenberg, 2005.

2 Central Bureau of Statistics, 2005.

3 Trajtenberg, 2005.

4 Ibid.

5 Swirski and Knoro-Attias, 2004.

6 Ibid.

7 Ibid.

8 Trajtenberg, 2005.

9 Central Bureau of Statistics, 2005.

10 Indeed, as Trajtenberg explains, in the area of ICT, developing countries are more interested in simplicity, reliability of operations, and backward compatibility, rather than in the development of highly complex software packages.

Conclusion

The government policies described above helped to unleash the astonishing development of the high-tech sector in Israel. During the decade of the 1990s, despite ongoing concerns for basic security, Israel took full advantage of its high educational levels, skilled immigrants, and capacity for innovation to cultivate the ICT sector, which grew 16 percent per year and increased its GDP participation from 5 to 14 percent (Trajtenberg, 2005). In 2004, Israel ranked 6th in the world in the number of US patents per capita, preceded only by the United States, Japan, Taiwan, Switzerland, and Finland.

Since Israel is not a low wage country, it must compete in high value-added products and technologies. Its success comes from niche players who have learned to stay focused. A number of companies have become world leaders in domains such as the Internet, communications, semiconductors, consumer electronics, and digital printing.

In an export-oriented industry such as ICT, it is difficult for companies to grow far from their main customers in the United States and Europe. The solution is outward migration, moving headquarters abroad and establishing multiple locations close to clients, while maintaining R&D in Israel. Also, since small- or medium-sized software companies targeting niche markets are unable to deliver the complete solutions that many customers require, there is a strong tendency for them to be bought up by larger outside conglomerates, leaving them as local R&D shops specializing in innovative technology and unique solutions, whose benefits are largely unrealized by the overall economy.

Israel faces a major challenge in managing the ongoing processes of innovation, which constitutes its competitive edge in the globalized economy. The question is how this small country will be able to create and preserve the critical mass of companies necessary to maintain their competitive advantage.

Notes

- 1 The authors would like to thank Gilad Almogy, Yair Amitay, Yair Averbuch, Eli Barkat, Dan Catarivas, Arthur Dahl, Joseph Gansel, Assaf Harel, Moshe Katzenelson, Gillam Keinan, Ami Levin, Erel Margalit, Yoram Oron, Rina Pridor, Rachel Roei-Rothler, Israel Shamay, Yacov Sheinin, Amiram Shore, Manuel Trajtenberg, Joseph Vardi, and Zohar Zisapel for their helpful comments and insights. The views expressed in this paper, as well as any errors or omissions, are the authors' own.
- 2 In 2004, for the first time, the government's Research Committee deviated from the neutrality principle, by announcing the granting of priority support to the bio-technology and nano-technology sectors. As a result, the first bio-technology incubator was established, together with a center of nano-technology at the Technion (Israel Institute of Technology) in Haifa.

- 3 As argued in Trajtenberg (2005), the existence of two types of market failures in this context will lead to sub-optimal amounts of investment. The first refers to the inadequate returns to private investment in innovation due to the spillovers of technological externalities and excess benefits to customers. The second concerns information asymmetries associated with the creation of knowledge and the related so-called "funding gap."
- 4 Florida, 2005; Israel follows the Scandinavian countries, Japan, USA, Switzerland, Netherlands, Germany, Canada, Australia, and Belgium, but precedes the United Kingdom.
- 5 MATIMOP (2005), the principal technology clearinghouse, is the Israeli Industry Center for R&D, a public, nonprofit organization, which coordinates industrial R&D cooperation between Israel and the international hi-tech community. Available at: <http://www2.mati-mop.org.il/1/index.html>.
- 6 Not surprisingly, a number of Asian companies have been extremely good at copying existing technologies, in some cases without adequate regard for the intellectual property rights of others. For a thorough discussion of Asian approaches to development and, in particular, the interaction between civil and human rights and authoritarian forms of governance, see *Development as Freedom*, by Amartya Sen (1999).
- 7 Under this law, the country is divided into three National Preference Zones: A (the Galilee, Jordan Valley, the central and southern Negev, Jerusalem (for high-tech enterprises), B (lower Galilee and the northern Negev), and C (the rest of the country). The most preferential treatment, in terms of investment incentives, is given to enterprises located in zone A.
- 8 The last revision entered into force on 1 April 2005.
- 9 The LECI applies to all industrial sectors, as well as to hotels, tourism, industrial and residential construction, and—not by chance, given Israeli R&D competitive advantage and willingness to nurture a qualified workforce—industrial development centers.
- 10 Microsoft built its first R&D facilities outside the United States in Israel; Cisco has its first R&D center outside the United States in Israel, and Motorola's R&D center in Israel is its largest worldwide.
- 11 This argument gained ground in the late 1990s when, at the peak of the dot-com bubble, Israel's supply of qualified labor turned quite inelastic against the background of a growing demand from the local sector. Currently (2006), as the Israeli economy picks up again after a few years of recession, the labor supply still remains rather elastic (Trajtenberg, 2005).
- 12 IVC Research Center, 2005, p. 13.
- 13 For projects located in Zone A or along the Israeli northern border, grants can cover up to respectively 60 and 70 percent of the approved R&D budget.
- 14 Israel is, indeed, a peculiar case in this respect. Since the regional market is ruled out for obvious security and political considerations, its export markets tend to be remote. According to data from the Israel Association of Electronics & Software Industries for 2003, 38 percent of exports from the electronics and information sector were directed to the US, 35 percent to Europe, and 22 percent to Asia.

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