Samuel Neaman Institute
For National Policy Research

Science, Technology and Innovation Indicators in Israel: An International Comparison

Submitted to:
Israel National Council for Research & Development

Third edition

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הלשכה המרכזית לסטטיסטיקה
Central Bureau of Statistics

TECHNION
Israel Institute of Technology

STATE OF ISRAEL
MINISTRY OF SCIENCE AND TECHNOLOGY
Israel National Council for Research & Development

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Policy research and surveys are executed at the Samuel Neaman Institute and their conclusions and recommendations serve the decision makers at various levels. The policy research is conducted by the faculty and staff of the Technion and scientists from other institutions in Israel and abroad and specialist from the industry.

The research team is chosen according to their professional qualifications and life achievements. In many cases the research is conducted by cooperation with governmental offices and in some cases at the initiative of the Samuel Neaman institute and without direct participation of governmental offices.

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The chairman of Samuel Neaman Institute is professor Zehev Tadmor and the director is professor Moshe Moshe. The institute operates within the framework of a budget funded by Mr. Samuel Neaman in order to incorporate Israel's scientific technological economic and social advancement.

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Message from the Chair of the Samuel Neaman Institute for National Policy Research

The Samuel Neaman Institute at the Technion performs national policy studies on a wide range of topics including science, technology, and innovation policy and higher education, under which the Institute carries out a wide range of activities, such as creating an infrastructure of quantitative tools and developing methodologies for the evaluation of research, technology and innovation in order to promote the systematic and organized discussion of these topics by national policymakers.

Back in the early 2000s, the Neaman Institute identified the need to create an infrastructure for the advancement of long-term systematic national policymaking in research, technology, and innovation. The construction of a database and a set of comparable and self-updating indicators was the first stage in this program, which aimed to help policymakers to map and evaluate Israel's R&D activities, capabilities, and scientific infrastructure, how they have been financed over the years and where Israel stands compared to other countries. The Institute's initiative in creating this infrastructure was submitted as a proposal to the Ministry of Science and presented at the Forum of Chief Scientists (2002), which provided its approval. The Neaman Institute commenced the program with its own funding and published the first edition of *Science, Technology and Innovation Indicators* in 2005. A second and expanded edition was published in 2007; it was prepared in conjunction with the Central Bureau of Statistics, which was responsible for preparing and verifying the data on Israel, and used international databases such as those of the OECD for international comparisons.

In 2008, the Israel National Council for Research and Development entered into a joint venture with the Neaman Institute while considering the importance of creating a national infrastructure of data and indicators as a basis for intelligent national policymaking on science, technology, and innovation. This publication, the third in the series, is the outcome of this joint venture. Previous chapters were updated, new chapters were added, and new indicators were provided on numerous topics, such as globalization and government subventioning of R&D.

The information presented here will be useful for decision-makers in their discussions of alternatives for science, technology, and innovation policy for Israel and the examination of their effect on the country's economy and society. I am grateful to Dr. Daphne Getz, who initiated and spearheaded this activity; the Neaman Institute research team (Tsipy Buchnik, Ilia Zatcovetsky, and Yair Even-Zohar), and Prof. Dan Peled for his contribution. I thank and congratulate them for their fruitful cooperation with the National Council for Research and Development, the Central Bureau of Statistics, and everyone who contributed to the effort.

Prof. Moshe Moshe
Director, Samuel Neaman Institute

Greetings from the Chair of the Israel National Council for Research and Development

The Israel National Council for Research and Development is responsible by law for the formulation of national policy on civilian research and development in Israel. A precondition for prescribing a wise and intelligent national policy on science and technology is the existence of an up-to-date, comprehensive, thorough and reliable picture of the state of R&D and innovation in Israel in all respects. For this purpose, the Council began to set up a national R&D database several years ago. The database, under construction at the present writing, is composed of a wide array of surveys in all relevant sectors of the economy. Its purpose is to bring together data on inputs invested in R&D and innovation, the processes through which these activities take place (e.g., cooperation with other players in Israel and abroad in financing and carrying out the operations), and the scientific, technological, and economic outcomes of these activities. Outcomes are measured by monitoring the publication of scientific articles, patents, commercialization of knowledge, production and export of goods and services, and so on. The Council also collects information about Israel's future scientific and technological labor force by means of special surveys on science and technology studies in high schools and post-secondary and higher-education institutes and about phenomena such as brain drain. The surveys are performed by various entities, foremost the Central Bureau of Statistics.

Each of these surveys amasses copious and detailed information about a narrowly defined topic. Therefore, along with the surveys, it is necessary to analyze the data from a comprehensive perspective and to develop a set of indicators that will allow comparisons between Israel's situation and that of other developed countries. The Samuel Neaman Institute for National Policy Research and the Central Bureau of Statistics mobilized for this mission, and the current edition of *Technology and Innovation Indicators in Israel* is the result of this collaborative effort with the National Council. Although it is quite a wide-ranging publication, it still marks only the beginning of the way because many of the surveys have not yet been completed and analyzed. Their results will be integrated into the next edition of this publication, scheduled to appear in another two years.

I wish to thank the researchers at the Samuel Neaman Institute and the Central Bureau of Statistics who collaborated in preparing this comprehensive and thought-provoking document for publication; I also thank Mr. Shlomo Hershkowitz, who coordinated this activity for the National Council. At this opportunity I also wholeheartedly thank my predecessor as chair of the National Council, Prof. Oded Abramsky, who with his vision and vigor realized the importance of having a national R&D database, raised and allocated the budgets that were needed for its establishment and operation, and gave this effort his enthusiastic and unreserved support throughout his term in office.

Prof. Yitzhak Ben Yisrael
Chair, Israel National Council for Research and Development

The Samuel Neaman Institute for National Policy Research is pleased to present the third edition of *Science, Technology and Innovation Indicators in Israel: An International Comparison,* published in conjunction with the Israel National Council for Research and Development and the Israel Central Bureau of Statistics.

This publication reports many development indicators relating to inputs, outputs, and activity in science, technology, and innovation in Israel and under international comparison, over periods of a decade or longer. The data and the indicators make it possible to analyze Israel's situation, the effects of government policies on higher education and R&D in the public and private sectors, and their effects on the overall economy and society.

We hope this publication will provide useful insights that will affect national policy on science, technology, and innovation in all respects.

We wish to thank everyone who assisted, advised, and contributed to the preparation of this work.

Dr. Daphne Getz
and the Neaman Institute team

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Acronyms

BERD	Business Sector Expenditure on Research and Development
CAD	Computer Assisted Design
CAGR	Composed Average Growth Rate
CAM	Computer Assisted Manufacturing
CHE	Council for Higher Education
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GERD	Gross domestic Expenditure on Research and Development
HERD	High Education Sector Expenditure on Research and Development
ICT	Information, Communication Technology
IEA	International Association for the Evaluation of Educational Achievement
ISCED	International Standard Classification of education
MOITAL	Ministry of Industry, Trade and Labor
MOLMOP	Israel National Council for Research & Development
NESTI	OECD National Experts on Science and Technology Indicators
NGO	Non-governmental organization
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
PGC	The Planning and Grants Committee
PISA	Program for International Student Assessment
PPP	Purchasing Power Parities
R&D	Research & Development
S&E	Science & Engineering
S&T	Science & Technology
SME	Small and Medium sized Enterprises
SNA	System of National Accounts
TIMSS	Trends in International Mathematics and Science Study
UNESCO	United Nations Educational, Scientific and Cultural Organization
USPTO	United States Patent and Trademark Office
VC	Venture Capital
WIPO	World Intellectual Property Organization

1. Introduction

1.1 General Preface

Israel's unique situation compels it to base its economic, social, and security strength on scientific knowledge and technological development. The way Israel weathered the recent economic crisis demonstrates not only the accuracy of this statement but also the immense importance of a policy that fosters scientific-technological creativity and the development of human capital as an essential infrastructure for this kind of activity. In recent years, the development of manufacturing and service industries based on advanced knowledge, scientific and technological development, and trained human resources has allowed Israel to attain impressive rates of economic growth, of which about one-third originates in knowledge-intensive industry. After temporary setbacks in 2001–2003 and during the global economic crisis of 2008–2009, the Israeli economy is once again growing at impressive rates. Israel's admission to the OECD in 2010 offers a further reflection of its economic, scientific, and social achievements.

Israel's success in leveraging scientific and technological R&D into economic growth traces back to circumstances and massive public investment in research and higher education in the country's first decades. However, even if Israel was one of the first countries to cultivate scientific and technological endeavor as a major component of its socioeconomic policy, today most developed countries are well aware that new technologies and their application are the keys to economic growth and well-being. Accordingly, Israel faces steadily growing global competition in the markets of technology-intensive goods and services and in competition for R&D activities, which themselves are becoming tradable in the international arena. This intensifying rivalry is reflected in competition over foreign investments that provide crucial capital for technological development, and over professionals who acquire their scientific, technological, and managerial training in Israel.

The need for a cohesive long-term national policy on matters related to scientific and technological R&D stems not only from such far-reaching international changes but also from the massive investments that are needed for the advancement of scientific and technological research in its various forms, and the lengthy lead times for the development and preservation of scientific and technological human-capital infrastructures. No less important are the economic and social challenges that accompany an economy that bases most of its development on science and high-tech, domains that by nature are not equally accessible to all strata of the population. A policy that addresses itself to these matters should serve as a blueprint that will allow the country to raise the requisite resources and allocate them among the various domains of science, between those who engage in scientific research and technological development, and prioritize the fields of research that should be developed in Israel. The formulation of such a policy should be based on an up-to-date and comprehensive picture of all economic activities in science and technology, their costs, and economic returns.

Many entities in Israel are involved in setting science and technology policy, in encouraging the investments needed to attain the policy goals, and in monitoring the economy's performance in these regards. These entities include, but are not limited to, the National Council for Research and Development, the Council for Higher Education, the Israel National Academy of Science, the Knesset Science and Technology Committee, the Ministerial Committee for Science and Technology, the Forum of Chief Scientists of Government Ministries, the Office of the Chief Scientist at the Ministry of Industry, Trade, and Labor, the Central Bureau of Statistics and others. Although the existence of this gamut of policymaking and monitoring entities in science and technology underscores the importance of these fields for the Israeli economy, it also attests to the growing need to develop a systematic and wholesome approach to the formulation of this policy, one based on reliable and up-to-date quantitative data about national R&D activities, the achievements of the country's scientific research, and the inventory of relevant infrastructures and activities. To enact this approach, a dedicated database of R&D and scientific activities is needed, along with methodologies for the analysis of these activities and evaluation of the effectiveness of the policy measures that support them. To promote such an endeavor, the Samuel Neaman Institute for National Policy Research (SNI) at the Technion—Israel Institute of Technology, the National Council for Research and Development, and the Israel Central Bureau of Statistics (CBS) have come together to produce this publication.

CBS is responsible at the national level for the collection of diverse data on national scientific and technological development activities, those who engage in them, the investments they attract, and the economic returns that they produce. The National Council for Research and Development is tasked by the government and by law with formulating national R&D policy. The Samuel Neaman Institute performs ramified research on various scientific topics and their effect on the Israeli society and economy. This document reflects an ongoing effort to describe and analyze the resources pledged to scientific research in Israel and their outcomes. Its intention is to present composite indices that are comparable over time and across countries, thereby giving policymakers, budgeting entities, researchers and investors in science- and technology-intensive sectors an up-to-date snapshot of Israel's capabilities and achievements in scientific research, the distribution of research activities across various disciplines of science and economic branches, and the infrastructures on which such activities are based.

1.2 Data for the Formulation of Science and Technology Policy

Studies have shown repeatedly that the creation and dissemination of scientific and technological knowledge and the training of workers and researchers in these fields are an effective engine of economic growth, and that public investments in these activities generates very high social returns. The significant economic and social implications of scientific and technological research capabilities underscore the need for a science and technology policy in Israel. Policymaking for the enhancement of competitiveness and the expansion of scientific research and technology development is becoming central in all industrialized countries. The European Union is allocating massive resources to the development of indicators of such activities and the creation of policy alternatives based on these indicators, for improving the outcomes of S&T investments.

It is widely agreed that scientific-technological research processes suffer from high potential of market failures resulting in under-investment. The main reasons for such underinvestment are difficulties in appropriating all the returns from scientific discoveries and technological developments, the high costs and high degree of uncertainty involved with them, problems associated with asymmetric information between inventors and developers and long fruition times for the of economically valuable outcomes. In response to these ubiquitous factors, governments in developed countries offer a range of subventions for scientific research and R&D activity. Government support of this kind is all the more necessary in a country that suffers from lack of natural resources, is distant from its potential markets, and endures political isolation. The dual society composition of the Israeli workforce and the low participation rates provide additional reasons for developing a cohesive and comprehensive science and technology policy.

We are in the midst of a process of reducing the size of the public sector and cutting government support for many activities. Support for universities and basic research were among the activities that suffered severe cuts in what is now called the "lost decade". What implications will such policy changes have for Israel's ability to maintain its advanced position in various fields of science and technology? How will they affect the academic disciplines that students elect to pursue? How will changes in government support for R&D affect the ability to raise capital in the future for private investments in Israel's high-tech establishments? Will we succeed to maintain attractive economic conditions and a supportive environment for science and technology, in which startups will continue to flourish and tomorrow's scientists will thrive?

As changes occur in Israel's domestic scene, the global picture in R&D and high-tech is also changing. There are growing signs of risk to Israel's leading status in science and technological development. These risks result from the confluence of several mutually independent processes: (a) slackening demand from the defense system for technological development, which used to be the driving force for the creation of a flourishing high-tech industry, especially in ICT; (b) growing R&D capabilities and investments in technological development in all industrialized countries, including in particular the East Asia Tigers; (c) increasing global competition for outsourced R&D, and the resulting brain drain that lures the best researchers and technology experts abroad. While this global R&D competition and "flatter world" phenomena create both risks and opportunities, Israel's size and geo-political instability weaken its competitive edge; (d) Israel's higher-education system, which produces the R&D human capital for future years, is suffering from steep cutbacks in resource allocation, in dwindling and aging body of faculty members, coupled with steep increases in university enrollment. Such changes cannot but have grievous effects on the quality of the scientific training that tomorrow's researchers are receiving; (e) available sources of funding for high-tech startups have become scarce in recent years due to the dotcom and the 2008 economic crises. Future areas of development, such as nanotechnology and biotechnology, require innovative funding mechanisms different from those that nurtured the ICT industry in Israel. Consequently, Israel lacks the supportive infrastructures needed to become a leader in these fields.

The creation of a science and technology policy that will address such problems must start with an up-to-date data on, and long-term tracking of, the development of scientific and technological research activities in Israel. Such a dataset would make it possible to identify the economy's main strength and weaknesses in research, the entities that are producing basic and applied scientific-technological knowledge, their sources of funding, and the human infrastructures and resources that are needed in various scientific disciplines and economic branches. With an up-to-date dataset of this kind, it would be possible to channel public resources to the areas of activity that will deliver the highest social return, give investors and potential research partners an accurate picture that will encourage them to invest wisely, and allow higher-education institutes and their students to plan the development of the country's future human capital in a manner that responds to the world changing situation.

Our aim is to present a picture of both the inputs and outputs of R&D processes using various measures. The picture we wish to offer will facilitate monitoring and evaluation of R&D activities and achievements, and the effectiveness of government supporting measures to these activities.

1.3 Goals of this Publication

The purpose of this publication is to give policymakers and researchers at various levels (government, research and academic institutes, and business community) a database that will allow them to subject scientific and technological activity in Israel to systematic examination. By using such data, they may develop and apply quantitative methodologies for the description and surveillance of the country's scientific infrastructure and the extent of activity in the relevant fields. The data in this publication use modern methods and conventions, adjusted to Israel's special conditions and characteristics.

Such monitoring is essential for various reasons. First, it allows the evaluation of government policies, which play central role in providing funding for inventive activities and in training scientists, engineers and technicians. Second, the mapping of strengths and weaknesses of Israel's scientific activity, may identify areas of activity and training that can generate the highest return on public and private investments. Third, a systematic and comprehensive database of the country's scientific and technological abilities, and their development over time, may contribute to research cooperation in various domains and encourage foreign investment in domestic R&D activities.

1.4 Methodological Background and Survey of Topics in this Publication

To achieve these goals we chose to report on a set of various indicators of scientific and technological activities. In this we follow the general approach of the benchmarking method, which has been adopted for similar purposes by the EU. Essentially, the method is based on establishing several quantitative and measurable indicators that have been carefully defines, and examine their development through time, and across different countries. International comparison of scientific activity, including the resources for and achievements of this activity, is instrumental in the evaluation of government policy and its outcomes and facilitates identifying factor that foster or slow down progress. These indicators do not constitute a policy goal, nor are they a final product. They are intended to serve not as answers but as a basis for qualitative discussion and quantitative assessment of S&T activities and their effects on the economy. The abilities to trace development through time using a consistent set of indicators, and compare it across different countries all employing similar indicators are invaluable aid for designing effective S&T policies.

Importantly, such a process must be comprehensive and consistent over time. In year 2000, the EU decided to lend its ongoing and continual encouragement to a process that would support the formulation of R&D policy by applying the benchmarking method. The idea was to facilitate discussion, comparison, and mutual learning from the experience accumulated in the EU countries in order to develop a comprehensive policy that would take into account each member state's resources, needs, goals, and specific local culture. Pursuant to its decision, the EU has been producing an annually updated document that presents data and describes developments in the field of scientific and technological endeavors. Each year's publication elaborates on one of the main components of R&D policy.

This publication, focusing on indicators of science, technology, and innovation in Israel—is the third in the series that started in 2005. It focuses on eight major themes:

- National gross civilian expenditure on R&D: measurement of R&D activities and investments in Israel, distinguishing between those performing of R&D and those funding such activities, (Chapter 2).
- The ICT industries, on which attracts most Israeli R&D activities. The assimilation of the ICT products and services in other industrial and service branches, may improve productivity throughout the economy and generate balanced and stable economic growth, (Chapter 3).
- Capital inputs and government assistance—two crucial ingredients of scientific and technological endeavor. These two factors require government involvement in both instigation and ongoing support due to the proliferation of market failures in R&D, (Chapter 4).
- Human capital in science and technology: how many people engage in the development and assimilation of various areas of science and technology, the fields in which they are trained, where the training is provided, and additional characteristics, (Chapter 5).
- Indicators of the economic return and output of science and technology activity in terms of growth of sector product, economic growth, and improvement of labor and total productivity, (Chapter 6).

- The knowledge outputs of investments in science and R&D: scientific publications, quality measures of these publications, and the number of patents applications and grants, (Chapter 7).
- Globalization of R&D and scientific endeavor: indicators of the development of the international relations based on technological developments and scientific research—the extent of international trade in technology and in knowledge-intensive products, multinational firms and foreign companies' R&D centers, foreign investments in high-tech, and international research relations, (Chapter 8).
- Technological preparedness: ICT infrastructures and technologies and their assimilation in society and government (Chapter 9).

