Chapter VI: Leveraging Scientific/Technological R&D

Chapter Summary

While Israel is currently among the world's ten most advanced countries in scientific/technological research, with high-tech sectors that are among the world's most developed, there is a concern that the absence of public policy on R&D, along with the intensification of global competition in many R&D fields, may undermine the historic basis of Israel's current position. To maintain its leading technological status in the world, Israel must act towards achieving the following objectives:

- Ensuring the availability of a labor force that has appropriate technological training and is able to assimilate and implement advanced technologies in numerous realms of life in the state: economic sectors, education, health, the environment, etc.
- Creating a competitive, free business environment, shaping clear, transparent, and stable public policy that supports R&D, and building modern infrastructures that will attract multi-national high-tech corporations to Israel.
- Nurturing basic and applied research at universities and transferring the results to the business sector, as a basis for creating new scientific/technological knowledge, an appropriately-trained labor force, and the coming generations of researchers.
- Appointing a Science and Technology Advisor to the Prime Minister and creating a **National Science and Technology Council** to coordinate between the numerous government agencies that impact upon achievement of these goals, and to delineate strategic priorities and a plan of action for their realization.

Introduction

Over the past decades, Israel has enjoyed international status as a thriving technological incubator with an economy that has developed an impressive industrial sector based on advanced knowledge and technology. This was achieved through strong entrepreneurship and an ability to take advantage of business opportunities in a developing international high-tech world. Israel was one of the first countries to adopt technology-based economic growth. This was done initially without comprehensive deliberation or a complete, carefully-delineated strategy. After a few tentative years, a consistent and comprehensive policy was formulated, at its center stood the Office of the Chief Scientist. This policy relied on an appropriate human infrastructure, made up of university graduates in the sciences and former defense system and IDF personnel, who successfully realized advanced technology's practical and commercial potential. Bold in its technological innovation, the defense establishment allocated significant resources to R&D

and technological applications, and served as a major catalyst for the development of Israel's knowledge-based industries. The domestic supply of skilled employees and the abundance of educated, motivated new immigrants in the 1990s also made a significant contribution towards accelerating this industry's progress. Beginning in the 1980s, government policy also played a significant role in creating the venture capital industry, which was crucial in promoting technological entrepreneurship. To this day, this model is emulated in numerous countries. These factors, along with the policy delineated for supporting business entrepreneurship and civilian R&D, promoted Israel's leading status world-wide in high-tech enterprise and produced a flow of foreign investment directly into scientific and technological innovation. The timing of Israel's advanced technology developments corresponded with the world business cycle, facilitating attainment of these achievements.

World-wide, development of these industries gathered speed. International demand for new technologies was not satiated: on the contrary, new inventions produced new demand, creating non-linear growth in the advanced technology markets. Israel has a competitive advantage in supplying these technologies, whether through cultivation of new companies, or as a global sub-contractor of new inventions and technologies that develops and sells technologies to existing companies. One manifestation of the success of the business model of Israel's high-tech sector, which combines science and technology with enterprise, is Israel's ranking second in the number of technology companies traded on US capital markets. As long as Israel continues to protect it leading status in science and technology fields, this model will succeed and even expand beyond technology producers to sectors that use these technologies. In the field of ICT (information communication technologies), Israeli excellence is especially prominent, with extensive production by Israeli companies in Israel and abroad. Maintaining and promoting Israel's comparative advantage in advanced technologies will require Israel's increasing support for scientific research and technological development, and employing new tools that are appropriate to changing conditions.

In order to enable economic growth rates of over 6% real annual growth for the coming years, Israel's success as a focal point of high-tech industries must be maintained and even augmented, on the basis of leveraging R&D and technology: deepening and further expanding the utilization of their gains in existing areas, and dispersing their benefits across new realms.

High-tech sectors have made a very substantial contribution to Israeli export (high-tech exports currently comprise about 40% of the total export), which has been almost exclusively responsible for solving the problem of the economy's balance of payments in recent years. However, in the future the economy will not be able to be based solely on a single growth engine. High-tech sectors produce about 9% of Israel's business sector's output, and employ, by the broadest definition, only 6-7% of Israel's civilian labor force (see list of high-tech sectors in Table 1 in the appendix to Chapter VII). Achieving balanced, sustainable economic growth of 6% a year overall will require making balanced, concerted efforts in other channels as well – those of traditional and service sectors (see elaboration in Chapter VII). Given Asian countries' rapid technological development, Israel must promote innovation and creativity in order to maintain its leading position in advanced technology sectors and their applications.

Policy measures must be adapted to the objectives for the coming years, and new tools must be constructed that are appropriate and effective for high-tech sectors. These include providing infrastructure and training manpower, which involve considerable public investment (see discussion in Chapter VIII on higher education and scientific research and Chapter XI on national infrastructures). Instruments of support and encouragement, and new or amended incentives must be created to promote the use of the economy's existing resources and abilities, in order to create and utilize new business opportunities at home and abroad. In a 2006 study conducted by the RAND Corporation for the US National Intelligence Council, a forecast was constructed of 16 most promising applied advanced technology fields to the year 2020 (in the fields of bio-technology, nano-technology, materials and information technologies).[7] The study also assessed the capability of 29 different countries to develop and assimilate applications in these fields, based on numerous characteristics, including scientific and technological capabilities, availability of funding sources, support for innovation, ability to absorb advanced technology, and other measures from the realms of government, society and economy. Israel is among the most advanced countries that were assessed, along with the US, Canada, Germany, Japan and Korea. However, this positive assessment, based on the state's past achievements, requires nurturing of Israel's scientific/technological research and education capabilities.

The following five most influential factors in terms of promoting economic growth and productivity arise from many other studies that have been conducted throughout the world[8]:

1. **Strengthening human capital and realizing its potential.** Ensuring a regular supply of scientific, technological and engineering manpower on a large scale and of the current standard; increasing higher education's quality and technological relevancy; providing incentives for ongoing training and life-long learning; cultivating and managing organizations based on entrepreneurial knowledge. The IDF is one of the primary sources of human capital for ICT in Israel.
2. **Maintaining the advantages of ICT** in which impressive achievements have been made in recent years, and developing ICT skills; encouraging competition in the communications markets; expanding the use of computers and communications to additional areas; developing digital content and reducing the local "digital divide" in the population.

7 The list of technological application fields identified in the study as having substantial potential can be found in Table VI-1 in this chapter's appendix.
8 See for example: Going for Growth, OECD 2007; and Micro-Policies for Growth and Productivity, OECD 2007.

3. **Creating close cooperation between science and technology.** Improving the quality of publicly-funded university research; encouraging the relationship between industry and academia; encouraging the demand for new technology intensive products, processes and services.
4. **Building new science-intensive areas with business potential** in fields beyond the information and telecommunications industry, in which Israel has specialized so well in recent years. Examples: bio-technology, chemistry, materials, molecular biology, etc.
5. **Promoting the creation of new companies, entrepreneurship and innovation.** Increasing access to venture capital; training for innovation management in various areas. Technological and scientific innovation will continue to serve as the base for maintaining Israel's comparative advantage in the future. Chapter IV, Israel and the Global Challenge, expands on the issue of creating global companies. However, given the rapid economic/ technological development of economies in Asia and elsewhere, Israel must enhance its advantages in creativity and scientific/ technological innovation in order to maintain its leading position.