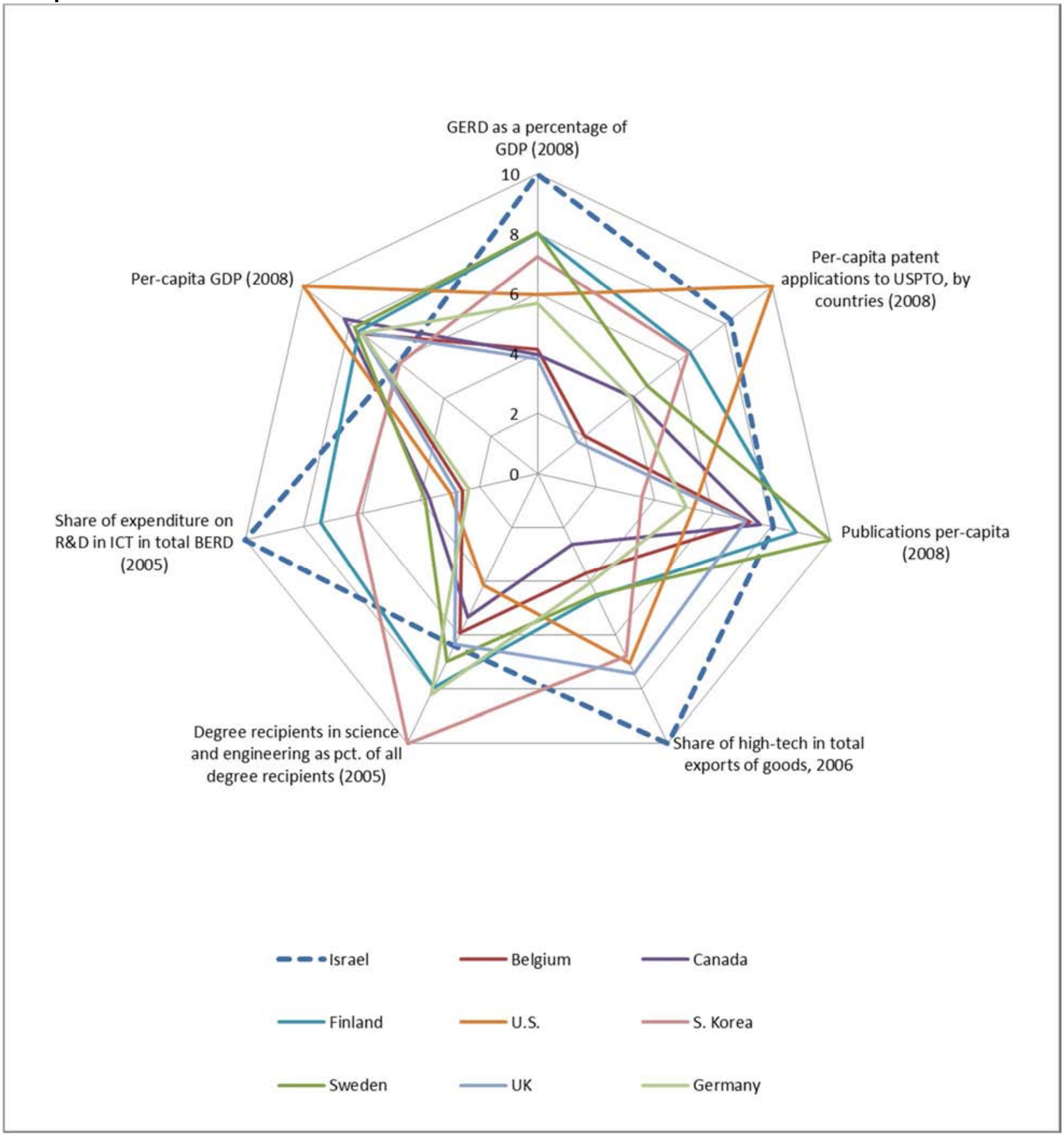
1.5 Trends in Key Indicators of Science, Technology, and Innovation

Table 1.1: Key Indicators of Science, Technology, and Innovation in Israel—1995, 2000, 2003, and 2009

	1995	2000	2003	2009
General				
Population (000s)	5,612	6,369	6,748	7,552
GDP (mil NIS, 2005 prices)	423,489	541,749	546,580	704,632
Per-capita GDP (PPP $)	17,316	21,253	21,436	[3]27,902
Innovation and R&D resources				
GERD as a percentage of GDP	2.54%	4.27%	4.26%	4.27%
GERD **per** capita population (current prices, PPP, $)	444	1049	998	1182
GBAORD of total R&D expenditure (%)	36%	24%	23%	[1]14%
BERD of total R&D expenditure (%)	48%	71%	69%	[1]79%
HERD as percent of GDP	[2]0.66%	0.65%	0.73%	[3]0.58%
R&D budgets of the Chief Scientist (mil NIS)		1,795	1,674	1,690
Human capital				
Percent of population aged 25–64 with tertiary education			[4]45%	[1]44%
Business-sector R&D workers as share of total business-sector employment	[5]16.8	26.4	23.2	[3]25.1
Academic degree recipients in sciences and engineering as percent of total degree recipients		19%	23%	24%
Output per-worker: high-tech industry relative to total manufacturing	1.20	1.42	1.26	[1]1.29
Globalization				
International trade in high-tech (mil USD)	9,097	19,031	14,666	28,293
High-tech exports as percent of total manufacturing exports	37%	53%	46%	42%
Exports of computer and information services and R&D services as percent of total services exports			[3]44%	[1]46%
Sales of Israeli startups abroad (mil USD)			218	1442
Israeli students abroad		[6]7,541	8,781	[1]10,005
Economic outputs				
Share of high and medium-high technology industries in GDP	6.1%	7.9%	6.4%	7.1%
Gross wage per worker in high-tech relative to national average	1.71	2.06	1.97	1.95
Venture capital raised by Israeli funds (mUSD)		3,092	1,011	1,122
R&D outputs				
Total patent applications in Israel Patents Bureau	4,457	6,740	5,895	7,745
Of these - by Israeli inventors	1,341	1,490	1,432	1,600
by foreign investors in Israel	3,116	5,250	4,463	6,145
Patent applications by Israeli inventors in USPTO	1,072	2,509	2,539	[3]4,550
Israeli publications (N)	8,683	9,667	11,109	[3]13,919
Israeli publications per 100,000 of population	119.70	133.26	153.14	[3]188.75

[1]2007
[2]1996
[3]2008
[4]2004
[5]1997
[6]2001

Figure 1.1: Key Indicators of Science, Technology, and Innovation, International Comparison



2. Gross Expenditure on R&D

- **Israel spent NIS32.8 billion on civilian R&D in 2009 (current prices).**
- **National R&D expenditure was 4.3 percent of GDP in 2009, the largest fraction among OECD countries but down from 4.8 percent in 2007.**
- **The business sector funded 79 percent of national R&D expenditure (2007), outpacing most developed countries in this respect. Government (including the Planning and Grants Committee—PGC) funded only 14 percent, foreign sources funded 3 percent, and the remainder was funded by higher education and NGOs.**
- **Some 81 percent of government expenditure on civilian R&D in Israel accrues to the promotion of manufacturing technologies and the PGC research budget, as against an average of only 41 percent for similar purposes in the OECD countries.**
- **In Israel, the share of the R&D and computer-services industries (Divisions 72 and 73) in national R&D expenditure is very high by international standards—62 percent in 2009.**
- **In manufacturing R&D, as in other fields, Israel suffers from over-concentration by international standards. Thus, 70 percent of manufacturing R&D is concentrated in one industry: telecommunication equipment (2007).**
- **Small and medium enterprises (up to 250 employees) in Israel are responsible for 44 percent of business R&D (2007)—an especially high proportion by international standards.**

Gross Expenditure on R&D (GERD) and its derivatives are the accepted aggregate indicators for the classification of main economic activities related to science and technology. The Frascati Manual, published by the OECD Statistics Directorate and first disseminated in 1963, was the first international guide to methodologies for the definition, measurement, gathering, and use of statistical data on R&D activities. These definitions were adopted by most countries' bureaus of statistics, including Israel's Central Bureau of Statistics (hereinafter: CBS). In today's era of rapid technological change, it has become necessary to update the definitions. Thus, the sixth edition of the Manual, containing improved and adjusted guidelines for the measurement of R&D—e.g., measurement of R&D in service industries, globalization, and human resources—appeared in 2002. Another guide is the Oslo

Manual, which offers guidelines for the gathering and use of data on innovative activity in manufacturing. The third edition of the Manual, published in 2005, was updated to reflect progress in understanding the process of innovation, the experience accrued in the previous round of innovation surveys, expansion of the field of research to other sectors of manufacturing, and updates of the International Standard **Industrial** Classification.

Notwithstanding the inflexibility of these definitions, their adoption by a large number of international players facilitates international comparisons that further our understanding of processes in the development of research infrastructure and abet the performance of policy analyses. In May 2010, Israel was admitted to membership in the OECD. By then, CBS had already aligned its statistics with those published by the OECD. In 2006, for example, the Bank of Israel revised its methods of calculating Israel's Gross Domestic Product to match them with those used by the OECD and facilitate Israel's accession to this organization.

R&D activities are part of a broad domain that includes Science and Technology Activities (S&T), which the UNESCO Institute for Statistics defines as activities related to the creation, advancement, distribution, and application of scientific and technical knowledge. S&T activities include, in addition to R&D, technical and scientific education and instruction, technical and scientific services, and services such as the activities of scientific libraries and museums, gathering of data on socioeconomic phenomena, checks, standardization, and quality auditing.

Per recommendation of the OECD, GERD is classified by performance sectors and financing sectors. This chapter first surveys Israel's R&D data at the aggregate level in 1990–2009 or the last year for which data exist. Most indicators presented below are suitable for international comparisons. Then we focus in depth on the three main sectors that perform/finance R&D: business, government, and higher education. Finally, we compare the data and trends in Israel with those in selected countries, mostly EU member states.[7]

[7] The term "European Union" denotes a group of states that came together under a series of agreements to create a political and economic bloc that shares basic values such as belief in peace, democracy, rule of law, and upholding of personal liberties. Today, the European Union comprises twenty-seven member states. The data in this document relate to two groups: the EU15, comprised of member states before the recent expansion (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and UK) and the EU 27 (the EU15 plus Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, and Romania.

Notably, all the Israeli indicators relate to civilian R&D only. The government also finances and performs defense R&D on a rather large scale; this activity is not surveyed in this document.

Basic definition of R&D (Frascati Manual)

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of knowledge to devise new applications".

"The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty".

"The term R&D covers three activities: basic research, applied research and experimental development.

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

Experimental Development is systematic work, drawing on existing knowledge gained from research and/or practical experience which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed".

:Sources

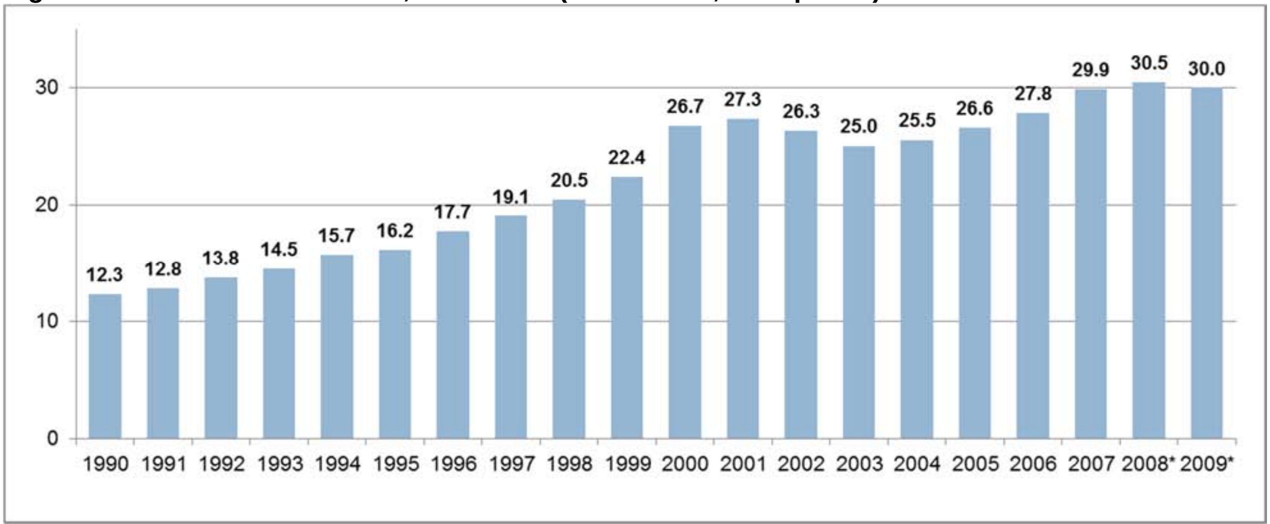
OECD (2002). *Frascati Manual Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris (p. 30).

2.1 Aggregate View

2.1.1 Gross Expenditure on R&D (GERD)

The basic conventional measure of R&D activity is Gross Expenditure on R&D (GERD). Figure 2.1, describing Israel's inflation-adjusted civilian GERD in 1990–2009 in 2005 prices, shows that GERD increased by 7.5 percent on annual average between 1990 and 2001 and slowed to 1.2 percent on annual average in 2002–2009. Notably, the latter years included a global recession and the domestic effect, still unknown, of the international financial [or economic] crisis that began in 2008.

Figure 2.1: Israel Civilian GERD, 1990–2009 (NIS billions, 2005 prices)



* Provisional data
Source: CBS

2.1.2 R&D Intensity

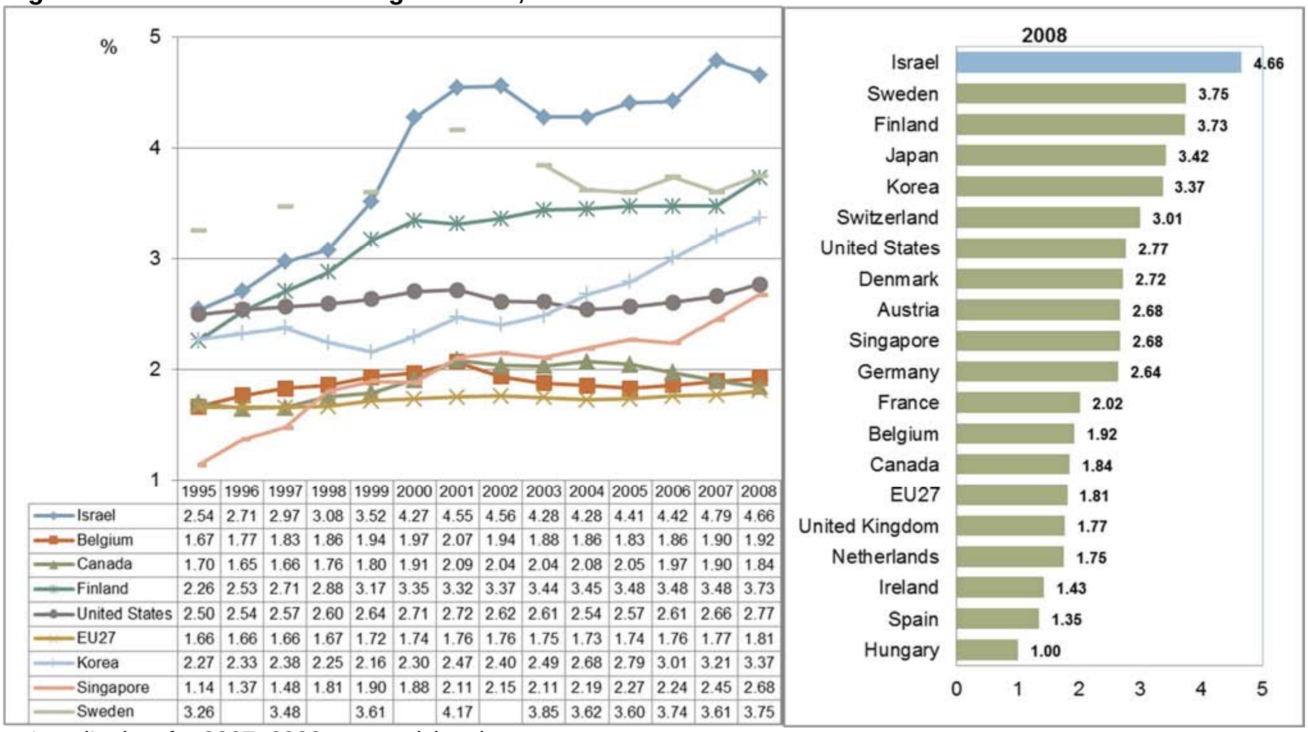
To compare R&D expenditure among different countries, the figures have to be normalized to the sizes of the respective economies. The most widely used indicator for international comparison is GERD as a share of GDP, also known as "R&D intensity."

Figure 2.2 presents the data for this indicator in Israel and other countries that were chosen due to their size, such as the U.S. and Canada, or due to characteristics similar to Israel's, such as Finland and Belgium, for 1995–2008, along with a broader international comparison for 2008. Although the indicator shown for Israel does not include defense R&D, it ranks Israel as the first in the world, reflecting its strength in this field by international standards and illuminating the importance of R&D in the Israeli economy.

Examining other countries' defense GERD as a percent of GDP in 2007, we find the following: 0.4 percent in the U.S., 0.2 percent in the UK, 0.15 percent in France, 0.12 in Sweden, 0.04 percent in Germany, 0.03 percent in Spain and Japan, and negligible (less than 0.01 percent) in Ireland, Belgium, Austria, and Finland. For Canada, Denmark, Hungary, S. Korea, the Netherlands, Switzerland, and Singapore, there are no data on civilian GERD only.

Israel's civilian GERD was 4.27 percent of in GDP in 2009, slightly below the 2008 level (4.66 percent). By international comparison, Israel's indicator has been exceptionally volatile. In 1995–2001, it rose steeply, making Israel the leader in this respect by far. Since 2002, Israel has maintained its lead but its rate has remained at around 4.5 percent on average. Indicators presented below show that most of the increase has been financed and performed by the business sector.

Figure 2.2: GERD as Percentage of GDP, 1995–2008[a]

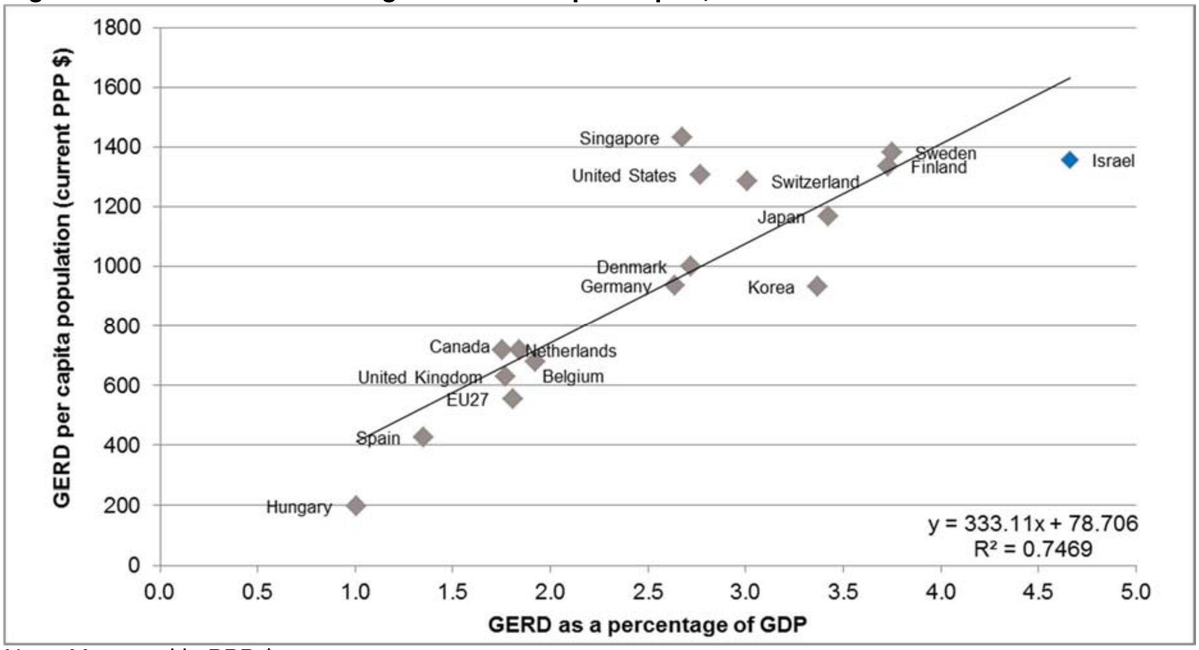


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Israel	2.54	2.71	2.97	3.08	3.52	4.27	4.55	4.56	4.28	4.28	4.41	4.42	4.79	4.66
Belgium	1.67	1.77	1.83	1.86	1.94	1.97	2.07	1.94	1.88	1.86	1.83	1.86	1.90	1.92
Canada	1.70	1.65	1.66	1.76	1.80	1.91	2.09	2.04	2.04	2.08	2.05	1.97	1.90	1.84
Finland	2.26	2.53	2.71	2.88	3.17	3.35	3.32	3.37	3.44	3.45	3.48	3.48	3.48	3.73
United States	2.50	2.54	2.57	2.60	2.64	2.71	2.72	2.62	2.61	2.54	2.57	2.61	2.66	2.77
EU27	1.66	1.66	1.66	1.67	1.72	1.74	1.76	1.76	1.75	1.73	1.74	1.76	1.77	1.81
Korea	2.27	2.33	2.38	2.25	2.16	2.30	2.47	2.40	2.49	2.68	2.79	3.01	3.21	3.37
Singapore	1.14	1.37	1.48	1.81	1.90	1.88	2.11	2.15	2.11	2.19	2.27	2.24	2.45	2.68
Sweden	3.26		3.48		3.61		4.17		3.85	3.62	3.60	3.74	3.61	3.75

a. Israel's data for 2007–2008 are provisional.
Sources: CBS and OECD

The next graph compares national GERD in GDP with national GERD per capita. In the former metric, Israel leads by a wide margin. One would expect this to be reflected in per-capita GERD, but such is not the case. Israel does rank among the leading countries but stands in third place, after Singapore and Sweden, and the gaps are much smaller relative to Finland, Switzerland, and the U.S. The reason is that Israel's per-capita GDP is below the OECD average.

Figure 2.3: GERD as Percentage of GDP and per Capita,[a] 2008



Note: Measured in PPP $
Sources: CBS and OECD

2.1.3 GERD by Sectors

The Frascati Manual divides GERD into four main performing and financing sectors: business, government, higher education, and private nonprofit.

CBS defines these four sectors as follows[8]:

- business: private and governmental enterprises and entities of business nature in various areas of the economy;
- government: general government including central-government offices, municipal authorities, national institutions, the National Insurance Institute, and NPOs financed largely by government;
- higher education: the country's seven research universities and their related research institutes;
- private nonprofit: private and semi-private not-for-profit institutions that do not derive their main funding from government.

Table 2.1 and Figure 2.4 show the performance of GERD in Israel by these four sectors in 1990–2009. The share of the business sector in performance increased considerably during this time, from NIS 6,634 million (2005 prices), 54 percent of total GERD in 1990, to NIS 23,913, 80 percent of the total, in 2009—an 8 percent

[8] Central Bureau of Statistics, *National Expenditure on Civilian Research and Development, 1989–2007,* Publication 1352, Jerusalem, 2009.

compound average growth rate (CAGR[9]). The CAGR of GERD by the government sector, in contrast, grew by 0.1 percent in terms during the respective years. In real terms, too, government GERD was basically unchanged. Government's share fell from 10 percent in 1990 to 4 percent in 2009. Several factors explain the increase in business GERD, including a government policy that encourages business R&D via a range of programs (foremost those of the Office of the Chief Scientist at the Ministry of Industry and Trade—OCS), rapid development of the high-tech sector, the influx of foreign investors, and strong development of the VC industry. Higher-education GERD also remained almost flat during these years and its share in total GERD fell from 32 percent in 1990 to 13 percent in 2009. Thus, higher-education research in terms of monetary investment is not managing to keep up with the massive increase in R&D expenditure, which traces largely to business. The composition of R&D—its apportionment among basic research, applied research, and experimental development—is being materially affected by the powerful increase in the share of R&D in Israel performed by the business sector. (See also Figure 2.5 and Section 2.3 on business R&D.)

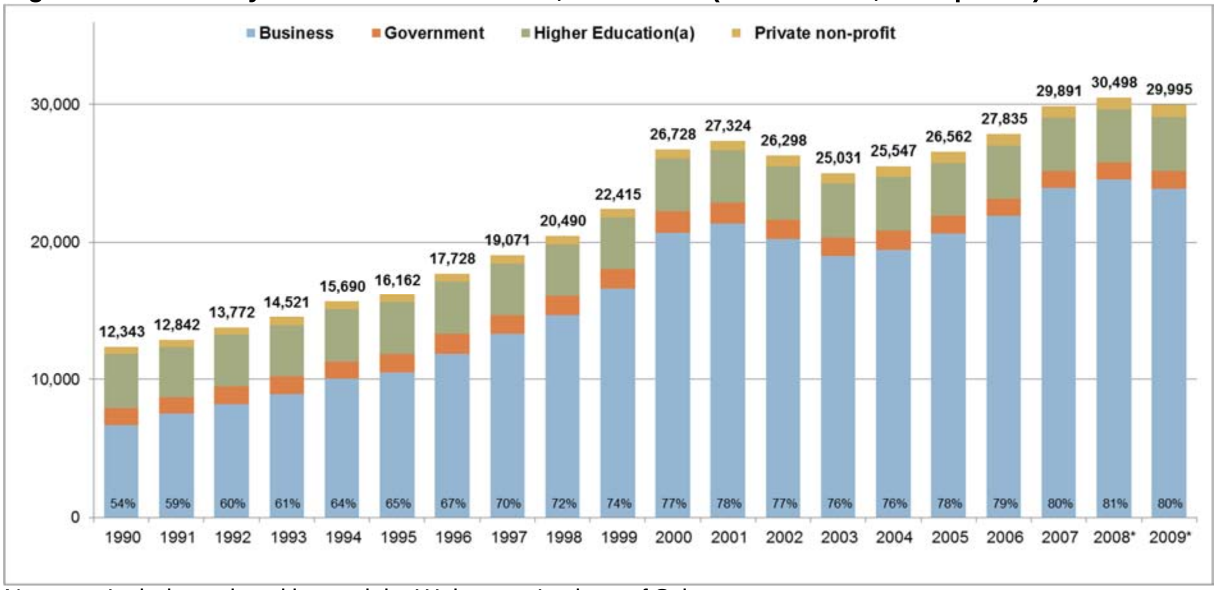
Table 2.1: GERD by Performing Sector, 1990–2009 (NIS millions, 2005 prices)

	Total		Business		Government		Higher education[a]		Private non-profit	
	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%
1990	**12,343**	100%	6,634	54%	1,255	10%	3,976	32%	479	4%
1991	**12,842**	100%	7,528	59%	1,158	9%	3,668	29%	487	4%
1992	**13,772**	100%	8,198	60%	1,290	9%	3,758	27%	526	4%
1993	**14,521**	100%	8,907	61%	1,290	9%	*3,752*	26%	573	4%
1994	**15,690**	100%	10,022	64%	1,244	8%	3,818	24%	606	4%
1995	**16,162**	100%	10,500	65%	1,317	8%	3,787	23%	558	3%
1996	**17,728**	100%	11,868	67%	1,426	8%	3,832	22%	602	3%
1997	**19,071**	100%	13,330	70%	1,317	7%	3,802	20%	621	3%
1998	**20,490**	100%	14,657	72%	1,435	7%	3,739	18%	658	3%
1999	**22,415**	100%	16,647	74%	1,382	6%	3,779	17%	606	3%
2000	**26,728**	100%	20,703	77%	1,559	6%	3,825	14%	641	2%
2001	**27,324**	100%	21,391	78%	1,498	5%	3,775	14%	661	2%
2002	**26,298**	100%	20,232	77%	1,434	5%	3,852	15%	780	3%
2003	**25,031**	100%	18,987	76%	1,386	6%	3,923	16%	735	3%
2004	**25,547**	100%	19,466	76%	1,400	5%	3,869	15%	813	3%
2005	**26,562**	100%	20,641	78%	1,287	5%	3,842	14%	792	3%
2006	**27,835**	100%	21,931	79%	1,249	4%	3,842	14%	814	3%
2007	**29,891**	100%	23,946	80%	1,238	4%	3,863	13%	844	3%
***2008**	**30,498**	100%	24,556	81%	1,237	4%	3,841	13%	863	3%
***2009**	**29,995**	100%	23,913	80%	1,280	4%	3,906	13%	896	3%

Notes: a. Includes universities and the Weizmann Institute of Science
* Provisional data
Source: CBS

[9] CAGR: $\mathrm{CAGR}(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$

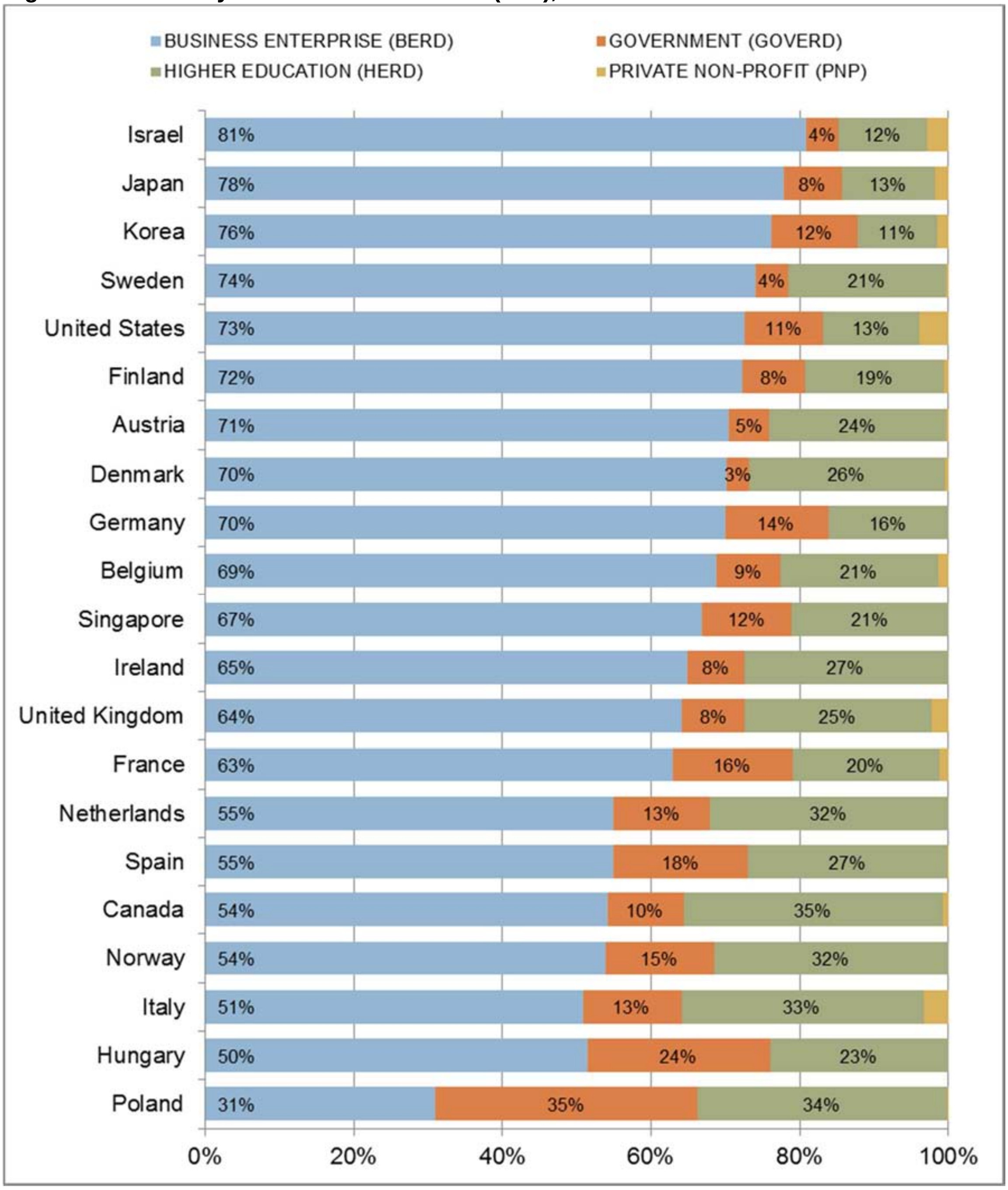
Figure 2.4: GERD by Sector of Performance, 1990–2009 (NIS millions, 2005 prices)



Notes: a. Includes universities and the Weizmann Institute of Science
b. Provisional data
Source: CBS

The next graph presents an international comparison of GERD by performance sector in 2008. While Israel stands out in its rate of business GERD by international standards, most GERD in most countries is performed by business. As for the higher-education sector, its share in Israel's GERD is low (12 percent) relative to other small and advanced countries such as the Netherlands (31 percent), Denmark (27 percent), Sweden (21 percent) and Finland (19 percent).

Figure 2.5: GERD by Sector of Performance (Pct.), 2008



Note: the data for Austria, Hungary, Germany, Japan, and S. Korea relate to 2007.
Sources: CBS and OECD

It is also important to examine GERD by funding sectors. By analyzing the difference between GERD by performance sector and GERD by source of funds, one can assess the development of the different sectors' independent abilities to perform R&D, the professionalization of R&D and its requisite infrastructures, and awareness of the importance of R&D for the advancement of the sector's goals even if it assigns performance to some other player. The sectoral distribution resembles that described in R&D by sector of performance but also makes reference to foreign sources of funds. The "Abroad" sector, according to the 2002 Frascati Manual, is composed of all institutions and individuals located outside the political borders of the state, with the exception of motor vehicles, ships, aircraft, and space satellites operated by domestic entities and testing grounds acquired by these entities and international organizations (except business enterprises), including facilities and operations within the territory of the state. (The R&D performed by Multinational firms are included in exports and not in foreign financing; for elaboration, see chapter on Globalization.)

The following are included in the classification of GERD by source of funds: the cost of R&D that the sector performs and funds by itself; the domestic purchase of R&D; and donations, grants, and other capital transfers to other domestic sectors for R&D funding. Table 2.2 and Figure 2.6 parse Israel's national GERD by sources of funding in current prices in 1991–2007. The funding that the government forwards to universities via the Planning and Grants Committee of the Council for Higher Education (hereinafter: PGC) is included in government funding. The higher-education column includes only R&D that research universities perform by themselves and finance using their own sources (tuition and non-earmarked donations), donations, grants, and other capital transfers.

Notably, since the data in the table are presented in current prices, the monetary values cannot be compared over the years. The reference is only to each sector's share in funding GERD.

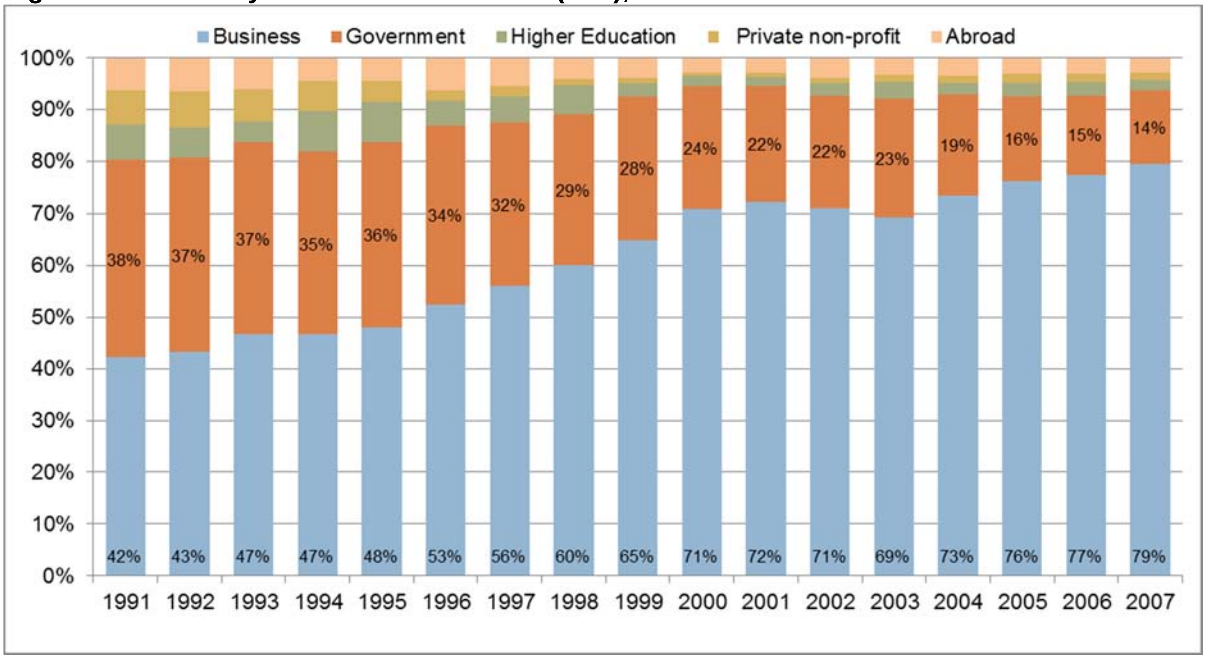
The trends in GERD funding resemble those in GERD performance. The share of business in funding increased from 42 percent in 1991 to 79 percent in 2007, whereas that of government fell from 38 percent to 14 percent in the respective years.

Table 2.2: GERD by Source of Funds,[a] 1991–2007 (NIS millions, current prices)

	Total		Business		Government		Higher education		Private non-profit		Abroad	
	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%
1991	3,523	100%	1,486	42%	1,340	38%	244	7%	231	7%	222	6%
1992	4,325	100%	1,870	43%	1,621	37%	252	6%	302	7%	281	6%
1993	5,107	100%	2,380	47%	1,894	37%	209	4%	314	6%	311	6%
1994	6,307	100%	2,939	47%	2,229	35%	486	8%	369	6%	284	5%
1995	7,361	100%	3,542	48%	2,623	36%	570	8%	298	4%	327	4%
1996	9,101	100%	4,782	53%	3,126	34%	432	5%	195	2%	567	6%
1997	11,113	100%	6,230	56%	3,503	32%	548	5%	217	2%	615	6%
1998	12,868	100%	7,740	60%	3,734	29%	707	5%	152	1%	535	4%
1999	16,144	100%	10,483	65%	4,470	28%	398	2%	154	1%	639	4%
2000	21,740	100%	15,394	71%	5,140	24%	438	2%	165	1%	603	3%
2001	23,526	100%	17,002	72%	5,248	22%	432	2%	172	1%	672	3%
2002	24,463	100%	17,391	71%	5,311	22%	548	2%	275	1%	938	4%
2003	23,061	100%	15,990	69%	5,242	23%	751	3%	315	1%	763	3%
2004	24,191	100%	17,758	73%	4,717	19%	522	2%	357	1%	837	3%
2005	26,312	100%	20,078	76%	4,259	16%	689	3%	463	2%	825	3%
2006	28,539	100%	22,106	77%	4,373	15%	736	3%	470	2%	854	3%
2007	32,953	100%	26,190	79%	4,695	14%	647	2%	507	2%	913	3%

Notes: a. Includes universities and the Weizmann Institute of Science.
Source: CBS

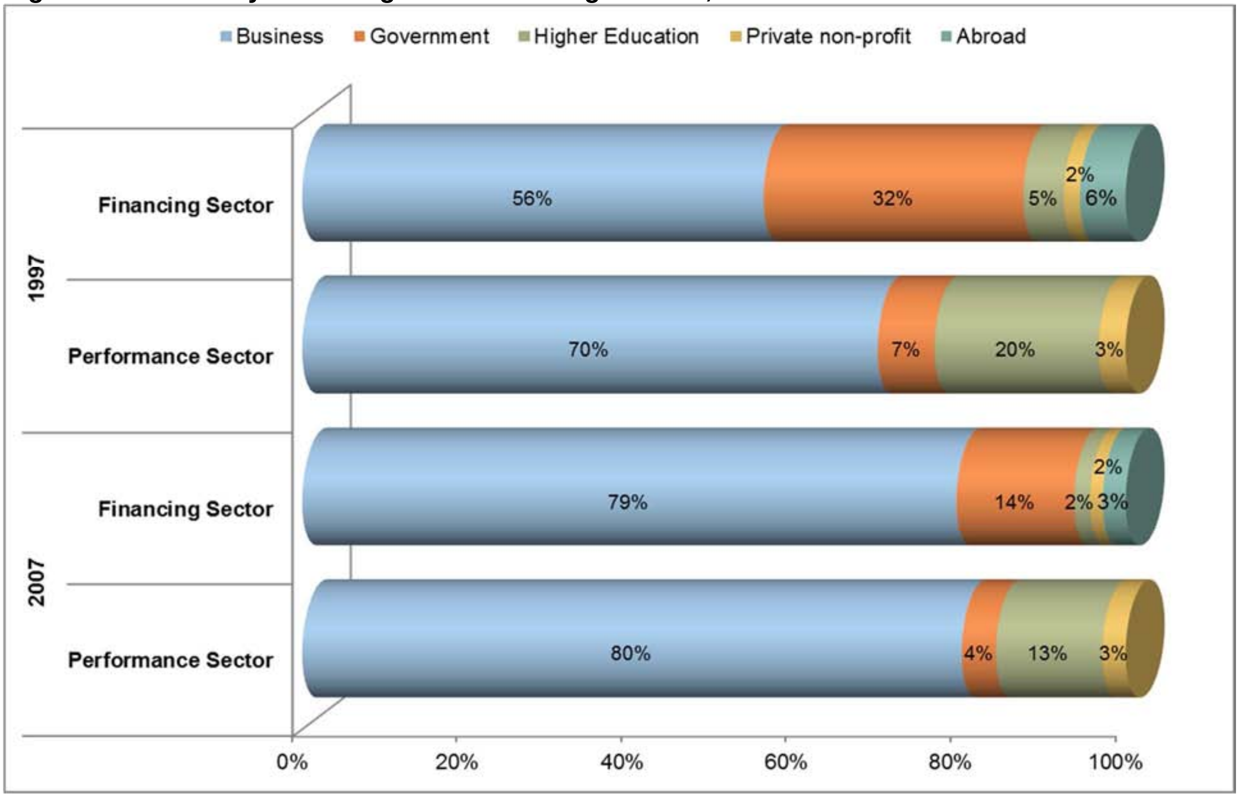
Figure 2.6: GERD by Main Source of Funds (Pct.), 1991–2007



Source: CBS

Figure 2.7 compares GERD by financing sector against performance sector in 1997 and 2007. The comparison shows that most government-funded R&D is performed by the business and higher-education sectors and that the share of government in both performance and the financing of R&D contracted by some 50 percent between 1997 and 2007.