Vision and Strategy

The prosperity and growth that Israel has experienced in recent years must be cultivated and intensified, through the formation of a science- and technology-intensive industry cluster that includes a variety of influential leading industries, while creating new areas of innovation and excellence. To this end, the establishment of new enterprises must be promoted in an extensive, comprehensive manner, and large, globally-influential companies must be nurtured and efficiently utilized, through directed economic development processes. Economic development processes, especially those relating to knowledge-based industries involving skilled, educated manpower, combined with social assurance to low wage earners and traditional sectors, may ultimately lead to: improved efficiency; attracting young people to science/technology studies; more balanced growth among the various sectors; employment opportunities for all; a greater degree of equality in income distribution and reduction in poverty; the adoption of modern technologies in various sectors; continued promotion of basic and applied research; improved transfer of technologies from universities to industries; and a dynamic policy attentive and adaptable to the needs of a frequently changing, competitive world.

Government's Role in Technological Development and Research

Government activity in various areas can critically impact upon the economy's technological development and research activity. R&D is defined as a systematic, original activity designated to add new scientific or technological knowledge, or to develop a new application on the basis of existing scientific or technological knowledge.

The following survey of these effects underscores achievements and future needs for government support.

1. **Basic Research and Creating a Research Infrastructure vs. Business R&D**

   For a number of years, Israel's R&D expenditure (4.5-4.7% of the GDP in recent years) has been the highest in the world, first by international measures. Even in terms of R&D expenditure per capita, it is higher than that of other industrialized countries, about $1100 per capita for civilian R&D (comparable to the highest among OECD countries, including Sweden). However, in recent years substantial changes have occurred in R&D funding: a significant reduction in government funding, and a significant increase in business sector funding. Business R&D is directed toward short-term results, not towards ensuring knowledge and human capital infrastructures for the long term. This development is two-sided. On the one hand, relatively decreased government funding for R&D demonstrates the maturity of Israel's business sector, which has taken upon itself a larger share of investment and risk. On the other hand, the business sector prefers less risky R&D investments. Thus the economy foregoes investments involving a larger degree of basic research and innovation. Typically not directed toward one product or process, these investments bear fruit in the longer term. By their nature, they are riskier, but have greater external advantages. Therefore, government support must focus primarily on basic research and basic development, in which the business sector invests less, while less-risky applied development will be under the responsibility of business.

2. **Promoting Technologies and R&D – Direct Impact**

   Government programs dedicated to the promotion of technology and R&D fulfill an important role in encouraging innovation and R&D activity, both directly and indirectly. Due to market failures stemming from the difficulty in imposing a price on all sectors that enjoy the fruits of R&D spillovers, relying exclusively upon private funding will produce an insufficient scope of R&D activity in the economy, particularly in fields of high scientific-technological uncertainty, that involve finding breakthrough solutions. In the past, Israel's governments contributed significantly to the shaping of R&D and the high-tech industry in Israel, including taking the role of leading user/client/developer of advanced military technologies; establishment of the Office of the Chief Scientist in the Ministry of Industry, Trade and Labor; and establishing the Israeli venture capital fund industry. It is important that government continue to contribute to future technological advancement and support R&D, but in new ways.

3. **Promoting Technologies and R&D – Indirect Impact**

   There are a number of government support programs for capital investment in various fields and geographical areas, which encourage creation, dispersion and assimilation of advanced technologies. Not specifically geared toward R&D or innovation, or even considered an R&D expenditure, these programs do in fact support these issues, at times significantly:

- **National geographical priority areas:** The Law for Encouragement of Capital Investments allows companies to receive generous government grants in return for investment in development areas in Israel (for example, Intel in Kiryat Gat). In 2004, subsidization for these and other programs came to about NIS 1,400 million. Opinions are divided as to the advantages of the Law for Encouragement of Capital Investments. Studies conducted on this issue do not support the premise that providing grants increases employment and output in development areas. The benefit to technological advancement is even more dubious. Use of this support tool should be focused only on needy communities that can produce proven benefit.
- **Tax incentives**: Israel offers various tax incentives for capital investment, including for moving one's domicile or business to development areas, which gives "approved enterprise" status that entitles to forgoing of VAT and income tax. This is not considered a direct expenditure in the government budget (although a budget estimate is published every year along with the state budget by the State Revenue Administration). Thus for example, in 2006, the scope of tax benefits under the Law for Encouragement of Capital Investments totaled an estimated NIS 2.4 billion, some of which contributed to technological development and job creation in advanced and mixed/advanced technology. Tax benefits for R&D were estimated at about NIS 1 billion. It is difficult to assess the contribution to promoting R&D and technological development in Israel. In the case of encouragement through tax benefits as well, use of the tool should be examined on the basis of a clear cost-benefit approach.
- **Funding of higher education institutions**: Another subsidy that is not directly taken into consideration as support for innovation and R&D activities includes the funding of seven universities (two-thirds of the higher education budget) and of "public" college budgets. This amounts to approximately NIS 3.5 billion for universities, beyond research fund grants. Of the national expenditure on R&D, only 40% of the Planning and Budgeting Committee's contribution to universities' budgets is considered a direct R&D expenditure. This percentage was determined by an (historic) employment survey of researchers at Israeli universities, according to the guidelines of the Frascati manual for compiling R&D expenditure data, which is used by the OECD countries.

4. Promoting Technologies and R&D – Impact of Government Investment on Private Investment

Experience shows that government investments can potentially impact significantly on business sector investments supporting innovation and creation of new industrial clusters. For example, since 1991, the Chief Scientist has invested about $30 million a year to support 24 technology incubators and hundreds of projects operating within them. Only some years after this investment was initiated did the business sector begin to understand its hidden business potential. In the late 1990s, private investors began to invest in incubators; this investment has increased significantly in recent years. In 2006, private investment in technological incubators and the projects operating within them was four times greater than that made by the Chief Scientist. This is an example of government intervening where there was previously a market failure, creating a business field that subsequently matured and gained legitimacy, similar to the process that occurred in the 1990s in the field of venture capital funds. These examples illustrate the importance of government activity in developing new technological/economic realms in the future as well.

5. Ensuring a Competitive, Open Environment for Doing Business in Israel

The World Bank publishes a yearly international report on the Ease of Doing Business, in which countries are ranked according to ten equally weighted topics[9]. In 2007, Israel was ranked 26th out of 175 countries. Israel must improve its business environment in order to attract foreign multinational companies and companies established in Israel, to develop advanced technology and create global companies. Israel's weaknesses are primarily in obtaining licenses, employing workers, registering property, paying taxes and enforcing contracts. Other rankings, such as the World Economic Forum's Global Competitive Report, also indicate the need for improving many aspects of Israel's business environment, especially those affected by the size of the public sector, public institutions, and public policy. Having a technologically-skilled labor force will not suffice in order to make Israel a magnet for multinational high-tech companies. Its distance from markets, as well as the diminishing human capital and wage gaps for skilled employees in Israel versus other developing countries, reduce Israel's comparative advantage and necessitate improvements in additional areas.