Figure 2.7: GERD by Financing and Performing Sectors, 1997 vs. 2007



2.2 <u>The Business Sector</u>

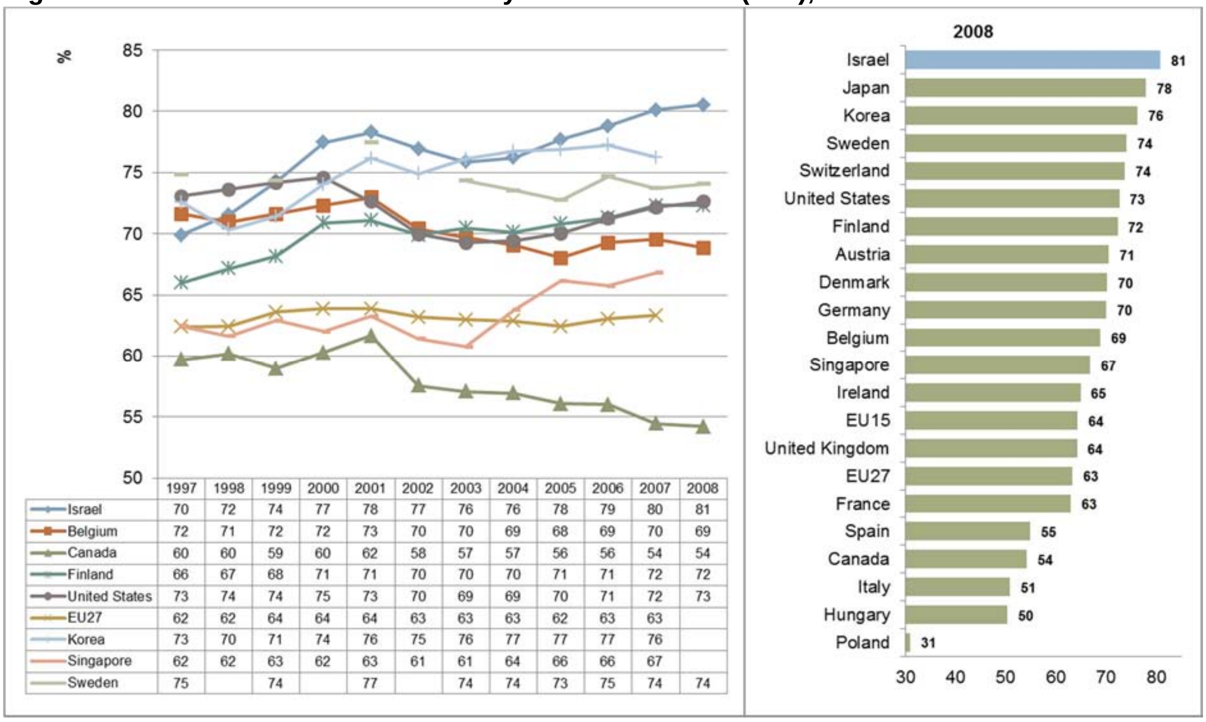
In most developed countries, the share of business in R&D activity has been growing perceptibly. Part of the reason for the upturn is the transition to a knowledge-based economy, in which a major component of economic activity concerns the creation, use, application, and assimilation of knowledge. This component is a material source for the growth and profitability of business firms (e.g., Microsoft and Internet companies such as Google and Yahoo). As the involvement of business in R&D activities has grown, the share of government in financing national GERD has been contracting. When the business data for Israel are shown and, above all, when cross-country comparisons are performed, one should take into account that Israel's data do not include defense GERD performed by business and funded by government.

2.2.1 An Aggregate Look at Business R&D

The relative importance of the business sector in domestic R&D activity may be examined in two basic respects: the share of GERD that this sector **performs** and the share of GERD that it **finances**.

As Table 2.1 shows, the share of Israel civilian R&D performed by the business sector has been growing appreciably over the years and came to 80 percent in 2009. Figure 2.8 presents data on the development of this rate and its 2008 level from a broader international perspective. Israel's indicator is very high by world standards, surpassing Japan, South Korea, and Sweden. It grew between 1997 and 2001, stagnated in 2001–2004 due to the high-tech crisis, and increased gently from 2004 on, mirroring the domestic economic recovery in those years. The trend in other countries was similar although usually less volatile.

Figure 2.8: Share of GERD Performed by Business Sector (Pct.), 1997–2008[a]



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Israel	70	72	74	77	78	77	76	76	78	79	80	81
Belgium	72	71	72	72	73	70	70	69	68	69	70	69
Canada	60	60	59	60	62	58	57	57	56	56	54	54
Finland	66	67	68	71	71	70	70	70	71	71	72	72
United States	73	74	74	75	73	70	69	69	70	71	72	73
EU27	62	62	64	64	64	63	63	63	62	63	63	
Korea	73	70	71	74	76	75	76	77	77	77	76	
Singapore	62	62	63	62	63	61	61	64	66	66	67	
Sweden	75		74		77		74	74	73	75	74	74

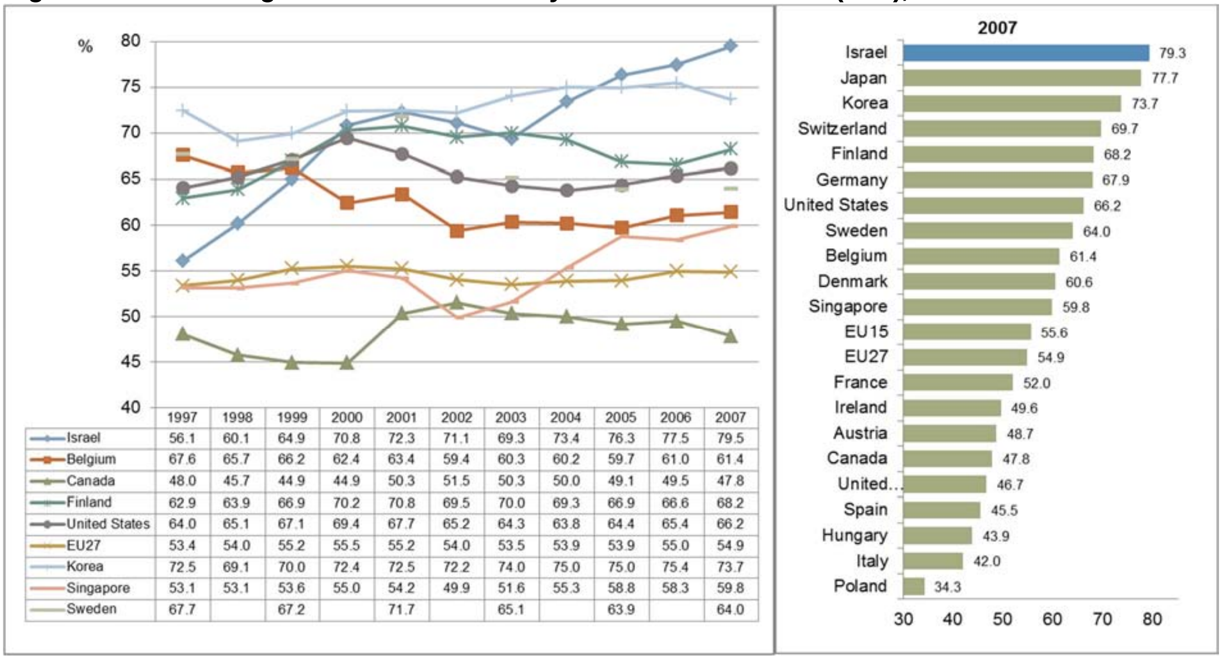
Note: a. The data in the graph to the right relate to 2008 or the latest year for which data were received. For Israel, the 2008 data are provisional.
Sources: CBS and OECD

The share of R&D performed by the business sector is an important indicator of the extent of innovation in the private sector. However, the importance of the business sector's efforts to create new knowledge and innovation is also reflected in expenditure that the business sector **finances**. This expenditure is usually aimed at performance by the sector itself and its economic objectives are generally more direct than those of public research. As Table 2.4 shows, this parameter has also been rising considerably in Israel over the years. Figure 2.9 shows the proportion of

R&D financed by Israel's business sector in total national GERD by international comparison.

Until 2003, this indicator was lower in Israel than in countries such as Belgium, South Korea, and Finland. Between 2003 and 2007, it rose by 3.4 percent on annual average, catapulting Israel to the top of the table. The trend of this indicator in Israel resembles that of the indicator of R&D performed by business, i.e., a steep increase between 1997 and 2000, stagnation if not decline between 2001 and 2003, and the resumption of upward movement afterwards. The behavior of this indicator in Israel over the years does not resemble that of countries that made less powerful transitions. This reinforces the proposition that business R&D in Israel is concentrated in high-tech and is acutely sensitive to its fluctuations.

Figure 2.9: Percentage of GERD financed by the Business Sector (Pct.), 1997–2007

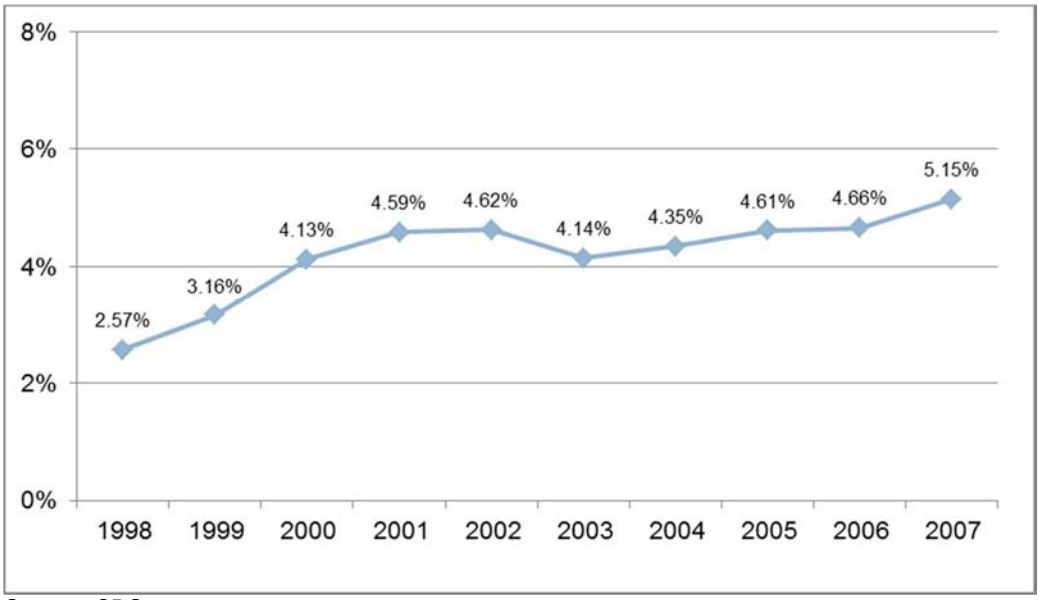


	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Israel	56.1	60.1	64.9	70.8	72.3	71.1	69.3	73.4	76.3	77.5	79.5
Belgium	67.6	65.7	66.2	62.4	63.4	59.4	60.3	60.2	59.7	61.0	61.4
Canada	48.0	45.7	44.9	44.9	50.3	51.5	50.3	50.0	49.1	49.5	47.8
Finland	62.9	63.9	66.9	70.2	70.8	69.5	70.0	69.3	66.9	66.6	68.2
United States	64.0	65.1	67.1	69.4	67.7	65.2	64.3	63.8	64.4	65.4	66.2
EU27	53.4	54.0	55.2	55.5	55.2	54.0	53.5	53.9	53.9	55.0	54.9
Korea	72.5	69.1	70.0	72.4	72.5	72.2	74.0	75.0	75.0	75.4	73.7
Singapore	53.1	53.1	53.6	55.0	54.2	49.9	51.6	55.3	58.8	58.3	59.8
Sweden	67.7		67.2		71.7		65.1		63.9		64.0

Note: The data for Switzerland relate to 2004.
Sources: CBS and OECD

An accepted indicator of the importance of this activity and the examination of business R&D intensity is the proportion of BERD (business GERD) in total business output. This ratio shows how much of the business sector's product is re-invested in R&D. The next figure presents business-funded R&D as a percent of business product in Israel in 1998–2007. Here, as in other indicators, the major increase took place in 1998–2002, at 16 percent on annual average, as against only 2 percent in 2003–2007.

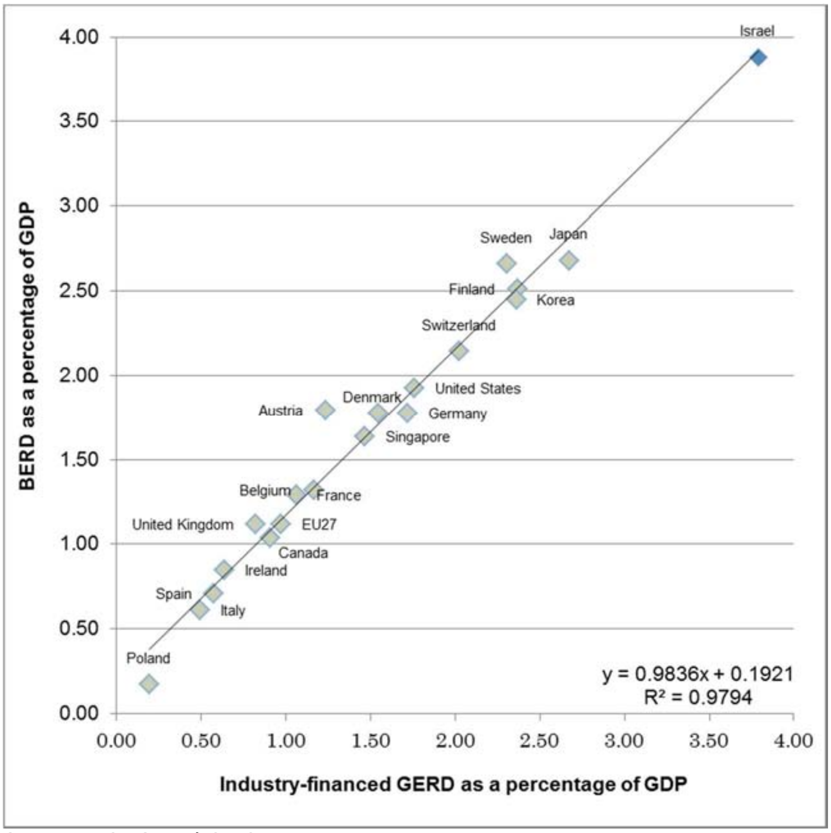
Figure 2.10: Industry-Financed GERD as Percentage of Business Sector Output, 1998–2007



Source: CBS

There is a strong correlation between the rates of R&D financed and performed by the business sector and GDP. Figure 2.11 presents both indicators in 2007 by international comparison.

Figure 2.11: Share of Business Sector in Performing and Funding GERD (Pct.) International Comparison, 2007

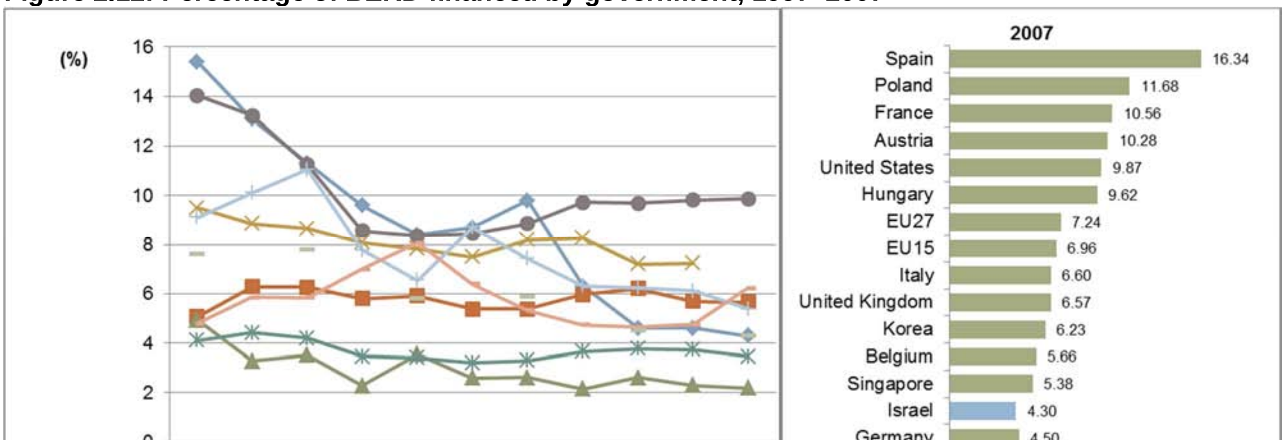


Sources: CBS and OECD

In a knowledge-based economy, relations between the business sector and other sectors, e.g., government financing of business and business financing of R&D performed by higher education, are important.

Israel's business sector has received lavish government support in the past decade, especially via the R&D encouragement programs run by OCS. (For a specification of these programs, see the section on economic indicators of S&T activities, below.) Figure 2.12 presents the share of direct government financing (not including tax benefits) in performance by Israel's business sector by international comparison. Importantly, government transfers to the business sector include direct and gross support only.[10] Indirect support such as tax relief and recognition of accelerated depreciation are not included here even though they are rather large in certain countries. Until 2002, the share of government financing in R&D performance by the business sector declined considerably. After a mild upturn in 2003, steep decreases resumed in 2004 (partly due to a reduction in the OCS budget, discussed at length in Section 4.3—Government Support). By international comparison in 2007, Israel ranked below countries such as Spain, Poland, France, and U.S., and resembled Sweden, Germany, Ireland, and Finland. Notably, the indicator for Israel does not include national defense GERD. The comparison may be problematic for the U.S., the UK, and France, in which the proportion of defense GERD is large.

Figure 2.12: Percentage of BERD financed by government, 1997–2007



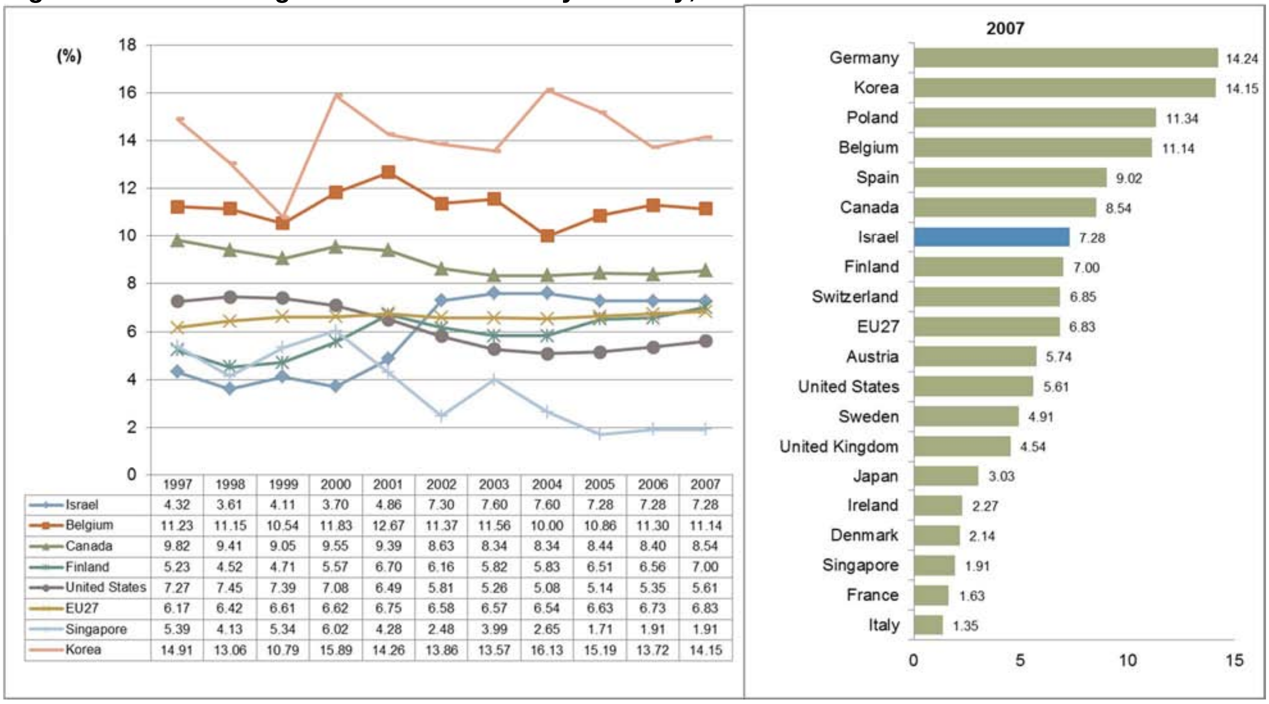
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Israel	15.40	13.10	11.30	9.60	8.40	8.70	9.80	6.30	4.60	4.60	4.30
Belgium	5.07	6.27	6.26	5.80	5.92	5.37	5.38	5.97	6.20	5.70	5.66
Canada	4.94	3.28	3.52	2.29	3.56	2.61	2.62	2.16	2.62	2.30	2.19
Finland	4.11	4.41	4.19	3.46	3.41	3.21	3.29	3.66	3.77	3.73	3.46
United States	14.03	13.22	11.26	8.56	8.37	8.46	8.87	9.73	9.69	9.81	9.87
EU27	9.50	8.87	8.66	8.09	7.84	7.50	8.19	8.26	7.20	7.24	
Singapore	9.12	10.11	11.04	7.78	6.53	8.72	7.42	6.32	6.24	6.12	5.38
Korea	4.79	5.85	5.83	7.00	8.06	6.40	5.32	4.74	4.64	4.74	6.23
Sweden	7.63		7.80		5.80		5.87		4.53		4.31

Sources: CBS and OECD

[10] Excluding subtraction of royalty revenues.

The way the business sector uses the knowledge and research innovation generated by higher education, and the way higher-education research is channeled to the economic markets, are of immense economic importance. One way to gauge the extent of academia–business cooperation is by using an indicator that examines the share of university R&D funded by business. This indicator (HERD), shown in Figure 2.13 below, was 7.28 percent in Israel in 2007. It hardly changed in 1997–2001 and remained low by the standards of most countries. In 2002, it surged from 4.9 percent to 7.3 percent, improving Israel's situation relative to other countries, possibly due to a government policy of investing in programs that required academia–business cooperation, such as Magneton (Technology Transfer Channel) and Nofar (From Basic Research to Applied Research). In 2002–2007, the index was basically flat. Still, Israel remains far from the standout performers in this field, including Germany (14.2 percent), South Korea (13.72 percent), and Belgium (10.86 percent).

Figure 2.13: Percentage of HERD financed by Industry, 1997-2007



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Israel	4.32	3.61	4.11	3.70	4.86	7.30	7.60	7.60	7.28	7.28	7.28
Belgium	11.23	11.15	10.54	11.83	12.67	11.37	11.56	10.00	10.86	11.30	11.14
Canada	9.82	9.41	9.05	9.55	9.39	8.63	8.34	8.34	8.44	8.40	8.54
Finland	5.23	4.52	4.71	5.57	6.70	6.16	5.82	5.83	6.51	6.56	7.00
United States	7.27	7.45	7.39	7.08	6.49	5.81	5.26	5.08	5.14	5.35	5.61
EU27	6.17	6.42	6.61	6.62	6.75	6.58	6.57	6.54	6.63	6.73	6.83
Singapore	5.39	4.13	5.34	6.02	4.28	2.48	3.99	2.65	1.71	1.91	1.91
Korea	14.91	13.06	10.79	15.89	14.26	13.86	13.57	16.13	15.19	13.72	14.15

Sources: CBS and OECD

2.2.2 BERD Parsed by Main Branches and Technology Intensivity

Thus far, we have related to BERD at the aggregate level. However, R&D policy should also address itself to the way business R&D is segmented among industries. The Central Bureau of Statistics (using the 1993 International Standard Industrial Classification) segments national R&D expenditure into four main industries:

manufacturing, computer and related services, financial services, and other, as specified below:

- **Manufacturing** (Divisions 13–39) includes all manufacturing establishments that employ five persons or more. Within manufacturing, there is segmentation by subindustries and by technological intensity; these are presented below.
- **R&D, computer and related services:**
  - *Computer services* (Division 72) includes companies active in computer, hardware, and software consulting; programming and system design services; data processing; preparation of databases and information retrieval; upkeep and repair of automatic data-processing equipment; computers; office and accounting machinery; and activities related to computer operation. Software R&D is a systematic process that accommodates an element of uncertainty and is meant to eliminate disparities and meet scientific and technological needs.
  - Startup firms and international R&D centers are classified in Division 72 only insofar as they engage in one of these fields.
  - *Research and development* (Division 73) includes firms active in basic research (i.e., experimental or theoretical work that is intended to create new knowledge of phenomena and facts, without application or immediate use), applied research (research work geared to the acquisition of new knowledge for a specific purpose), and experimental research (systematic work meant for the use of existing knowledge and the production of new materials, goods, and facilities) in the disciplines of medicine, engineering, natural science, humanities, and social science. These companies are research institutes, startup firms, international firms' R&D centers, fabless firms,[11] and technological incubators.
- **Financial services** include firms that engage in banking (i.e., defined as banks by the Supervisor of Banks), other financial activities such as financial leasing, credit, investments, lending, mortgages, etc.), insurance activity, and provident funds.

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[11] Fabless firms are those that have no fabrication capacity, instead focusing on and specializing in the design and development of chips. Fabrication takes place mainly by outsourcing to plants that specialize in the manufacture of chips; most such plants are in the Far East.

- **Other services** (Divisions 41–42 and 45–46) include firms that deliver and provide electricity, water, construction, transport, storage, and communication services, etc.

Israel's GERD is very high by international standards and its R&D, computer and related-services industry accounts for much of it. In 2005, the Helpman Committee was established to examine the profile and definition of national civilian GERD; its specific remit was to test the reliability and soundness of the measurement of civilian GERD in Israel. In its report (Helpman, 2005) the committee made seven recommendations; the first and most important of them concerned the estimation of expenditure on software in the computer-services industry. The committee expressed this recommendation because 40 percent of BERD in 2002 originated in the computer and related-services industry, a high proportion by OECD standards. This suggested the possibility of measurement problems in this field, which, in turn, raised doubts about the GERD data due to the size and importance of this industry in national GERD.

In 2009, an OECD expert team was invited at the initiative of the National Council on Research and Development (MOLMOP) to examine, evaluate, and propose improvements in the measurement of GERD in the computer-services industry and in surveys performed for this purpose by CBS. The initiative was supported by CBS, OCS, and the Ministry of Science and Technology.

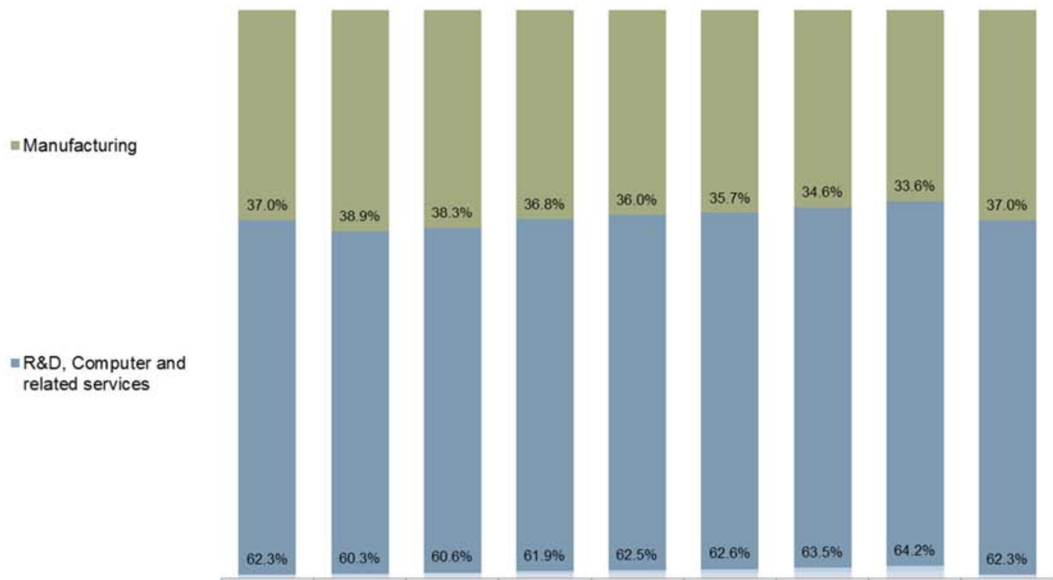
The expert team, visiting Jerusalem in November 2009, was given a survey of the situation, received an explanation of how the CBS surveys are performed, visited software-development firms, and presented initial findings. The team offered three possible explanations for the large share of computer services in Israel's BERD. The industrial composition of manufacturing in Israel, the high proportion of R&D companies in Israel that are foreign-owned, and the definition of R&D as shown in a survey of computer-services companies (ISIC 72). For elaboration, see the committee's report (2009).[12]

Figure 2.14, presenting the distribution of BERD across five main branches, shows that most R&D is performed by the Manufacturing and the R&D, Computer, and Related Services branches, whereas the Financial Services and Others branches accounted for 1–2 percent of BERD on average. In 1998, the distribution was 53 percent in R&D, Computer, and Related Services and 47 percent in Manufacturing. By 2008, R&D in the R&D, Computer, and Related Services branches

[12] "An Examination of the Measurement of R&D in the Computer and Related Services Industry in Israel: Findings, Recommendations and Questions Report of an OECD Expert Team," December 2009.

had grown to 65 percent of total BERD whereas the share of Manufacturing had contracted to 34 percent.

Figure 2.14: BERD by Main Branches, 2001–2009



	2001	2002	2003	2004	2005	2006	2007	2008	2009
Manufacturing	37.0%	38.9%	38.3%	36.8%	36.0%	35.7%	34.6%	33.6%	37.0%
R&D, Computer and related services	62.3%	60.3%	60.6%	61.9%	62.5%	62.6%	63.5%	64.2%	62.3%
Financial Services	0.2%	0.2%	0.3%	0.4%	0.5%	0.6%	0.7%	0.8%	0.2%
Others*	0.5%	0.6%	0.8%	0.9%	1.0%	1.1%	1.2%	1.4%	0.5%

*Others- includes electricity, water, construction, transport, communications, etc.
Source: CBS

Table 2.3 focuses on R&D in manufacturing[13] in 1995–2007, segmented by the following main divisions:

- Electronic Communication Equipment (Divisions 32, 33, 34)—manufacture of telecommunication equipment, computer communication equipment, and electronic equipment, industrial equipment for control and supervision, and medical and scientific equipment.
- Chemical products (Divisions 23 and 24)—basic chemical industries such as manufacturing of industrial chemicals, fertilizers, etc., pesticides, paints and lacquers, pharmaceutical products, soap and cleaning materials, and miscellaneous chemical products. Chemicals and their products include oil refining.
- Metal products (Divisions 27 and 28)—basic metal industry and manufacture and repair of ferrous and nonferrous products such as metal constructions,

[13] According to the 1993 International Standard Industrial Classification. From 1995 onward, the machinery and equipment division has included transport.

metal containers, shutters, coatings, manufacture of working tools, sheet-metal products, etc..

- Machinery and transport equipment (Divisions 29 and 35)—machinery and equipment industry including manufacture of general-purpose machinery and equipment such as motors, turbines, and furnaces; machinery and equipment for special industrial, agricultural, and other purposes; machinery and equipment for household use and the repair thereof. Transport industry includes manufacture of motor vehicles, chassis and trailers for motor vehicles, ships and aircraft, railroad track equipment, and other transport equipment.
- Electrical equipment (Division 31)—manufacture of electrical motors and accessories for distribution of electricity, e.g., industry of electrical motors, generators, and transformers, facilities for distribution and control of electricity, and manufacture of electrical wiring, cables, and other electrical equipment.
- Other—food, beverages, tobacco products, etc.

The data that follow accentuate the concentration of R&D in the communication and electronics industries—66 percent of all manufacturing by 1995 and 80 percent by 2001. From then until 2007, there was a slight decrease, to 70 percent. The share of the chemical-products industry in industrial R&D fell from around 14 percent in 1995 to 6 percent in 1999 and then rebounded to 14 percent in 2004 and thereafter. (Notably, Israel's chemical products sector includes pharmaceuticals.)

Table 2.3: intermural expenditure on R&D in selected manufactured industries, 1995-2007

	Electronic equipment	Chemical products	Metal products	Machinery & transport equipment	Electrical equipment	Other	Total industry
1995	**66%**	**14%**	**3%**	**8%**	**4%**	**5%**	**100%**
1996	**75%**	**11%**	**3%**	**5%**	**3%**	**3%**	**100%**
1997	**78%**	**11%**	**1%**	**5%**	**2%**	**3%**	**100%**
1998	**78%**	**9%**	**1%**	**6%**	**2%**	**4%**	**100%**
1999	**81%**	**6%**	**1%**	**6%**	**3%**	**3%**	**100%**
2000	**79%**	**7%**	**1%**	**8%**	**3%**	**2%**	**100%**
2001	**80%**	**8%**	**1%**	**7%**	**2%**	**2%**	**100%**
2002	**77%**	**10%**	**1%**	**8%**	**1%**	**3%**	**100%**
2003	**78%**	**11%**	**1%**	**7%**	**1%**	**2%**	**100%**
2004	**72%**	**15%**	**2%**	**9%**	**1%**	**1%**	**100%**
2005	**74%**	**14%**	**2%**	**6%**	**1%**	**3%**	**100%**
2006	**72%**	**13%**	**2%**	**9%**	**1%**	**3%**	**100%**
2007	**70%**	**14%**	**3%**	**9%**	**2%**	**2%**	**100%**

Source: CBS

Table 2.4 presents an international comparison of the distribution of manufacturing R&D by selected industries in 2006. Concentration of R&D is very high in Israel by international standards, as 72 percent of business R&D is performed by the electronic communication equipment industry. In large countries that have heavy industry, such as Germany, the UK, and the U.S., one finds high levels of expenditure in industries such as machinery and transport equipment; Israel's transport-equipment industry, in contrast, spends nothing on civilian R&D. Israel does have an aerospace industry but it belongs chiefly to the defense sector and is not presented in the data. However, even in comparison with economies that resemble Israel's in size, such as Switzerland, Ireland, and Belgium—which have meaningful proportions of R&D in the chemical products industry and, in some cases, also in machinery and equipment and transport equipment—the share of industrial R&D in these industries is relatively small in Israel.

Table 2.4: intermural expenditure on R&D in selected manufactured industries, International Comparison, 2006[a]

	Electronic equipment	Chemical products	Metal products	Machinery & transport equipment[b]	Electrical equipment	Other	Total industry
Israel[c]	72%	13%	2%	9%	1%	3%	100%
Finland	67%	7%	2%	12%	4%	8%	100%
Korea	54%	9%	3%	27%	2%	5%	100%
U.S.	36%	15%	0%	26%	4%	19%	100%
Ireland	33%	34%	1%	14%	4%	14%	100%
Canada	31%	18%	7%	30%	2%	12%	100%
Japan	31%	17%	4%	29%	9%	10%	100%
France	21%	28%	1%	37%	4%	9%	100%
Belgium	19%	50%	3%	12%	4%	12%	100%
Denmark	19%	47%	0%	14%	5%	15%	100%
Switzerland	18%	55%	21%	0%	0%	6%	100%
Germany	17%	19%	2%	51%	3%	8%	100%
UK	13%	41%	0%	36%	4%	6%	100%
Hungary	11%	63%	1%	14%	6%	5%	100%
Netherlands	6%	32%	2%	16%	2%	42%	100%
Sweden	0%	25%	3%	68%	0%	4%	100%

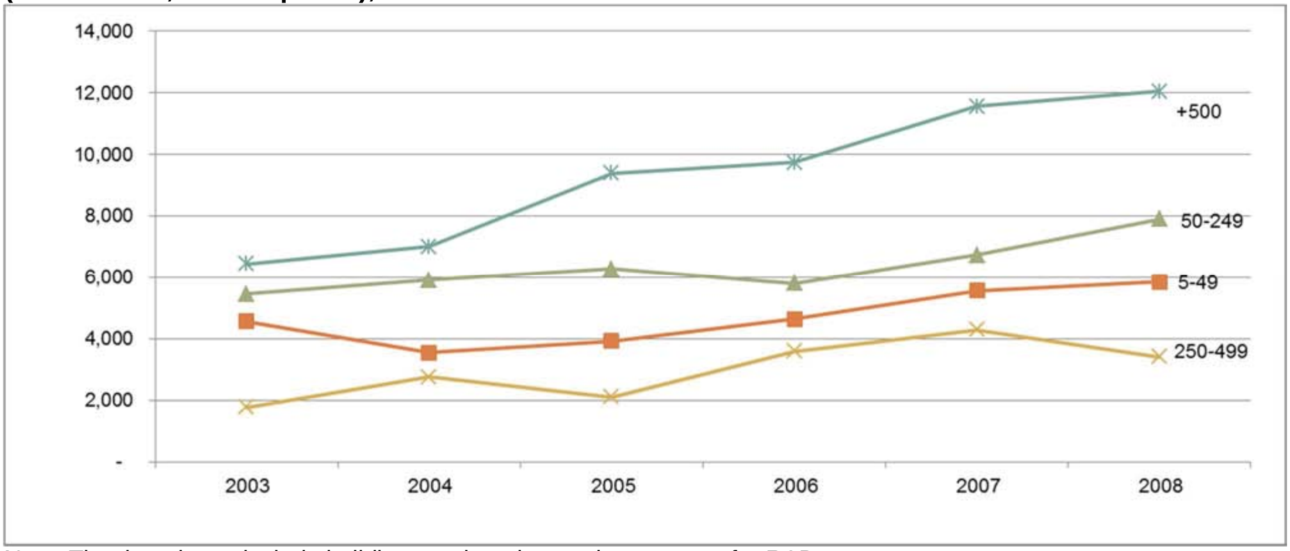
a. The data relate to 2006 or the latest year for which data were obtained.
b. The machinery and transport equipment industry includes transport vehicles.
c. The data for Israel do not include defense R&D.
Sources: CBS and OECD

Another interesting way to parse business R&D is by the size of R&D-performing firms, specifically the share of SMEs (small and medium-size enterprises) in the performance of business R&D. One may determine firm size on the basis of turnover, balance sheet, or number of employees. In Israel, both CBS and the Ministry of Industry, Trade, and Labor define firm size on the basis of number of employees.