Dilemmas and Problems

Israel's thriving entrepreneurial high-tech sector enjoys leading status in the world, especially in ICT. It conducts excellent academic research in many areas. This notwithstanding, we must remember that today's achievements are the fruits of yesterday's investments in research and wise government policy, along with external factors and circumstances that will not necessarily recur. Concerns regarding Israel's future status intensify in view of the following threats:

9 The World Bank and other bodies such as the World Economic Forum, publish measures for ranking competitiveness and quality of the business environment in different countries in the world. These measures are influenced in part by the quality and efficiency of government, and in part depend upon the business sector's development. The measures are based on data regarding the bureaucracy involved in starting and closing a business, employment and dismissal regulations, the ease of achieving authorization and permits, registration of ownership of assets and intellectual property, achieving credit, protecting investors and stockholders, taxation, foreign currency regulations and international trade, and so on.

1. **The risk of deterioration in Israel's future scientific abilities** due to **universities' weaknesses**, a thinning of academic faculty and a "brain drain". In the past, these very factors were the secret of success of Israel's knowledge industry.

2. **Cuts in Israel's scientific research** in recent years, cumulatively totaling about 20% in university budgets (despite the doubling of the number of graduates), and inadequate budgeting for research and designated support programs in science-based industries, such as biotechnology, agriculture, space, alternative energy and more.

3. **Diminishing of Israel's comparative advantages versus EU and Eastern Asian countries**, which are currently making giant steps towards developing their own high-tech sectors, some of them employing characteristics of government R&D policy that was taken by Israel for years.

4. **The challenges of globalization and maintaining Israel's competitiveness in the new competitive world** will require altering the formula for non-industrial R&D activities. Compared with many other countries, Israel's government expenditure on R&D objectives for public welfare, especially in areas such as agriculture, the environment, and public health, is very low. Also, support for university R&D is based on historical costs by various fields of knowledge, in accordance with development programs set by the higher education institutions, and does not adequately reflect national strategic objectives for scientific/ technological development. See Table 2.

5. **Incompatibility between state priorities and a dynamic world of global competitiveness** in the technology, capital and R&D markets. For example, the priority given to allocation of public resources for defense purposes over civilian or social purposes; the emphasis placed in industrial policy on developing manufacturing products and technologies, while ignoring innovation in its broad sense and the services sector; the low priority given to investment in public welfare, the environment, and development for future generations.

6. The direct government expenditure on civilian R&D and support for R&D totals about NIS 4 billion (0.8% of the GDP), so that the government's direct share in civilian R&D activity in Israel is about 17%[10]. Other support programs (the Law for Encouragement of Capital Investment, support for development areas, support for all levels of education, etc.) add about NIS 6 billion, some of which supports investment in innovation and attaining education. Allocating and managing these considerable sums is not necessarily compatible with the great challenges facing the Israeli economy. Policy-makers have not set clear explicit goals that withstand the test of benefiting public welfare and the foundation for future scientific/ technological capabilities. The overall systemic view of the total support for science and

10 Israel's R&D accounts for about 4.7% of the GDP; the government's share through direct funding is about 0.8% of the GDP, or 17% of civilian R&D (0.8 divided by 4.7).

technology, which is currently dispersed among various branches of government, is inadequate. A long–term view is needed, that integrates the issues of investment in basic research, training of researchers, training of academic and engineering manpower, and coordination between government branches (the Chief Scientist and the Investment Center in the Ministry of Industry Trade & Labor, the Ministry of Science, the Ministry of Education, the Council for Higher Education-Committee for Planning and Budgeting, the Ministry of Housing, the Ministry of Finance, the National Council for R&D, etc.).

7. **Most of the government expenditure on R&D is focused on supporting R&D in technological industrial sectors and universities**. About 30% of the government expenditure for civilian R&D, about NIS 1.2 billion in 2005, is directed towards supporting industrial R&D (of which over 60% goes to ICT sectors), and about 49% towards supporting university research (the Planning and Budgeting Committee's support for universities in the framework of the "research model" – about NIS 2 billion in 2005). **This is despite the fact that all manufacturing sectors together produce only about 22% of the business product** in Israel. **The government's limited support for R&D outside of the advanced technology manufacturing sectors diminishes the possibility for developing the majority of business sector industries** and increases the risk involved in these sectors' growing share in the economy, given the intensifying international competition (see expansion in Chapter IX). Table 1 presents the scope of government R&D expenditure (direct government R&D and support for civilian R&D at two points in time – 1998 and 2005). As we can see, the absolute government expenditure on R&D has increased by about 2.2% a year (totaling about 17% over seven years). However, this rate is lower than both the economic growth rate and the increase in the overall scope of R&D. The table also illustrates that only small changes have occurred in the targets of government R&D expenditure during this period. The important question is whether government expenditure is directed to the right targets, that is, is support directed to areas of significant market failure, high risk and high likelihood of innovation and sectoral breakthroughs with external impact.

Table I: Government Expenditure on Civilian R&D by Target

(in NIS and % of government R&D expenditure)

	1998	2005
Total government expenditure on R&D (millions NIS)	3,580	4,173
Technology and product development (mainly programs of the Chief Scientist in the Ministry of IT&L)	36.7%	30.1%
Agricultural R&D	7.7%	7.2%
University research	43.9%	48.8%
Support for other technological R&D	5.1%	3.1%
Research on education, welfare, and social sciences	3.3%	6.9%
Support for research infrastructure	0.6%	1.6%
Other	2.7%	2.3%

Source: National expenditure on R&D 1989-2005, Central Bureau of Statistics

8. Israel's knowledge and technology industry has relied on government policy guided by two principles. **The first principle** was that of government intervention by supporting R&D due to the market failure in this area, primarily of positive **external impacts** on society, that are not expressed in returns to firms or individuals. **The second principle** was that of **neutrality** in government involvement, based on the recognition that the government lacked the knowledge that could give it an advantage over the market in selecting preferred sectors. In fact, criteria were adopted for R&D grant allocation, which gave clear preference to R&D projects in ICT fields, where results can be seen relatively quickly – within a few years – as opposed to the longer time periods and riskier prospects of fields such as bio-technology. Government intervention in supporting R&D will be needed in the future as well, as market failures will exist in knowledge industries, justifying an active government support policy. On the other hand, significant changes have occurred that warrant re-evaluation of the neutral support policy. Expansion of knowledge and technology industries based on government R&D policy has gained significant impetus world-wide. Many countries, large and small, have entered this activity with great force, not on the basis of market preferences but rather by government selection that has been formulated into extensive, comprehensive government support for targeted sectors. **Targeting** does not take a neutral stance but rather actively chooses sectors on which the state will focus. We must consider this policy's implications for Israel: should Israel maintain its completely neutral approach as it has done for the past thirty years or so, or should it change and vary its approach?