There is a considerable scale difference between a medium enterprise by American standards and one in Israel. In Israel, such an enterprise is defined as one that employs 50–250 people. To compare the countries, we will use the OECD standard, which bases firm size on number of employees: a micro business employs up to 10 people, a small one up to 50, a medium one up to 250, and a large one 250 or more.

Figure 2.15 shows the distribution of BERD in Israel grouped by firm size (number of employees) in 2003–2008. Some 55 percent of BERD is performed by large firms (≥250 employees), 25 percent by medium-sized enterprises, and 20 percent by small businesses. This state of affairs reflects the proliferation of technological incubators and startups in Israel.

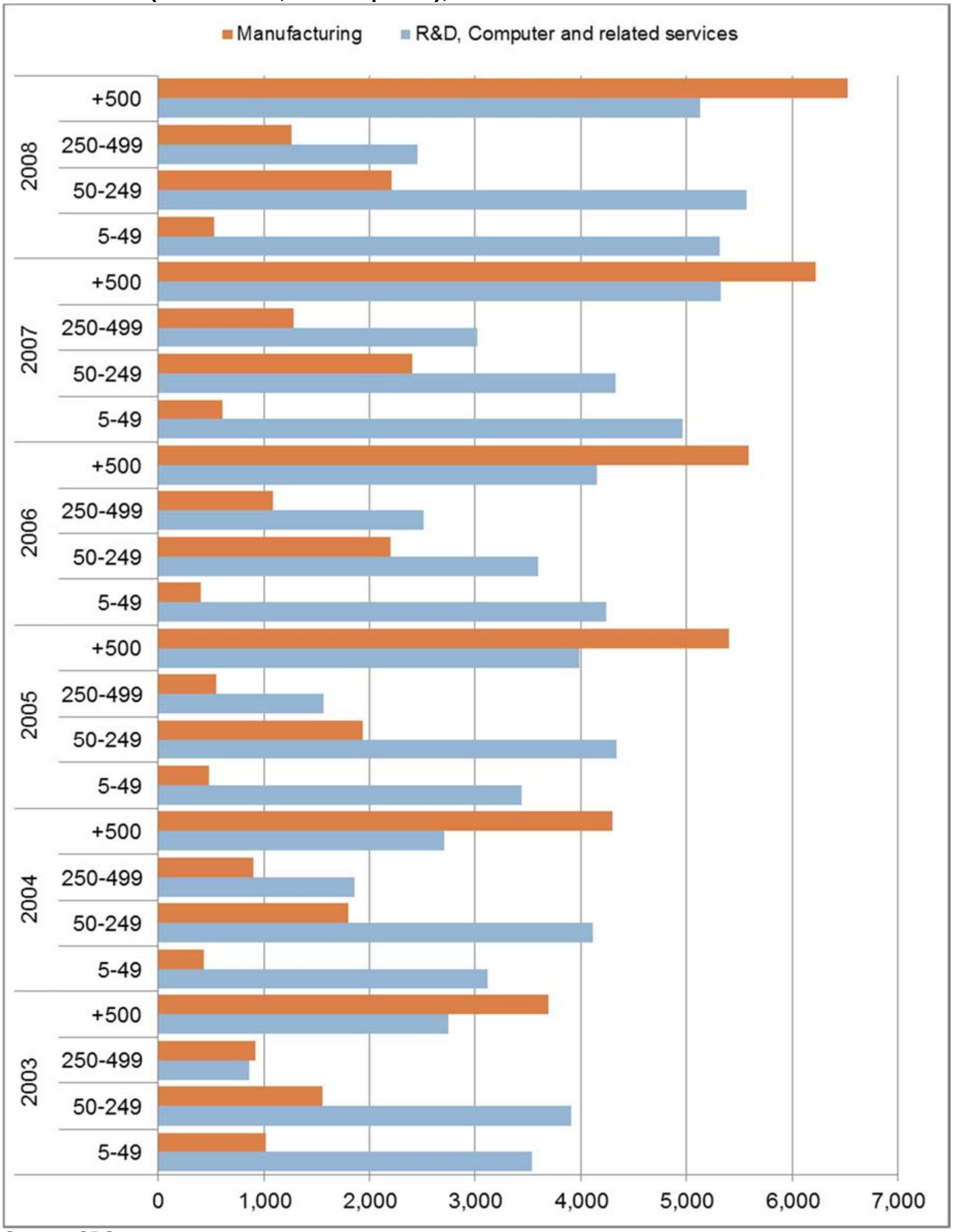
Figure 2.15: Business Enterprise R&D Expenditure by Firm Size (Employees), (NIS millions, current prices), 2003–2008



Note: The data do not include buildings-and-equipment investments for R&D.
Source: CBS

Figure 2.16 shows the distribution of business-enterprise R&D by size of performing firm, separating manufacturing from R&D, computer, and related services. Most manufacturing investment is made by large firms (>500 employees). In large firms, the investment in manufacturing surpasses that in R&D, computer, and related services. Most investment in R&D, computer, and related services is made by SMEs (≤250 employees). SMEs invest more in R&D, computer, and related services than they do in manufacturing.

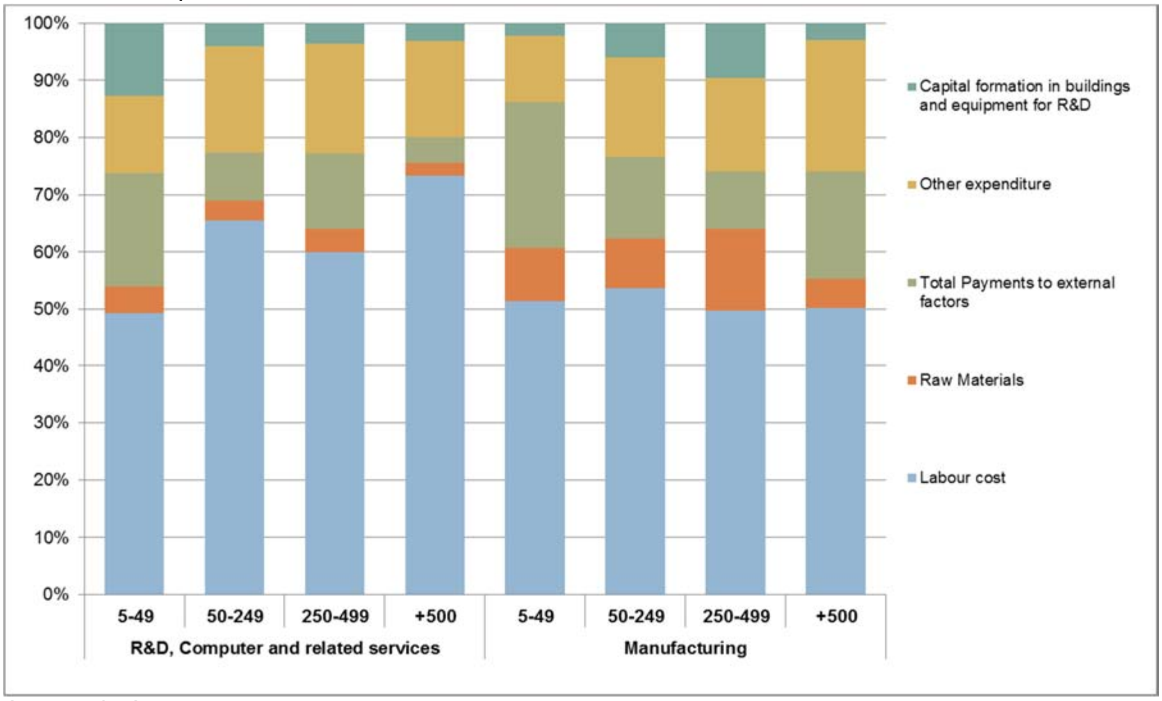
Figure 2.16: Business Enterprise R&D Expenditure by Firm Size and Industrial Classification (NIS millions, current prices), 2003–2008



Source: CBS

Figure 2.17 presents the distribution of BERD by industrial classification and type of expenditure. In R&D, computer, and related services, 60 percent on average is labor cost (and in large firms, those with >500 employees, labor cost comes to 70 percent). In manufacturing, labor cost is lower but still constitutes 50 percent of total expenditure. In 2008, the business sector invested NIS 1,759 million, 5.7 percent of total BERD, in buildings and equipment. The distribution of this sum is 72 percent invested by R&D, computer, and related services firms and only 28 percent invested by manufacturing enterprises.

Figure 2.17: Share of Business Enterprise R&D Expenditure by Firm Size and Industrial Classification, 2008

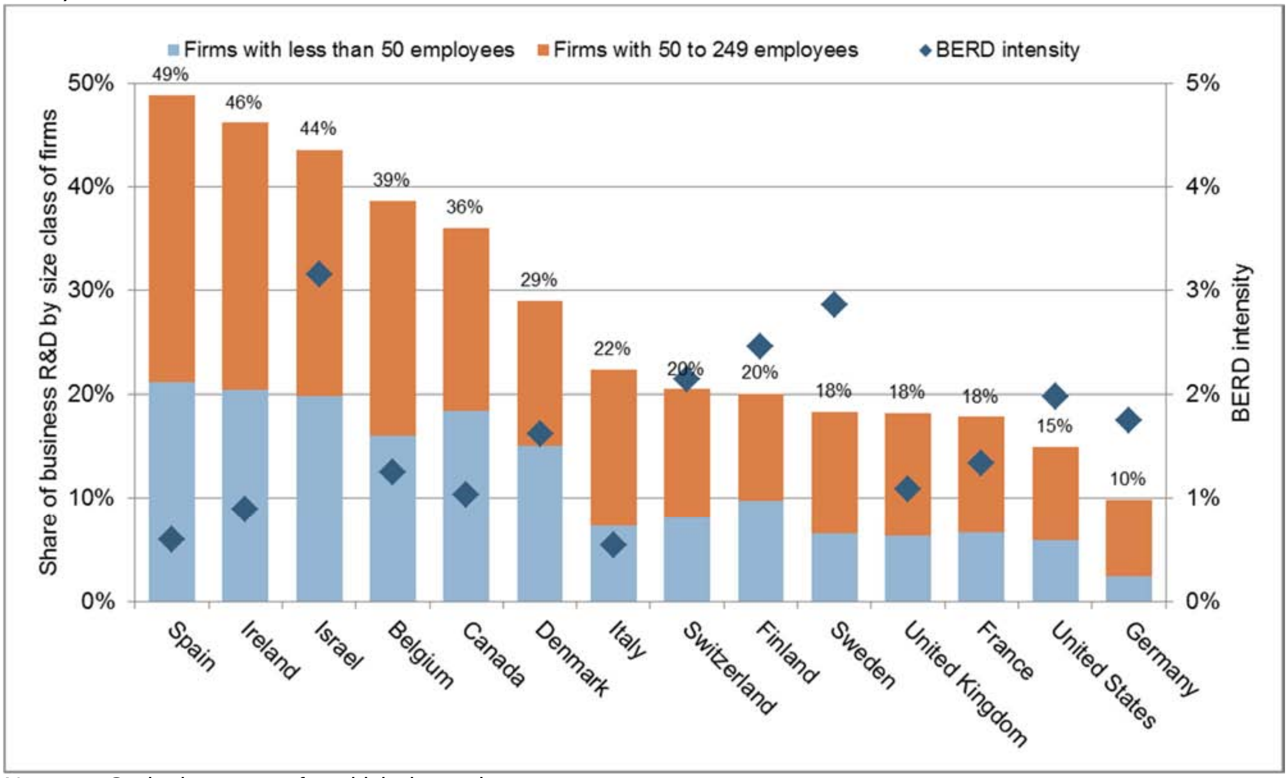


Source: CBS

Figure 2.18 presents an international comparison of the shares of business R&D performed by small enterprises (<50 employees) and medium enterprises (<250 employees) in total R&D in 2007. As an extra parameter, the intensity of each country's business R&D (= share of BERD in GDP) is shown.

Various studies contend that countries with higher rates of SME participation in R&D have low rates of business R&D intensity; this is said in particular about the countries of southern Europe and the new members of the EU. One way of explaining this, perhaps, is that countries with low business R&D intensity and less developed research systems do not have large R&D-intensive firms; therefore, SMEs are dominant in these countries' business R&D. Israel is an outlier in this respect: even though its business R&D is very intensive by international standards, a very large share of its business R&D is performed by SMEs. The exceptional nature of Israel's proportion of small-firm contribution to R&D in total GERD deserves attention in discussions about government aid programs for R&D activities.

Figure 2.18: Share of Small and Medium-Sized Firms (<250 employees) in Business R&D, 2007[a]



Notes: a. Or the latest year for which data exist.
Sources: CBS and OECD

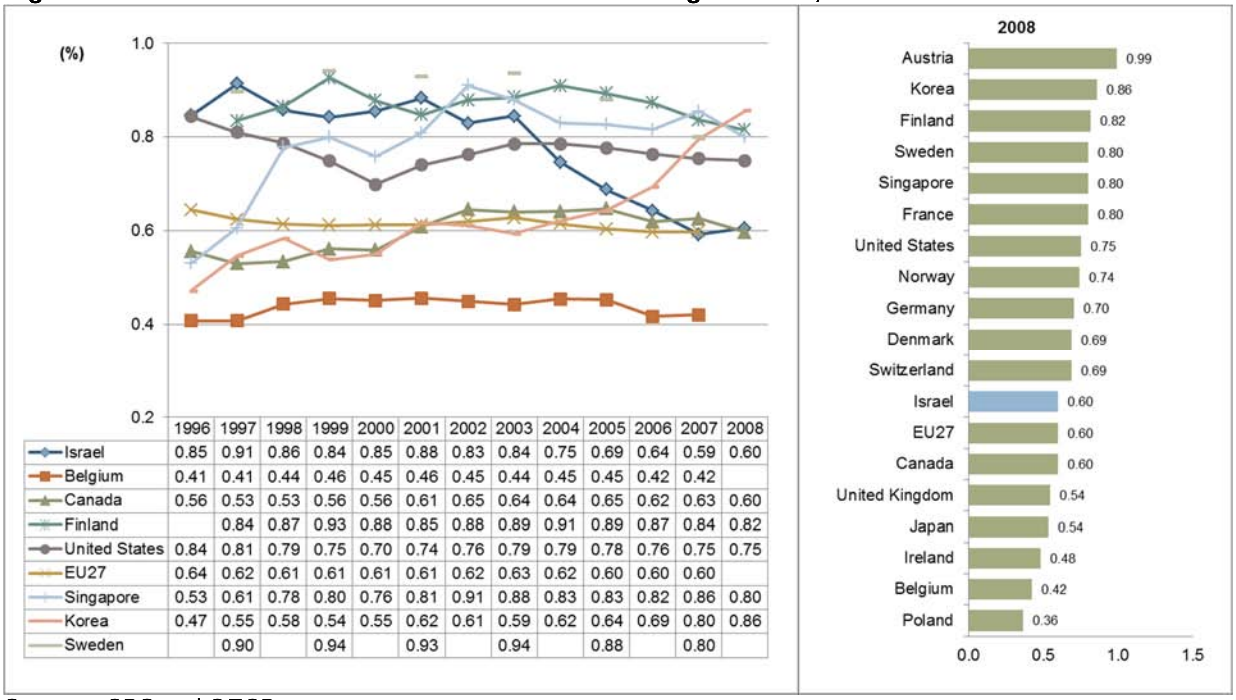
2.3 The Government Sector

Government support of R&D includes performance and financing of R&D in areas for which government is responsible. The operation of various programs that support activities in R&D, technological development, and scientific research is part of government policies that seek to promote Israel's future in respect of society, environment, health, and economy, and to place the economy on a growth trajectory. In 2006, government (comprised of central-government offices, public nonprofits, municipal authorities, and national institutions) performed 5 percent of total civilian R&D and financed 16 percent of GERD. Notably, the data pertain only to civilian R&D; the government also finances and performs a large share of defense R&D, an area of activity not surveyed in this document.

Here we examine GOVERD (government gross R&D expenditure) at the more detailed level of financing by central-government offices. An accepted comparative indicator for the examination of the extent of government R&D financing is the share of GOVERD in GDP, also known as "government R&D intensity." Importantly, in Israel some of the PGC budget, representing government expenditure for research at higher-education institutes, is included in government R&D expenditure.[14] In 2008, government offices in Israel spent 0.6 percent of GDP on R&D. Until 2003, Israel appeared to be among the leading countries in this respect, at 0.84 percent of GDP. From then until 2007, however, GOVERD in GDP fell by 28 percent, to 0.6 percent, and stayed at that level in 2008.

By international comparison, Israel fell from the top of the standings to the middle; in 2008 it approximated the EU-27 average, Denmark, and Canada. R&D intensity of government offices in the surveyed countries has been generally stable during the decade. Singapore and South Korea are outliers; their government financing of R&D in GDP grew from 0.5 percent in 1996 to 0.8 percent in 2008.

Figure 2.19: Government-Financed GERD as Percentage of GDP, 1996–2008



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Israel	0.85	0.91	0.86	0.84	0.85	0.88	0.83	0.84	0.75	0.69	0.64	0.59	0.60
Belgium	0.41	0.41	0.44	0.46	0.45	0.46	0.45	0.44	0.45	0.45	0.42	0.42	
Canada	0.56	0.53	0.53	0.56	0.56	0.61	0.65	0.64	0.64	0.65	0.62	0.63	0.60
Finland		0.84	0.87	0.93	0.88	0.85	0.88	0.89	0.91	0.89	0.87	0.84	0.82
United States	0.84	0.81	0.79	0.75	0.70	0.74	0.76	0.79	0.79	0.78	0.76	0.75	0.75
EU27	0.64	0.62	0.61	0.61	0.61	0.61	0.62	0.63	0.62	0.60	0.60	0.60	
Singapore	0.53	0.61	0.78	0.80	0.76	0.81	0.91	0.88	0.83	0.83	0.82	0.86	0.80
Korea	0.47	0.55	0.58	0.54	0.55	0.62	0.61	0.59	0.62	0.64	0.69	0.80	0.86
Sweden		0.90		0.94		0.93		0.94		0.88		0.80	

Sources: CBS and OECD

Government is an important player in allocating resources for the production of scientific knowledge in research institutes—knowledge that abets innovation and growth—and in creating incentives for the production of knowledge in the business sector. Another way to examine the extent of government financing of R&D is by measuring R&D funding as a percent of the government budget.