9. From the outset, the policy of the Office of the Chief Scientist's for supporting civilian R&D in Israel was characterized by "neutrality". Selection criteria for applications were uniform across all areas, without explicit preference for one sector or another. Through

this policy, successful technological enterprises could receive support and could prosper, while unpreventable errors involved in trying to predict which areas would be economically successful, were avoided. In fact, however, **the policy created government R&D support that was oriented toward manufacturing and technology development sectors, primarily in ICT** (see Table 2, below). While the Chief Scientist's policy was neutral, the national system was biased in favor of these sectors, whose success stemmed in part from the national bias, and in part from military R&D investment's preference for ICT. Today, following high technology's impressive international achievements (especially those of ICT), we require a strategically directed policy with a long-term perspective, which will reconsider some of the basic assumptions of the past, in view of changing present and future conditions. Such directed policy is needed to balance the market failures and system failures that characterize time-intensive developments; global developments that point to a widespread expansion of countries that are entering the R&D realm with great force and that employ a targeting policy; technological and economic uncertainty; significant external effects of investments in various realms; built-in knowledge gaps between entrepreneurs and investors; and distance from markets. The more government support for civilian R&D is directed towards basic research and basic development, as we recommend here, the better the chances for creating a comparative advantage for a large cluster of existing and future sectors. We propose an additional structured consideration for assessing government involvement. According to our proposal, one of the most important considerations for assessing investment for the purpose of granting the Chief Scientists' support will be systemic evaluation, according to criteria to be set by experts in the field, regarding the significant external benefits of a given investment.

Table 2: Chief Scientist's Allocations by Target

Technological Category	2006	2005	2004	2003	2002	2001
Electronics, electro-optics, ICT	63%	66%	67%	71%	75%	73%
Chemistry	4%	3%	2%	3%	3%	3%
Life sciences	28%	27%	23%	22%	18%	19%
Other	5%	4%	8%	4%	4%	5%

Source: OCS 2006

10. **The overall expenditure on civilian R&D (4.7% of Israel's GDP), one of the highest in the world, is misleading. It conceals surplus allocation for "development" at the expense of "research".** The Israeli government's share in civilian R&D has declined continually from 37% in 1991 to 23% in 2003. At the same time, the business sector's share in R&D has increased over this period from 43% to 69%. Seemingly, this is not a negative occurrence, in that it may reflect the business sector's maturity and strong ability in recent years. The

business sector can and must fund business development, as it has indeed done increasingly in recent years; however, the "market" cannot lead research. Basic scientific research suffers from "market failure" due to its long-term and uncertain nature, and the relatively large investment it involves. Thus "research" is defined as investment of funds, primarily in order to produce knowledge. "Development", on the other hand, is the investment of knowledge primarily in order to create a product (i.e., income from sales). A large part of scientific research is done not in order to achieve a specific economic/technological end, but rather to achieve understanding of processes and produce scientific abilities, the practical outcomes of which cannot be foreseen. This research, however, is essential for creating the knowledge and insight by which to educate scientists and technologists, who can in turn harness and leverage innovative technologies to create products and services. Research that is funded primarily by the business sector will always be oriented toward achieving short-term results, at the expense of long-term development that only government (and generous non-business-motivated donations) can fund. The government is obligated to focus on funding research. Policy by which the government reduces budgets designated for support of **development** and transfers the funding burden to the market can only be appropriate if at the same time government increases its **research** ("science") and basic development (as opposed to applied development) budgets. In fact, a decline is occurring in both types of government activity. One of the problems that make policy analysis difficult is the binding of both research and development activities under one inclusive term - R&D.

11. **Cuts in research budgets inevitably affect the ability to recruit and keep university staff members,** who are to create the next generation of researchers and users of science and technology. The current policy intends to change the trend of recent years (this was one of the motives for establishing the Shohat Commission, which clearly stated the need for increased academic research). However, fixing the damage of recent years will require significant investment. International competition over academic talent is a strong lure for young researchers to make their future abroad, which constitutes a serious risk to the generation of technological and scientific researchers and developers in Israel.

12. **Existing funding mechanisms and available capital for establishing enterprises are also biased towards ICT industries.** Just as the government judiciously discerned the need to support the establishment of a capital venture industry to develop these industries 15 years ago, today government must activate venture capital in higher-risk areas requiring greater investment and longer-term returns on investment than in ICT (as in bio-tech, for example).

Recommendations

The recommendations listed below are to be implemented according to the following guiding principles:

1. Government intervention is warranted only in cases of significant market or system failure.
2. Government should address and treat "research" and "development" activities separately, and split the term "development" in two: "basic scientific/technological research" and "applied or engineering development"[11]. Government must provide resources and infrastructure to enable R&D and innovation, increase its investment in research, and, to a lesser degree, in basic development, and support engineering development only minimally (to be financed by business).
3. Government support programs should be assessed continually and regularly, and the findings of the assessment published. Implementing findings and establishing a government support policy for R&D requires that an updated database serve as an integral part of any government support program. Databases will be expanded and updated on an ongoing basis, and include data on science, R&D and innovation activities and their economic contribution.
4. The organizational system must be adapted to future action in three areas of poli**cy change**:
   - **Creating a very senior governmental body, to be responsible for prioritizing planning and policy-making** in an ongoing, forward-looking manner. The new body will address education, science, technology and innovation issues, hence its name: the National Science and Technology Council (Hebrew acronym *Malmat*). This recommendation stems from the complexity, the protracted development and the varied nature of the factors that need to be harmonized in order to create appropriate policy for science, technology and industry. It also reflects the need to adopt a dynamic, flexible, adaptable, active and initiating process for prioritizing policy, as opposed to setting reactive frameworks and means at the operational level, which were successful in directing Israel's' economy on the right path in its first stages (see also Chapter V on institutional changes in public service).
   - **Strengthening the free business environment** in Israel, which is open to competition and globally-oriented, and developing the necessary infrastructure to encourage Israeli companies to take advantage of technological achievements at home and abroad;

11 The term “research” relates to the stages of creating new scientific/technological knowledge and technological problem-solving that is not directed towards a specific economic goal. The term “development” relates to applying new knowledge and adapting it to a well-defined goal, typically in a business framework. Development will be considered “basic” if it is generic knowledge or technology that serves various applications. “Engineering development” is designated as the adaptation or assimilation of existing technology into a specific application.

making Israel attractive for multinational corporations in broad and varied sectors; and enabling strategic connections and cooperation with important forces in the world arena, new and old, at the national and corporate levels. Studies conducted abroad indicate that the presence of international high-tech corporations domestically, makes a significant direct contribution to the scope of domestic R&D activity (Intel in Israel, for example); its indirect contributions are no less important, in the form of “spillovers” of technological knowledge and experience in work methods and organization of business R&D activity.