Government's share in GERD may be divided into three sections:

[14] The Planning and Grants Committee (PGC), part of the Israel Council for Higher Education, is responsible for apportioning the state budget for higher education among domestic universities and colleges.

a. *Performance* of R&D at government offices—labor costs, current purchases, and investments (in buildings, equipment, and motor vehicles);

b. *Purchase of R&D* by government offices—the R&D purchased is used by the office for its needs;

c. *Subsidies and grants* by government offices in R&D performed by other sectors:

    — current transfers;

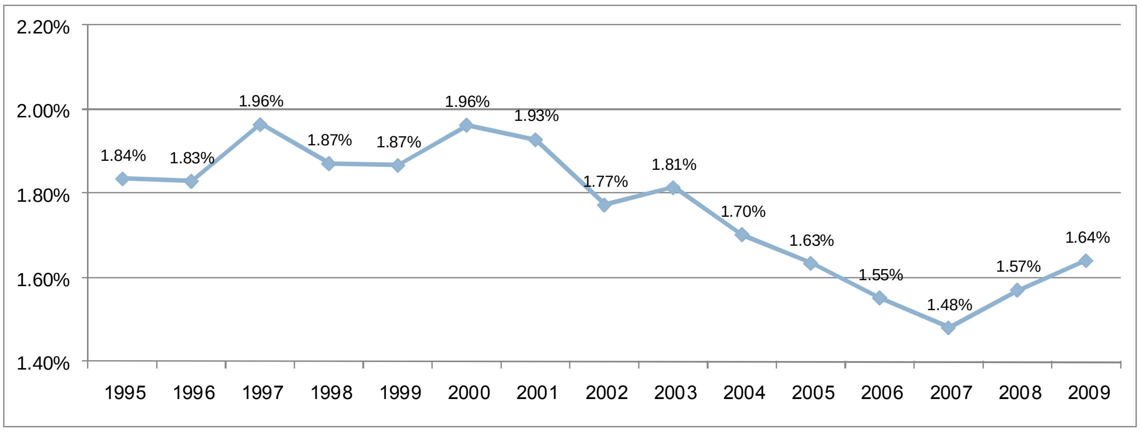
    — capital transfers (transfers earmarked for construction, purchase of equipment, and motor vehicles;

    — transfers for university research via PGC.

In 2009, government offices on (including PGC) spent NIS 4,916 million on R&D —NIS 400 million for R&D by government itself, NIS 144 million for purchase of R&D, NIS 2,310 million in subsidies and grants for R&D performance, and NIS 2,062 million in transfers by PGC.

Figure 2.20 presents actual GOVERD as a percent of annual government expenditure in 1995–2009. This metric shows where R&D stands on the government's list of priorities relative to other budget expenditures. Even though the ratio has been relatively constant in the long term, it has fallen in the past few years: from 1.96 percent in 2000 to 1.48 percent in 2007 and up mildly to 1.64 percent in 2009. The data for 2008 and 2009 are provisional.

Figure 2.20: Government-financed GERD as a percentage of Government Expenditure, 1995–2009



Source: CBS

Now we observe the distribution of government R&D subsidies by fields. Using the updated 2002 Standard Classification of the Frascati Manual,[15] we segment GOVERD by thirteen objectives that they are meant to attain:

1. **Exploration and exploitation of the earth**—includes hydrology, oceanic, geologic, and atmospheric studies; also includes meteorological research (apart from that performed by satellite).
2. **Infrastructure and general planning of land use**—includes R&D for research on infrastructures and urban development, including enhancement of housing, improvement of community environment, siting of hospitals, etc.
3. **Control and care of the environment**—government R&D meant to enhance environmental quality, including water, air, soil, and noise pollution, waste disposal, and radiation.
4. **Protection and improvement of human health**—includes R&D programs for the protection and improvement of human health; epidemiological research, prevention of industrial illnesses, and substance addiction.
5. **Production, distribution, and rational utilization of energy**—includes all R&D actions geared to the delivery, production, conservation, and distribution of all types of energy.
6. **Agricultural production and technology, including forestry and fishing**—all research for the advancement of agriculture, forestry, fishing, and food production, including research on chemical fertilizers, biocides, biological pest control, mechanization of agriculture, environmental impact of agricultural and forestry activities, and development of food productivity and technology.
7. **Industrial production and technology**—includes R&D programs meant primarily to support industrial development; also includes construction industries, wholesale and retail trade, restaurants and hotels, banking and insurance, and other commercial services; does not includes R&D performed by an industry in support of other objectives (e.g., defense, space, energy, and agriculture).
8. **Social structures and relationships**—R&D related to sociocultural problems such as national insurance, welfare services, culture, recreation and leisure, law and justice, consumer protection, working conditions, labor relations, personal advancement, peacemaking, national economy, and other international objectives.

[15] 2002 Frascati Manual, OECD, pp. 144–147.

9. **Exploration and exploitation of space**—also includes civilian R&D related to space.
10. **Research financed from general university funds**—all R&D financed from general funds and via PGC.
11. **Non-oriented research**—R&D meant for the enhancement of general knowledge that is not included as an investment in the attainment of a specific objective.
12. **Other civilian research**—civil research that cannot be classified to any of the foregoing.
13. **Defense**—research and development for military and security purposes.

Table 2.5 parses the distribution of civilian GOVERD in 2000–2009 (excluding defense GERD) on the basis of these objectives. Most government expenditure over the years has been allocated to the advancement of industrial technologies (40.2 percent in 2009) and university research (41.9 percent in 2009). The share of health and environmental-quality expenditure has doubled in the past decade but remains less than 1 percent of total government GERD.

Table 2.5: GBAORD by socio-economic objective, 2000–2009

Objective	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exploration and exploitation of the earth	0.4%	0.4%	0.4%	0.3%	0.4%	0.3%	0.4%	0.4%	0.3%	0.2%
Infrastructure development	0.4%	0.7%	0.5%	0.5%	1.7%	1.2%	1.1%	1.1%	1.2%	1.1%
Control and care of the environment	0.4%	0.9%	1.0%	0.8%	1.0%	1.0%	0.8%	0.9%	0.9%	0.9%
Health	0.5%	0.7%	0.7%	0.6%	0.8%	0.8%	0.8%	0.9%	0.9%	0.9%
Production and utilization of energy	1.1%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%
Agriculture, forestry and fishing	7.3%	7.2%	6.6%	6.5%	8.1%	7.6%	7.4%	7.9%	7.4%	6.9%
Advancement of industrial technology	37.9%	37.4%	34.2%	39.4%	33.2%	34.0%	35.8%	32.6%	35.3%	40.2%
Social services	4.8%	4.8%	5.2%	5.4%	5.3%	4.4%	4.6%	4.5%	4.5%	4.2%
Exploration and exploitation of space	0.1%	0.1%	0.1%	0.0%	0.0%	0.3%	0.2%	0.3%	0.3%	0.2%
General university funds	43.3%	43.4%	46.3%	43.6%	46.3%	47.3%	45.9%	48.1%	45.7%	41.9%
Non-oriented research	3.8%	4.1%	4.7%	2.7%	3.1%	3.0%	2.9%	3.2%	3.4%	3.3%

Source: CBS

Table 2.6 presents an international comparison of the distribution of government civilian GERD by the foregoing objectives in 2008 (sorted on the basis of the Advancement of Industrial Technology column). Israel is noted for proportionately large government allocations for technological and industrial R&D and university research (via PGC). Its low percent of investment in health and control and care of the environment, by all countries' standards, also stands out.

Table 2.6: GBAORD by socio-economic objective (Pct.), International Comparison, 2008

	Advancement of industrial technology	General university funds	Exploration and exploitation of the earth	Control and care of the environment	Exploration and exploitation of space	Infrastructure development	Production and utilization of energy	Health	Agriculture, forestry and fishing	Social services	Non-oriented research
Israel	35.3%	45.7%	0.3%	0.9%	0.3%	1.2%	0.1%	0.9%	7.4%	4.5%	3.4%
Belgium	33.4%	15.5%	0.9%	2.0%	12.0%	1.9%	1.5%	2.0%	1.3%	5.8%	23.7%
Korea	32.3%	0.0%	2.6%	4.0%	5.0%	2.1%	8.5%	7.7%	8.1%	0.0%	29.6%
Finland	23.0%	25.6%	1.3%	1.5%	1.9%	2.3%	9.0%	6.6%	5.6%	5.7%	17.5%
Spain	15.7%	20.8%	1.5%	4.8%	2.0%	10.3%	5.0%	14.3%	8.0%	5.1%	12.5%
Austria	14.9%	57.1%	1.6%	1.6%	0.2%	1.1%	0.9%	3.1%	2.0%	3.0%	14.5%
Ireland	13.0%	23.9%	0.6%	1.3%	0.0%	1.5%	3.0%	5.5%	13.5%	10.8%	26.9%
Canada	12.7%	31.2%	2.0%	4.7%	3.9%	2.8%	5.8%	19.1%	7.7%	0.0%	10.0%
Germany	12.5%	41.2%	2.0%	3.2%	5.2%	1.8%	3.9%	4.6%	3.0%	4.0%	18.5%
France	11.9%	38.7%	1.3%	3.8%	12.4%	1.3%	8.3%	9.9%	2.6%	3.6%	6.3%
Italy	11.5%	31.1%	2.8%	4.1%	6.7%	1.9%	6.0%	12.5%	4.5%	13.0%	5.7%
Denmark	10.1%	43.0%	0.4%	2.5%	1.7%	0.8%	3.9%	7.6%	3.8%	7.4%	18.7%
Japan	7.7%	35.8%	1.9%	1.0%	7.4%	4.3%	14.5%	4.3%	3.9%	0.9%	18.1%
Sweden	6.5%	48.3%	1.0%	1.7%	0.9%	5.0%	4.0%	0.7%	1.8%	2.1%	28.0%
Switzerland	1.0%	0.0%	0.4%	0.9%	11.3%	0.8%	1.9%	1.2%	5.1%	5.1%	72.3%
U.S.	0.8%	0.0%	1.6%	1.2%	18.9%	2.3%	4.0%	51.1%	3.8%	2.1%	14.2%
UK	0.6%	31.0%	3.4%	2.8%	2.8%	1.7%	1.0%	22.8%	3.5%	5.9%	24.5%

Note: The data for Canada relate to 2007.
Sources: CBS and OECD

For additional data on government subsidies, see Chapter 4, "Capital Inputs and Government Assistance."

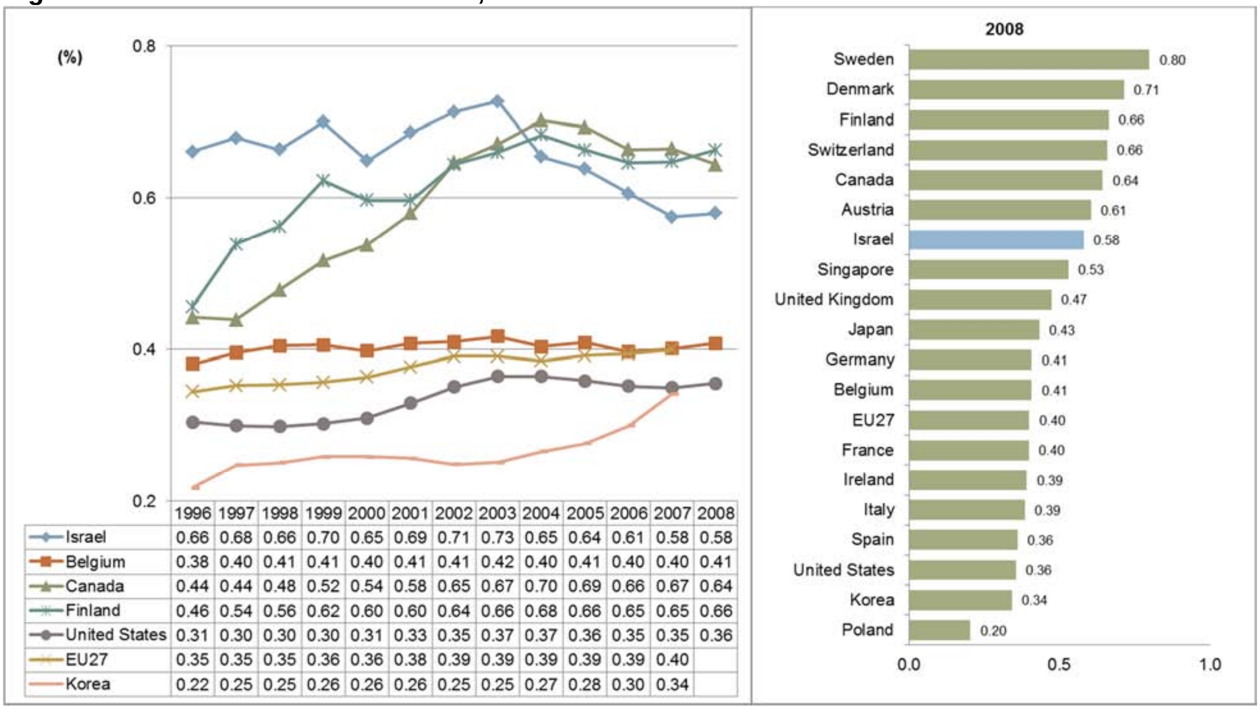
2.4 The Higher-Education Sector

The higher-education system plays an immensely important role in the creation of knowledge and innovation and the development of the national pool of human capital. This sector, as defined at the beginning of this chapter, includes Israel's seven research universities and their related research institutes. Here is where most basic research takes place. In the classification of GERD by performance sector, direct expenditure of the higher-education sector on the performance of R&D is recorded irrespective of the sources of the funding. In the classification of GERD by financing sector, R&D that higher education performs by itself on the basis of funding from its own sources, donations, grants, and other capital transfers is included. Government funding of universities via PGC is presented as part of government-funded expenditure. Some university research is also financed by miscellaneous government offices, NPOs, sources abroad, and national and binational foundations such as the BIRD (Israel-U.S. Binational Industrial Research and Development) Foundation. (These are largely government-funded.)

National civilian HERD (GERD performed by higher education) in 2009 was NIS 3,906 million in 2005 prices. This sum has hardly changed in the past decade even though enrollment in masters and doctoral programs has doubled during that time.

An accepted indicator in international comparisons of R&D performance by higher education is the share of higher education R&D in GDP, known as "intensity of higher-education research" (HERD intensity). In 2008, HERD intensity in Israel was 0.58 percent, unchanged from the previous year. Between 2003 and 2008, this indicator declined by 20 percent in compound terms. In a limited international comparison, it was found that the rates of R&D intensity in Israel's higher-education system were relatively high until 2003, as noted above, but have been falling ever since. A broad international comparison for 2008 ranked Israel (0.58 percent) below Sweden (0.8 percent), Denmark (0.71 percent), Switzerland (0.66 percent), Finland (0.66 percent), Canada (0.64 percent), and Austria (0.61 percent).

Figure 2.21: HERD as Percent of GDP, 1996–2008[a]



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Israel	0.66	0.68	0.66	0.70	0.65	0.69	0.71	0.73	0.65	0.64	0.61	0.58	0.58
Belgium	0.38	0.40	0.41	0.41	0.40	0.41	0.41	0.42	0.40	0.41	0.40	0.40	0.41
Canada	0.44	0.44	0.48	0.52	0.54	0.58	0.65	0.67	0.70	0.69	0.66	0.67	0.64
Finland	0.46	0.54	0.56	0.62	0.60	0.60	0.64	0.66	0.68	0.66	0.65	0.65	0.66
United States	0.31	0.30	0.30	0.30	0.31	0.33	0.35	0.37	0.37	0.36	0.35	0.35	0.36
EU27	0.35	0.35	0.35	0.36	0.36	0.38	0.39	0.39	0.39	0.39	0.39	0.40	
Korea	0.22	0.25	0.25	0.26	0.26	0.26	0.25	0.25	0.27	0.28	0.30	0.34	

Note: a. The data relate to 2008 or the latest year for which data were received.
Sources: CBS and OECD

Before we perform additional international comparisons, we need to determine how much funding universities receive for HERD and how the funds are apportioned.

Table 2.6 presents these data for 1995–2007. Notably, R&D activity is integral to the activity of research universities; in budget terms, it is inseparable from teaching activity. Thus, the budget that PGC allots to the universities is global; no budget is earmarked specifically for research. To estimate the universities' R&D expenditure, CBS estimates their current budgets for R&D and adds funding that is earmarked for R&D.[16] This estimate appears in a separate column in the table, which includes government R&D funding forwarded via PGC. Furthermore, according to recommendations in the Frascati Manual, tuition fees paid to a university and donations not earmarked for specific research activities are considered part of the university's own funding and appear in the "Higher Education" column of the table.

Table 2.7: Higher Education R&D by funding sector, NIS Millions, Current Prices, 1995–2007

	Total		Business		Government		Thereof: through general univ. funds		Higher education		Private non-profit		Abroad	
	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%	mNIS	%
1995	1,900	100%	43	2.3%	899	47.3%	747	39.3%	565	29.7%	111	5.9%	282	14.8%
1996	2,223	100%	91	4.1%	1,218	54.8%	1026	46.2%	422	19.0%	104	4.7%	389	17.5%
1997	2,539	100%	110	4.3%	1,358	53.5%	1187	46.7%	537	21.1%	114	4.5%	420	16.5%
1998	2,772	100%	100	3.6%	1,568	56.6%	1325	47.8%	687	24.8%	73	2.6%	344	12.4%
1999	3,209	100%	132	4.1%	2,166	67.5%	1437	44.8%	391	12.2%	93	2.9%	427	13.3%
2000	3,302	100%	122	3.7%	2,235	67.7%	1558	47.2%	429	13.0%	93	2.8%	423	12.8%
2001	3,497	100%	170	4.9%	2,137	61.1%	1850	52.9%	541	15.5%	116	3.3%	533	15.2%
2002	3,820	100%	187	4.9%	2,330	61.0%	1924	50.4%	592	15.5%	126	3.3%	585	15.3%
2003	3,935	100%	298	7.6%	2,157	54.8%	1882	47.8%	666	16.9%	256	6.5%	558	14.2%
2004	3,718	100%	283	7.6%	2,072	55.7%	1794	48.3%	593	15.9%	242	6.5%	528	14.2%
2005	3,830	100%	279	7.3%	2,028	52.9%	1771	46.3%	670	17.5%	333	8.7%	521	13.6%
2006	3,852	100%	280	7.3%	1,998	51.9%	1728	44.9%	714	18.5%	335	8.7%	524	13.6%
2007	3,854	100%	281	7.3%	2,068	53.7%	1798	46.6%	646	16.8%	335	8.7%	524	13.6%

Source: CBS

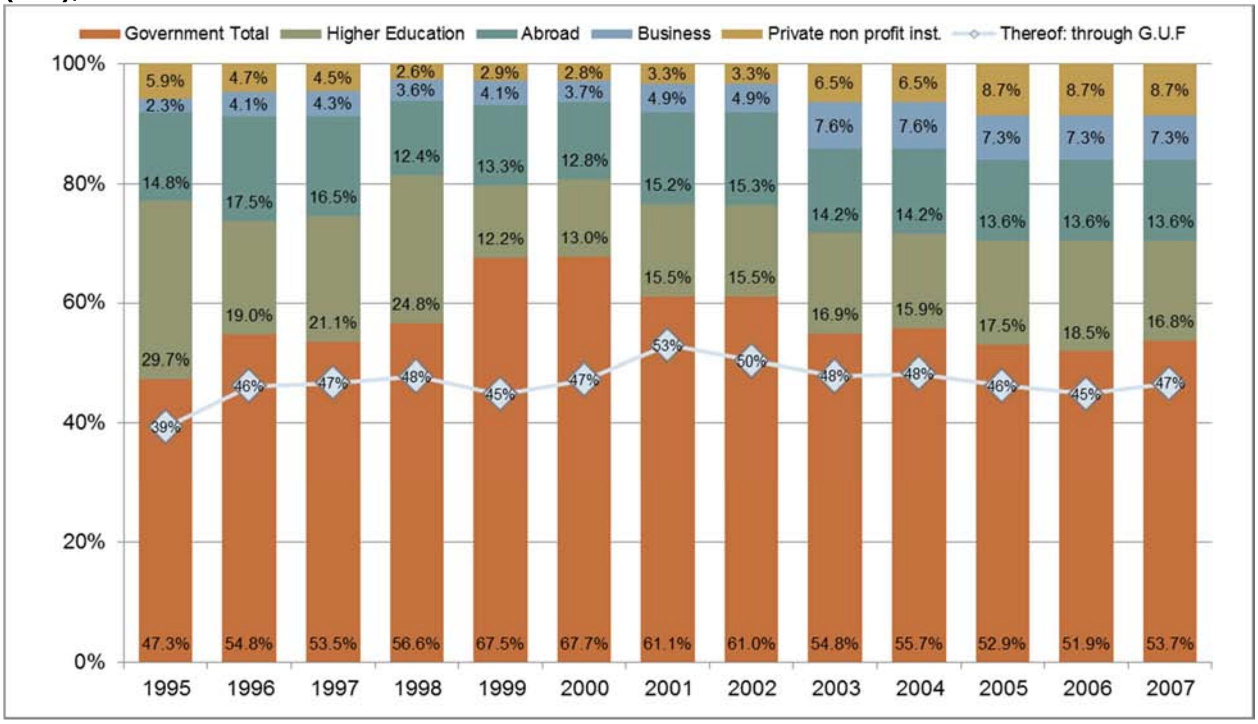
Figure 2.22 provides a graphic presentation of the trends in the table above. Until 2001, the share of funding originating with PGC increased considerably and reached 53 percent of total sources available to universities for R&D performance. This proportion remained stable in 2002–2007 at almost half of sources of funding for R&D in higher education. During this time, however, the percent of R&D funding from general university funds—mainly tuition fees and donations—declined conspicuously.