- **Promoting technological innovation and basic research in universities, and recognizing their third function** in transferring technology, assimilating innovation, and creating an ongoing base for existing and new high-tech sectors in the economy. This objective will be achieved by developing new relationships between the producers of new technologies and scientific inventions (the researchers) and potential users in the various industry and service sectors.

Following is a list of concrete recommendations for changes in each of the three policy areas detailed above:

4.1 Appointment of an Advisor to the Prime Minister on Science, Technology and Research and creation of a new, very senior government body to be responsible for the process of prioritizing planning and policy-making on these issues: the National Science and Technology Council (*Malmat*)

Given the vast implications of education, scientific and technological R&D and assimilation of new technologies in broad industry sectors and the economy overall, we propose to establish a **council** of senior rank that transects all relevant government ministries and bodies. The council will set priorities for delineating policy, and will coordinate the implementation of publicly-funded measures. The council will facilitate regular, ongoing activity at the strategic (not operational) level of outlining and assessing policy. It will be based in the Prime Minister's office, and, similar to the South Korean model, will obtain the PM's prior approval for its general operating budget. The council will also be linked to the Office of the Chief Scientist, as operational experience and developments on the ground are to be central in identifying new strategic priorities and translating them into new policy guidelines. However, the council must be independent of the Office of the Chief Scientist as regards proposals for new priorities, setting criteria for identifying the external benefits of single-discipline and sectoral R&D, new programs and reassessment of prior policy guidelines (all currently carried out by the executive units themselves). Actual budget allocation to firms according to the council's policy will be executed by the Chief Scientist.

- **The new council's main functions**:

- To identify and specify **strategic priorities** for areas under its responsibility which require investment. In setting priorities, the council will consider the state of the economy, its developmental level, the resources at its disposal, its needs and its integration into the global system. Council decisions will take into account the market failures that prevent achievement of the objectives under given circumstances.
- To characterize ***Malmat*'s general policy** for Israel, and for the next 5-10 years. For example: assimilating advanced technologies (especially ICT) into broad economic sectors and cultivating ICT firms to become Israel-based global companies.
- To set criteria for identifying significant external benefits of firms' investment in R&D, and to determine their weight in the decision on providing funding for the investment.
- To fulfill a central professional role in **setting an integrated national budget** for all aspects of science and technology policy in Israel.
- To fulfill a **"coordinating" role between the various ministries and bodies** involved in science and technology policy (especially at the strategic level).

- **Strategic priorities and principles for setting science and technology policy.** The recommendations for strategic priorities in these areas will be based first on **broad national objectives**, then on **specific goals to achieve these objectives**, and finally on **identifying specific areas of activity** that are affected by science and technology policy. These three levels must guide the priority-setting process. According to this approach, three criteria direct the setting of goals: a) the existence of active companies with very high abilities and large growth potential; b) a real possibility for *cooperation with leading reputable high-profile foreign elements* already active in the region; and c) the possibility to *achieve and maintain, within a relatively short period of time (five years, perhaps) a significant global market share.* Examples of potential areas whose transformation into Multi-Agent Structures (clusters of firms with horizontal or vertical affinity with each other) should be considered, include public security; stem cells; other specific life sciences fields; clean-tech and ICT fields.

- **Setting priorities in a systematic, comprehensive manner involves identifying promising areas and new technology applications that require appropriate support and public promotion in order for them to develop and grow into thriving industries with significant shares in world markets.** Promising new technology-based national industry and research clusters include water technologies, advanced agricultural technologies, ICT, alternative energy, space industries, life sciences, public security, chemical industries, and nano-technology. Discussion of these clusters will be expanded below.

4.2 Strengthening the free business environment

In this area, a number of vertical policy areas are specified that may affect productivity and innovation across industries. Also known as enablers, they offer fertile ground for encouraging innovation and enterprise based on R&D and advanced technology. Some of the policy measures involve public investment, whether by supplying infrastructure or free public services, or by direct support grants, or by tax reductions. Others involve legislation, regulation or setting standards, which do not require designated budget expenditure. While the measures in the second category are typically attained at low cost to government, mostly for enforcement of regulations, they are not necessarily any less efficient in encouraging innovative activity than measures involving public investment.

The following proposed measures will serve as general incentives; remove obstacles to innovation in Israel's business sector; and make Israel more attractive to companies competing and operating in global markets. Measures that should be utilized include: a) creating an open, competitive business environment, accompanied by efficient systems of law enforcement, capital market and public acquisition; b) reshaping regulatory rules and removing the protective measures that hinder innovation and the adoption of technology on the one hand, and adopting leading standards in new areas for the development of new technologies and industries, on the other; and c) providing incentives and building infrastructures that will help to attract global companies. Following is a list of issues that require attention and policy change in order to create a better business environment.

- Regulations regarding foreign experts, researchers, and students, that allow for temporary employment, shared R&D enterprises or academic studies; thus introducing knowledge acquired abroad and strengthening connections with other countries upon these individuals' return to their countries.
- Trade and taxation agreements with major trade partners and harmonizing legislation and regulations regarding intellectual property rights.
- **Fiscal incentives for R&D, innovative activity and global expansion**

- Considering granting tax credits for R&D expenditures, in addition to the existing tax deductions, as a substitute for some of the present direct support (factors to consider include, among others, the importance of timing of funding and of projected revenue), training and activities in the field of innovation. As a growing number of countries are encouraging domestic R&D activity and attracting foreign R&D investments by providing these kinds of incentives, Israel will suffer unless it offers similar benefits. The precise nature of activities that warrant incentives should be carefully defined.
- Careful assessment of competitive tools included in other countries' R&D policy, and their impact upon Israel.

- **Means to facilitate the attraction of multi-national corporations to Israel**

- Signing international agreements and strategic agreements.
- Providing tax benefits to Israeli companies that acquire other companies, in order to encourage the growth of global Israeli companies which otherwise would be too small to compete efficiently in the international arena.
- Instituting a program to motivate Israeli companies to maintain headquarters in Israel, and foreign companies (or Israeli companies that were sold abroad) to situate their headquarters in Israel. (See also Chapter IV, Israel and the Global Challenge, sub-chapter on creating global companies.)
- Considering providing a tax exemption on interest from foreign sources and profits from R&D royalties, as long as a certain percentage is invested in domestic R&D or in another recognized activity.
- Considering granting tax relief for transfer of capital and equipment between branches or subsidiaries abroad of international corporations whose headquarters are based in Israel.

- **Providing modern infrastructures for rapid growth and an innovation-driven economy**

- High-level labor force at all levels – technicians, researchers and scientists (see Chapter VIII).
- A high-quality, efficient physical infrastructure system (see Chapter XI).
- Modern, efficient communications and information infrastructures.
- Systems for sewage and waste removal and purification systems (see Chapter X).

- **Continued development of capital markets and funding mechanisms**

- Additional sources of entrepreneurial funding, particularly for sectors outside of ICT.
- Continued reforms for encouraging competition; capital market and banking reforms to enable varied funding tools.
- Creating funding mechanisms for small-scale start-ups.

- **Data collection and development of methodologies for evaluating government support programs**

- After years of neglect due to lack of funds, the government must ensure allocation of appropriate budgets for updating economic databases on an ongoing basis; databases should include input-output data and data on essential scientific research and innovation activity. Investment will also be required to develop new measures for evaluating technological trade balance and services sector development, which the OECD countries have been promoting. Data collection is the basis for policy planning and assessing outcomes; it is one of government's clear roles.

- A statistics infrastructure must be developed for evaluating government R&D support programs, based on specific data that enable estimating programs' economic impact. Awareness must be raised of the importance of assessment, by conditioning programs' execution/expansion upon the existence of a data infrastructure. In the OECD countries, it is customary to inform the public of the scope and impact of government support programs, through printed reports and on the internet. When Israel joins the OECD, it will be appropriate for it to adopt this transparency as well, regarding its support policies for industry and R&D.

4.3 Nurturing universities' technological innovation and basic research and recognizing their third role

- Significant investment is required in university teaching and research (see also recommendations in Chapter VIII, Higher Education and Scientific Research). In addition to their regular missions, universities must be recruited for a third task: promoting innovation and transferring knowledge to the business sector. This task of the universities includes technology transfer, conducting applied research and cooperating closely with industry in order to realize the fruits of scientific research. This third role may fail, however, if assessment of faculty members continues to be based entirely on the exclusive criterion of research and academic publishing. Thus, for universities to succeed in their third role vis-à-vis applied research and transfer of technologies, significant changes will have to be implemented in their structure, assessment procedures and incentives for faculty. The essential principle of academic freedom requires that this objective be fulfilled with the consent of the academic institutions, not coercively.
- Cooperation between academic and non-academic research institutions selected by the National Science and Technology Council (*Malmat*) should be considered. The business sector will be substantively involved in determining the activities (similar to the Engineering Research Centers model in the US). Cooperation with the business sector will be essential for ensuring the relevancy of the research topics and assimilating the fruits of research into economic sectors. The institutes may assume a virtual format, or use physical facilities, given justifiable considerations for operating laboratories and equipment. Experience has shown, however, that it is recommended **not** to establish independent government-sponsored laboratories and national research institutes. These require continued funding and do not enjoy the atmosphere of innovation and research assistance that students provide (and as exists in universities).

- Technology-transfer offices in universities and public research institutes should be made more efficient, and have a business/applications orientation, by speeding up processes of legislation regarding publicly-funded intellectual property, and determining researchers' share in the incentives.
- Including business sector-related projects in required studies for science and engineering undergraduates.
- Increasing the supply of entrepreneurship professions, conducting business plan competitions, and establishing entrepreneurship centers in academic institutions' management studies programs.
- Encouraging penetration into the global market of companies that are based on technologies which were developed in the Magnet program, as part of the attempt to leverage the Magnet program for success in the global market.
- Updating universities' and faculty's incentive systems in a way that will promote applications for the fruits of research; considering such applications' contributions in the academic promotion process.
- Providing incentives to universities and colleges to interact on the technological or business level with the local business community.
- Expanding cooperation between local R&D centers and local colleges, to enhance development and assimilation of innovative technologies, and encourage the periphery.

Required Investment

The national civilian R&D expenditure is nearly 5% of the GDP. This rate should be maintained in the future as well. Government expenditure for various R&D channels must constitute at least 1% of the GDP. The importance of government funding is its focus on decreasing entrepreneurs' risks in innovative, ground-breaking fields. The majority of government support should be directed to scientific research, in the framework of overall science, technology, innovation and higher education policy. The Chief Scientist's support must be focused on basic development, which offers external benefits to the economy. Support for encouraging relationships between higher education institutions and industry must be continued.

Examples of Technology-Intensive Industries with Potential for Excellence and Significant Impact on Israel's Technological Development, and the Risks They Face

The following are promising industries whose potential has not yet been fully tapped. Technology-intensive industries whose success has already been proven (e.g., the information industry) are not mentioned here.

1. Life Sciences

The Israeli life sciences industry is ranked 8th world-wide in terms of number of companies. According to international publications, there are about 500 life sciences companies in Israel (including medical devices, biotechnology, pharmaceuticals, veterinary medicine, and agriculture), a large number of which have been established in recent years. This achievement can be attributed to Israel's academic capability in the life sciences. Many of the companies were started by academics and are situated in proximity to academic institutions. Nonetheless, this industry still faces numerous obstacles, in the realms of funding, policy, infrastructure and human resources:

- **Funding** for life sciences companies is problematic all over the world. The current trend is of funding companies in their advanced, rather than initial, stages. Israeli venture capital funds do not invest in life sciences companies in their early stages. Thus there is a shortage in funding that is designated to bridge the interim stage, of the invention's transfer from academia to industry prior to the proof of concept stage – before the product can be presented to investors. Most of early-stage funding for life sciences companies comes from the Chief Scientist, but the Chief Scientist's direct investment in life sciences is very limited, restricted to R&D. On the other hand, Contract Research Organizations (CROs), which offer clients a wide range of pharmaceutical research services that are essential for the biotech industry, do not meet the Chief Scientist's funding criteria. Therefore, a shortage in CROs has been created, and many companies seek CRO services abroad, as they cannot afford to carry out these services (such as animal and protein research) on their own.

- Transfer of knowledge between universities to industry is deficient. Most of the study and development of new inventions is done through personal connections and social networks, rather than through structured channels of knowledge transfer.
- While academically Israel is ranked as one of the world's best, it has a shortage of life sciences employees who have industrial experience in the areas of management, development and production. The source of this problem is the industry's developmental stage in Israel. More than 80% of these companies are at the seed stage. Therefore, only a few companies have been successful in taking a product from the research stage to the production stage.

As life sciences industries have a large global market, developing Israel's academic dominance in this field may position Israel as a leader in this market. To this end, the following measures should be taken:

Giving an incentive to multi-national corporations (MNCs) to create development and production facilities in Israel, which will serve as a source for training manpower with industrial experience, and may perhaps even bring back Israelis who work in these industries abroad.

- Developing training programs for company employees and providing grants or alternatively financial support for start-up firms that are willing to implement training for new employees.
- Proposing interim stage funding. Short-term funding is required that will allow companies to present their proof of concept and to obtain funding from the private sector.
- Developing additional CROs.
- Obtaining funding for highly expensive life sciences equipment, in order to drive company development and the overall industry forward.
- Providing knowledge, counseling and training on how to request funding from the Chief Scientist.
- Evaluating IP policy. Sometimes projects funded by the Chief Scientist are part of a complete product and therefore royalties need to be distributed accordingly.
- Signing agreements with other countries, such as China, in order to help Israeli companies penetrate large markets. Currently, international cooperation is difficult.

2. Alternative Energy

Israel has a world-wide reputation for developing technologies for utilizing alternative energy, especially in the solar energy field: Israel is among the world's leaders in developing technology for the purpose of utilizing solar energy. The Ministry of Infrastructure invests in research for advancing the alternative energy field. But during 2002-2005, the Ministry's energy research budget was cut by 33% and budget implementation decreased as well. The National Council for Research and Development recommended establishing a fund for national energy research, to be operated by the public service authority[12]. In addition to considerable knowledge in the renewable energy field, Israel also has appropriate climate conditions for the broad development of green energy. In 2005, 45.5 million kw/hr of renewable energy was produced in Israel. This is only 0.09% of the total of electricity produced in Israel, some 48,600 million kw/hr (most –about 78%--of Israel's electricity is currently produced by coal, Israel's knowledge and climate conditions notwithstanding). The field of alternative energy use is still only in its initial stages in Israel, with less than one percent of the total electricity being produced by this kind of energy. Practically speaking, Israel trails behind the world's countries in this field. Israel must be a leader in solar energy use and research, considering its scientific and technological capabilities, its natural attributes, the environmental impact of energy consumption, and Israel's clear political interest in developing energy sources that do not rely upon oil and its products, which will in turn diminish the power of oil-producing countries.

3. Agricultural Technologies

Several of Israel's agricultural fields have succeeded for many years to be at the forefront of innovative production technologies and to achieve peak output. This success can be attributed to farmers; scientists; services, such as training, provided for agriculture; innovative input industry; successful export of quality products that are off-season in target markets; an efficient production and marketing/export chain that involves producers; innovative managing techniques; efficient exchange of labor into capital, with mostly skilled and innovative human capital and an abundance of entrepreneurs. Even initially negative features, such as sometimes-extreme environmental conditions within limited geographical bounds and water constraints, contributed to the need for innovation. The outcome is the ongoing, successful ability to cope with the challenges of land and climate; the constraints of difficult trade conditions; competitive markets for fresh and processed produce; unstable financing conditions; small production scales; and sometimes hostile public opinion in target countries. Israel's agriculture has had extraordinary results in the areas of technological progress, innovation with high productivity, exceeding those of other sectors. However, Israel has not leveraged the agricultural R&D sector as an export industry. Agricultural research

12 Research and Development in Israel: Report #1 (updated draft), the National Council for Research and Development, June 2006.

infrastructure is diminishing as a component of technological innovation. For example: The Agricultural Research Administration has been weakening continually: from 400 researchers a decade ago, it now employs only about half; only 35% of its budget is designated for research. The Institute of Agricultural Engineering, which is supposed to serve all agricultural sectors, is very limited. The Technion's Faculty of Agricultural Engineering has been merged with its faculty of Civil Engineering.

4. Water Technologies

In 2004, Israel's water industry exports totaled $825 million: 50% of exports were irrigation products, systems and projects; 15% were gate valves and water meters, 14% engineering and projects; 8% desalination; 8% filters, and the remainder were irrigation computers, pipes, connectors and miscellaneous. Israel's water field is growing and becoming a promising business field, given the high demand for its products in the world market.

The annual growth rate of the world market for "traditional" products such as water and irrigation conductors, for the years up to 2008 is estimated at 6-7%; the annual growth rate of the world market of "new" products such as desalination, recycling, quality, security and more is estimated at 10-12%; the overall market for water industry products is estimated at $400 billion, according to the following break-down: 65% for infrastructure products, 25% for water treatment, quality assurance and security and the remainder for consumption products and knowledge.

In 2006, Israeli exports in the water market exceeded $1 billion. Israel currently has a designated technological incubator (*Kanarot*) and more than 60 start-up companies directed to the global water market including massive entry of venture capital firms. 50% of the companies are involved in waste water treatment, water improvement and purification; 5% in desalination; 11% in monitoring and 33% in other issues. Seven countries -- England, Holland, Australia, Singapore, France, Denmark and Israel – have defined their core capabilities on the water issue. Sweden and Japan have established national knowledge centers on water issues and support international marketing of their water industries. Due to the reduction in technological and scientific training on these issues in recent years, a shortage is beginning to develop in professional manpower, which may damage the sector's future development.

5. Space Technologies

Israel is ranked among the world's ten leading countries in space technologies. Its prominent achievements in this field, despite its meager investments as compared with other countries, indicate a comparative advantage in at least some of these technologies. Israel's space activities have created a flow of foreign investors' capital into the economy, jobs, and purchase requisitions to industry. They have helped upgrade technological knowledge and create high-quality training centers. Israel has been active in space for 25 years. For each dollar of government expenditure on space, a return of 1.7 dollars has been received from other countries. The economic contributions of space research include developing advanced industry for export; creating penetration capability into the world market by utilizing Israel's expertise in the two most popular satellite fields: remote sensing and communications; promoting collaboration with various countries based on Israel's proven space capabilities, contributing in turn to foreign relations; creating human capital; creating a fertile ground for integrative technological applications; and contributing to employment.

A space technology infrastructure has indeed been developed in Israel, which can be utilized for financial returns, scientific research and prevention of a "brain drain", but the field requires ongoing renewal. We must maintain the quality gap that separates Israel from its neighbors. Unless decision-makers understand and recognize the importance of intensive Israeli space activity, Israel will be left behind and lose the advantages it has gained until now. Therefore, Israel must **turn the space program into a national project and formulate a national policy outlook on the subject of space.** The world's space market is about $170 billion a year (military and civilian), made up primarily of communications. Israel is one of only eight countries in the world with capabilities in this field. Therefore, a target of 5% of the market is not unattainable. Today the sales of Israeli space companies are an estimated $600 million (about 0.3% of the world market).

6. Public Security Industries

The world public security market has grown tremendously since the attack on the World Trade Center. In 2006, it reached about $55 billion (about half in the US alone). This market is expected to grow over the coming decade at a yearly rate of 14%. The sales of Israel's public security industry currently total an estimated $300 million a year, making up only 0.5% of the world public security market. Despite the huge investment in this area world-wide, in the six years since the September 11 attacks, most of the equipment and knowledge sold rely on knowledge that was developed a decade or more ago. The technological improvement of terror threats exceeds that of adapted anti-terrorism technologies. Therefore, the Israeli industry has a unique, but short, window of opportunity to become a world player, at least in a number of important sub-sectors in public security. However, realizing this opportunity requires an integrated government-led effort, which has not yet been mobilized.

6.1 Opportunities and advantages in Israel's public security industry

Successful multi-year experience in integrating technologies from various fields of knowledge for defense purposes.

- Areas of expertise developed in Israel: anti-terrorism; defense of land, air and sea borders; control and monitoring systems; software and communications for emergency and rescue services; long-distance sensing and observation devices; unmanned devices for observation, sighting, interception, neutralizing, etc.
- Advantages characterizing all of the Israeli security industries: short development periods, developers' practical/security experience; excellent professional and engineering manpower, etc.
- Israel's experience with different types and intensities of terrorism, with which it has coped relatively successfully over an extensive period, exceeds that of other countries exposed to terrorism over the past years.

Due to the multiplicity of players and technologies participating in the developing public security market, Israel should focus on a relatively small number of technological areas in which it has proven success and regarding which demand is expected to increase. For example: airplane, airport and seaport security; land transportation security; border control; security and monitoring systems for buildings and facilities; web and communications security; readiness for handling emergency situations; means of identification and defense against non-conventional (CBRN) weapons; intelligence and international cooperation; control and monitoring systems between various bodies (military, law enforcement authorities, war against terror, emergency services).

6.2 Why is government intervention required?

An estimated 200 private public security companies operate in Israel, some clearly export-oriented. While Israel's industry has a high potential for capturing a significant share of the world public security market, its realization will require special government intervention, for a number of reasons:

The world public security market is much less open to free competition among producers/suppliers than are regular high-tech markets, due to the centrality of government security branches in this market.

- Beyond technological risks, uncertainty regarding future standards and distribution of responsibility between and among government branches, and between private and public sectors, curbs private investment in research and development.
- As in the defense industry, maintaining a leading government client is a first-rate marketing asset that can determine chances of success/failure in the world market.
- Israel has special public security needs. Directed, efficient government investment can respond to these needs, saving hundreds of millions of wasted shekels, and covering the public expenditure by income from exporting technologies. Examples: Alarm and monitoring systems for security fences; devices for detecting tunnels, etc.

Therefore, government organization and support should include the following components in order to give the Israeli public security industry a chance to capture an appropriate market share within a relatively short period (5 years), at least in a number of key public security sub-sectors:

- A designated venture capital fund for public security by government cooperation or subsidization (a government investment of $10-20 million a year).
- A designated R&D program in the Office of the Chief Scientist's in the Ministry of Industry, Trade and Labor, integrated within a broad systemic perspective based on mapping of national needs in this realm.
- Creation of a staff unit for management and supervision of designated technological developments for public security in the Ministry of Defense (which has, as opposed to the Ministry of Public Security, proven and successful experience with technological development for security needs). Due to the unique connection between public security technologies to the civilian market, this unit should be separate from *MAPAT* (the Administration for Research and Development of Means of Warfare and Technological Infrastructure), but should operate in coordination and cooperation with it.
- Speeding up standards setting processes for standards required in various areas of public security, and defining in a clearer manner the bounds of responsibility for the provision of public security services among the different levels of government (national, district, municipal), among security branches and between the public and private sectors. (Financial investment – zero; organizational and political effort – considerable)

7. Chemical Industry

Israel's chemical industry, which creates about 25% of the industrial contribution to the national economy, has achieved in recent years an impressive increase in sales, export, profits, company market value, contribution to the added value of the business sector, and the number of employees. In 2005, this sector's product (added value) was about NIS 20 billion, some 4% of Israel's business sector product. Despite these achievements, this industry is vulnerable to challenges and restrictions that block its continued growth and threaten to create a crisis in the sector.

To prevent negative scenarios in the future and to enable continued growth, the chemical industry must make large investments in infrastructure, the environment and of implementation and absorption innovative technologies. At the same time, investments are required in physical infrastructure for industry, regulation and scientific and professional education. These last issues require government initiated policy. A detailed report by the Neaman Institute surveys the potential of Israel's chemical industry, and specifies the required investments and policy measures for realizing this potential. The report describes three potential paths for the development of Israel's chemical industry. On the optimistic path, the report projects growth of the chemical industry's product to about NIS 100 billion in 2025, as opposed to continuing on its current growth path, which will achieve less than half of this product level. The report emphasizes the need for coordination between government, academia and industry to create the conditions and resources that will enable fulfilling the optimistic path, and prevent the sector from spilling over into a waning mode. The report identifies seven recommended areas for development: nano- and bio-technology; pharmacology and bio-pharmacology; public security systems; environmental technologies; renewable energy; transport systems; synthesis of intermediate pharmaceutical and advanced materials. The report specifies numerous policy measures that relate to providing human capital, standards, infrastructures and investments – that will place the chemical industry on the optimal growth path. The report includes a recommendation to establish a coordinating body at the national level, to manage all policy aspects, and estimates the required yearly investment for the next twenty years at about $150-250 million a year (about 1% of the projected added value for this industry in 2025 on the optimistic path).

Appendix to Chapter VI

Table VI-1: Forecast for Major Technological Applications to 2020 and their Scope of Influence, according to RAND, 2006

		Implementation Feasibility			
		Niche market only (– –)	May satisfy a need for a medium or large market, but raises significant public policy issues (–)	Satisfies a well-documented need for a medium market and raises no significant public policy issues (+)	Satisfies a well-documented need for a large market and raises no significant public policy issues (++)
Technical Feasibility	Highly feasible (++)	• Chemical, biological, radiological, or nuclear (CBRN) sensors on emergency response teams (2,G)	• Genetic screening (2,G) • GM crops (8,M) • Pervasive sensors (4,G)	• Targeted drug delivery (5,M) • Ubiquitous information access (6,M) • Ubiquitous RFID tagging (4,G)	• Hybrid vehicles (2,G) • Internet (for purposes of comparison) (7,G) • Rapid bioassays (4,G) • Rural wireless communications (7,G)
	Feasible (+)	• GM animals for R&D (2,M) • Unconventional transport (5,M)	• Implants for tracking and identification (3,M) • Xenotransplantation (1,M)	• Cheap solar energy (10,M) • Drug development from screening (2,M) • Filters and catalysts (7,M) • Green manufacturing (6,M) • Monitoring and control for disease management (2,M) • Smart systems (1,M) • Tissue engineering (4,M)	• Improved diagnostic and surgical methods (2,G) • Quantum cryptography (2,G)
	Uncertain (U)	• Commercial unmanned aerial vehicles (6,M) • High-tech terrorism (3,M) • Military nanotechnologies (2,G) • Military robotics (2,G)	• Biometrics as sole identification (3,M) • CBRN sensor network in cities (4,M) • Gene therapy (2,G) • GM insects (5,M) • Hospital robotics (2,M) • Secure video monitoring (3,M) • Therapies based on stem cell R&D (5,M)	• Enhanced medical recovery (3,M) • Immunotherapy (2,M) • Improved treatments from data analysis (2,M) • Smart textiles (4,M) • Wearable computers (5,M)	• Electronic transactions (2,G) • Hands-free computer interface (2,G) • "In-silico" drug R&D (2,G) • Resistant textiles (2,G) • Secure data transfer (2,M)
	Unlikely (–)	• Memory enhancing drugs (3,M) • Robotic scientist (1,M) • "Super soldiers" (2,M)	• Chip implants for brain (4,M)	• Drugs tailored to genetics (2,M)	• Cheap autonomous housing (6,G) • Print-to-order books (2,G)
	Highly unlikely (– –)	• Proxy-bot (3,M) • Quantum computers (3,M)	• Genetic selection of offspring (2,M)	• Artificial muscles and tissue (2,M)	• Hydrogen vehicles (2,G)

In ( ) after "technology": number of industries in which this technology may be applied, and an estimate of degree of world-wide dispersion by 2020 - G- global dispersion, M- limited dispersion for various reasons.