Between 1995 and 2007, the share of business-financed HERD increased from 2.3 percent to 7.3 percent. This shows that while most business R&D is still

[16] Central Bureau of Statistics, *National Civilian R&D Expenditure 1989–2010,* Jerusalem, 2010.

performed by firms themselves, business financing of HERD has been growing in recent years amid government encouragement and funding of cooperation between business and higher education.

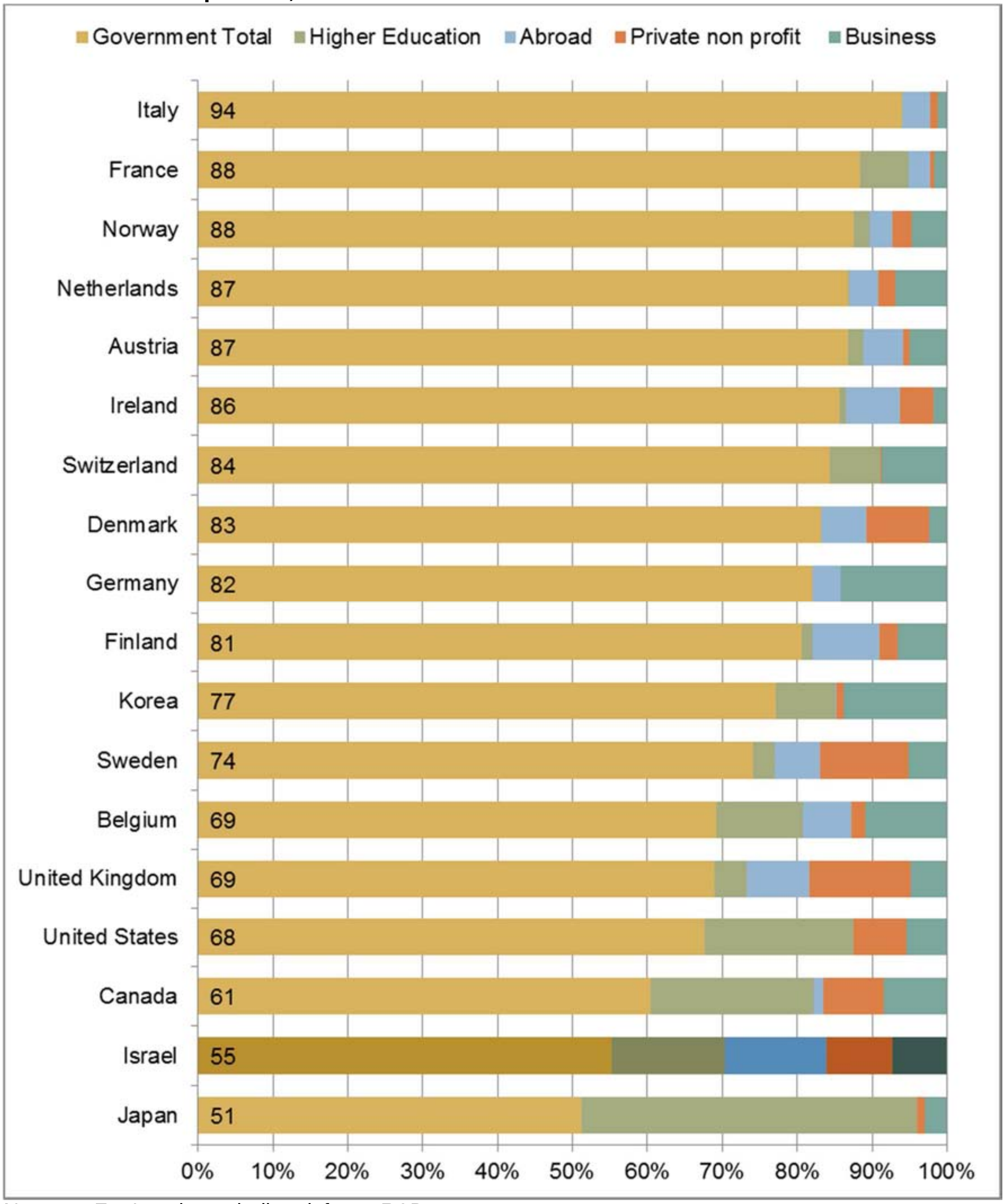
Figure 2.22: Distribution of Higher Education Expenditure on R&D by funding sector (Pct.), 1995–2007



Source: CBS

Figure 2.23 provides an international comparison of HERD by sources of funding in 2006. The segmentation by financing sector shows that governments in all countries fund HERD at a high level. In Israel, 55 percent of total HERD funding comes from government (PGC and direct), a small proportion by the other countries' standards. An in-depth analysis of the policies of South Korea, Belgium, and Germany, where cooperation between business and higher education is stronger, may be helpful in establishing an appropriate policy in Israel. Israel does have the highest share of HERD funding from abroad (14 percent) among the countries compared. This may be indicative of the high level of academic scientific research in Israel and growing trends abroad to outsource R&D internationally; it may also point to an aberrantly large component of financing of academic activity in Israel via donations from abroad. Absent detailed data about the commissioning of studies with Israeli universities by entities abroad, it is hard to tell these two components apart.

Figure 2.23: Higher Education Expenditures on R&D by Funding sector[a] (PCT.), International Comparison, 2006[b]



Notes: a. For Israel—excluding defense R&D.
b. The data relate to 2006 or the latest year for which data were received.
Source: CBS

3. Information and Communication Technologies (ICT)

- **Israel's ICT product (value added) was NIS 69.3 billion in 2009 (current prices), 16 percent of total business output.**
- **R&D expenditure in ICT industries was NIS 24 billion in 2007, accounting for most (88.6 percent) R&D expenditure in the entire business sector.**
- **The service industries included in ICT contributed 20 percent of the added value of all service industries countrywide in 2006—a higher proportion than in most developed countries.**
- **ICT exports accounted for 30 percent of Israel's total exports of goods and services in 2009 and were worth USD 18.5 billion (2005 prices.(**
- **Israel has one of the highest shares of ICT employment in business employment among OECD member states, at 8.3 percent on average in the past five years.**
- **68 percent of venture-capital investment is made in ICT industries, the highest rate among OECD member states.**

The Israeli economy is unique in that some 90 percent of its business R&D is concentrated in the ICT (Information and Communication Technologies) industries, foremost ICT services. In the past decade, these industries have undergone major development worldwide and specifically in Israel. As we saw in the previous chapter, much current innovation is taking place in the high-tech industries. In 2009, ICT product was 16 percent of total business output and ICT exports were about one-third of total exports of goods and services. In view of the material effect of the ICT industries on output and exports, we chose to devote a special chapter to these industries. Many studies have shown that these industries make an especially important contribution to labor productivity and total productivity and can serve as the basis of a process of long-term sustained growth.

In a departure from previous years, in which the growth of these industries typically outpaced that of business output, estimated ICT product has remained almost unchanged in the past two years while business output grew by 4 percent. Since ICT is responsible for a major share of total civilian R&D in Israel (see previous publications), the reasons for the slowdown in this sector must be examined.

The OECD defined the ICT industries in 1998 on the basis of the ISIC International Classification of All Economic Activities. The definition relates to activities that promote with electronic assistance the processing, preparation, transfer, broadcast, and presentation of information in manufacturing and service industries. The ICT classification does not include industries that produce information.

The industries included in this definition are sorted into two groups:

- **ICT manufacturing industries**—including industries that manufacture ICT equipment, such machines for office, accounting, and computers; electronic components; electronic communication equipment; and industrial equipment for control and supervision (excluding medical equipment).
- **ICT services industries**—including communication services, computer services, research and development services, and startups.

In accordance with the OECD definition, CBS divides its data on ICT industries into manufacturing and services. In addition to the OECD definition, however, the Israeli data add the R&D industry to the ICT services industries group. This is because the Israeli economy, unlike other economies, is typified by extensive startup activity in the ICT field; most of its startups are active in software and are classified as part of the R&D industry—a domain defined as belonging to the information-technology field. The data also include the activities of multinational corporations' development centers in Israel.

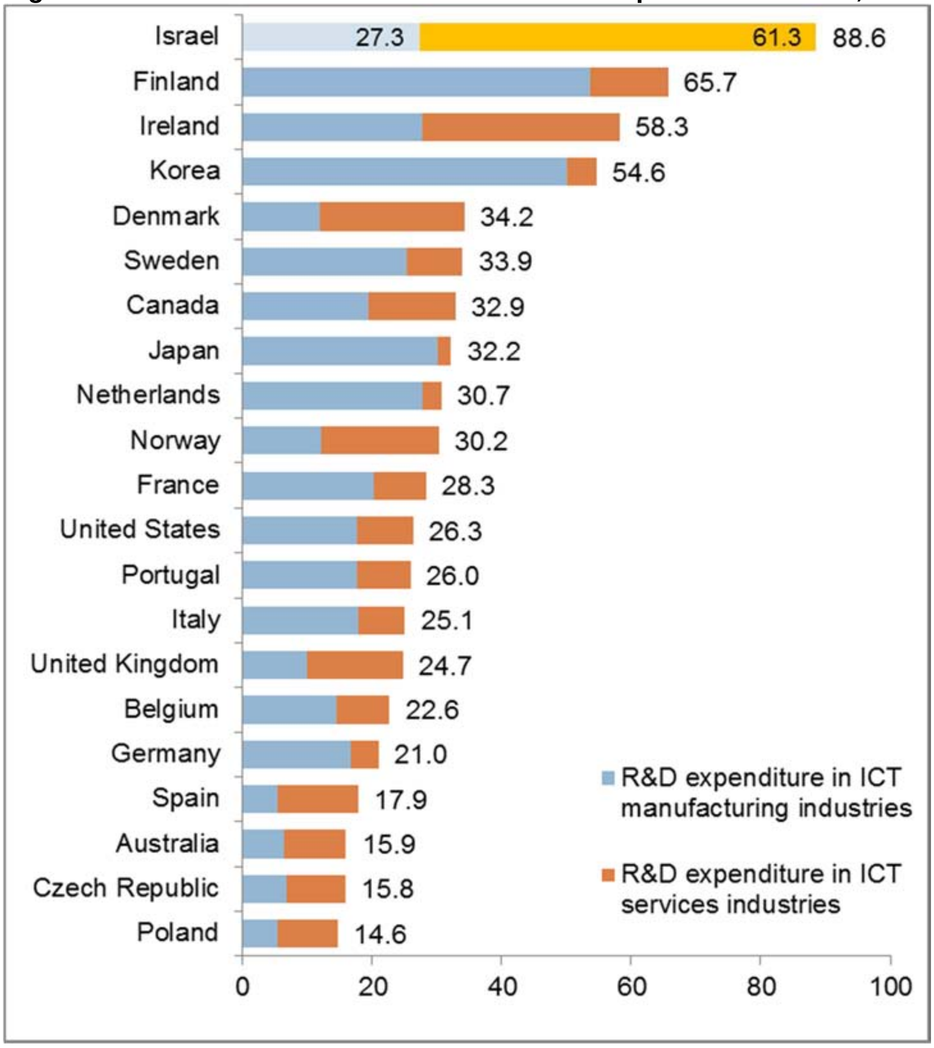
Notably, the CBS definition of ICT industries is different from that of "high-tech." CBS' definition of high-tech is based on two main criteria: a large share of expenditure on R&D in total business expenditure on R&D, and a large share of workers in academic occupations in total headcount.

3.1 R&D Expenditure in the ICT Sector

Most business expenditure on R&D takes place in ICT industries. In 2007, ICT spent NIS 24 billion on R&D—88.6 percent of business expenditure on R&D—broken down by 27.5 percent in ICT manufacturing industries and 61.3 percent in ICT services industries. The share of R&D expenditure in the ICT manufacturing industries in total business R&D expenditure has been trending down, from 31 percent in 2003 to 24.5 percent in 2007. The share of R&D expenditure in the ICT services industries in total business R&D expenditure, in contrast, rose from 57 percent in 2003 to 63 percent in 2007.

The graph below presents an international comparison of R&D expenditure in the ICT industries as a percent of business expenditure on R&D in 2005. Israel ranks first in this indicator (84 percent) and is an outlier in that its ICT services industries spend more on R&D than its ICT manufacturing industries do. The reason for this, evidently, is the large share of startups and multinational companies' development centers in Israel relative to other countries, and also the preponderance of Israeli firms that provide software and communication services.

Figure 3.1: Share of ICT Industries in Business Expenditure of R&D, 2005[a]



Note: a. The data pertain to 2005 or the most recent year for which data were received.
Source: Central Bureau of Statistics

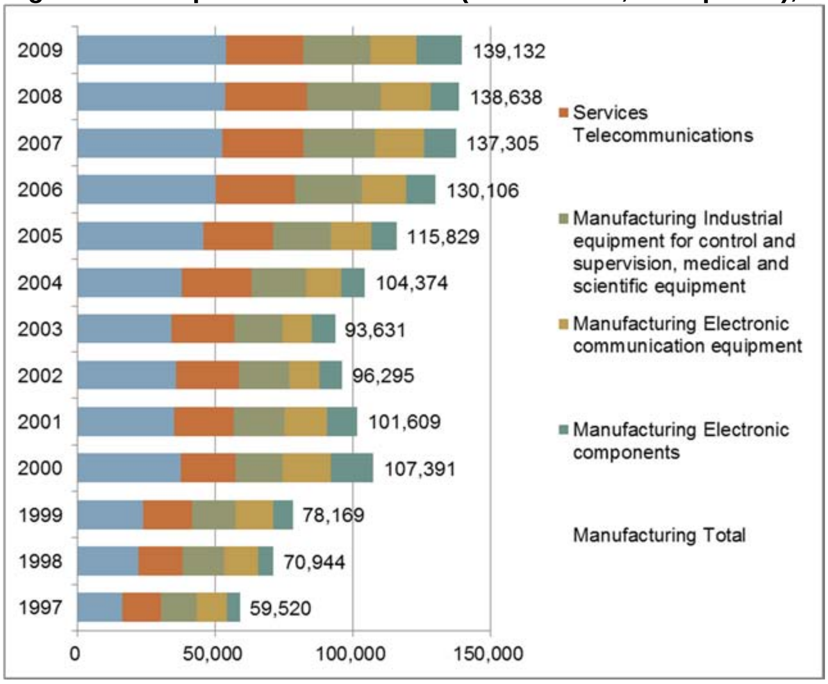
3.2 ICT Output

This section presents the output and product indicators of the ICT industries.17 The next graph shows the output of the ICT industries and the trends in its

[17] **Output:** the value of goods and services produced by an economic unit and that are available for use outside said unit, plus the value of goods and services produced for the unit's own final uses. Output in industries that manufacture goods is defined as the value of all goods produced for sale, including those not yet sold, plus the value of the change in inventory of goods. The output of services industries is defined as the total consideration received on account of services provided.

constituents. In 1997, output was equally divided between ICT manufacturing industries and ICT services industries. This has changed in the past decade: in 2009, the ICT services industries generated 60 percent of sector output. The share of the computer and related services and research and development branch in output grew in the past decade from 26 percent in 1997 to 38 percent in 2009, with the most significant change occurring between 1999 and 2000. The electronic components industry posted a 56 percent increase between 2008 and 2009, from NIS 10,437 million to NIS 16,345 million.

Figure 3.2: Output of ICT Industries (NIS millions, 2005 prices), 1997–2009

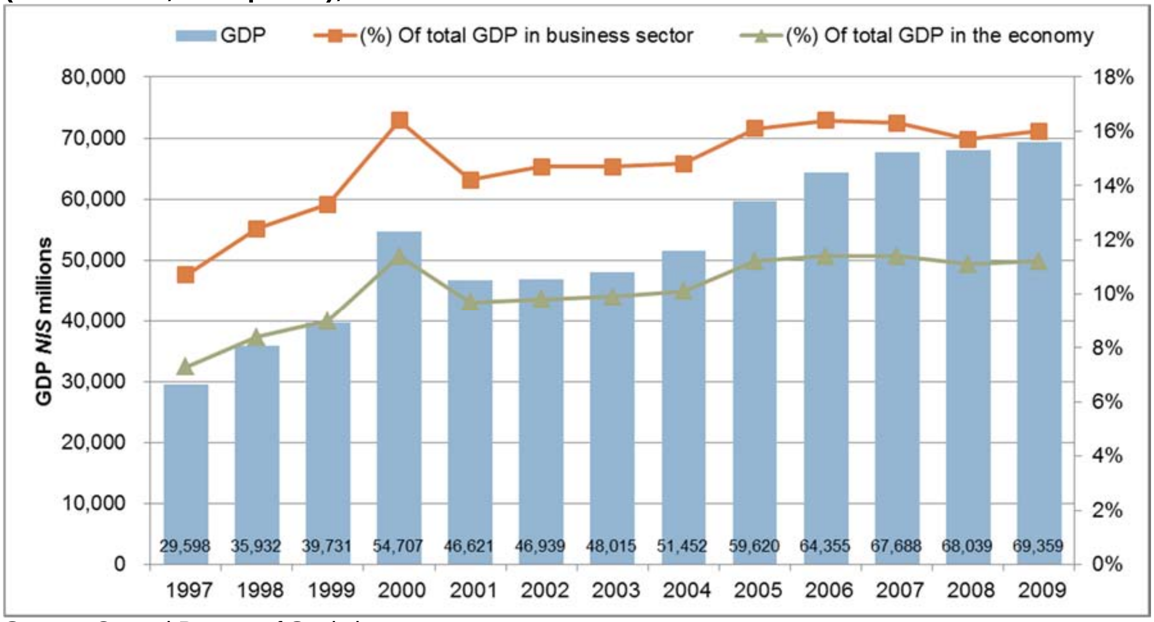


Note: 1. Including Subindustry 301—Manufacturing Machinery for Automated Data Processing, 312—Manufacturing Insulated Wires and Cables, and **not including** Subindustry 341—Manufacturing Medical and Surgical Instrumentation, and Subindustry 343—Manufacturing Optical Instruments and Photography Equipment.
2. Including startups other than those in biotechnology.
3. Based on classification of firms and not of goods.
Source: Central Bureau of Statistics

The next graph presents the gross output of Israel's ICT industries and its share in total GDP of the economy and in business output. In 2009, the ICT industries accounted for 16 percent of total business output, 50 percent more than the rate in 1997 but basically unchanged since 2005. A similar trend was typical of the share of ICT output in total GDP.

Gross Domestic Product: the total gross added value generated by all domestic manufacturers at prices to producer, plus net taxes on imports (taxes on imports less export subsidies) and non-refunded Value Added Tax or similar taxes applied to price to producer, e.g., purchase taxes.

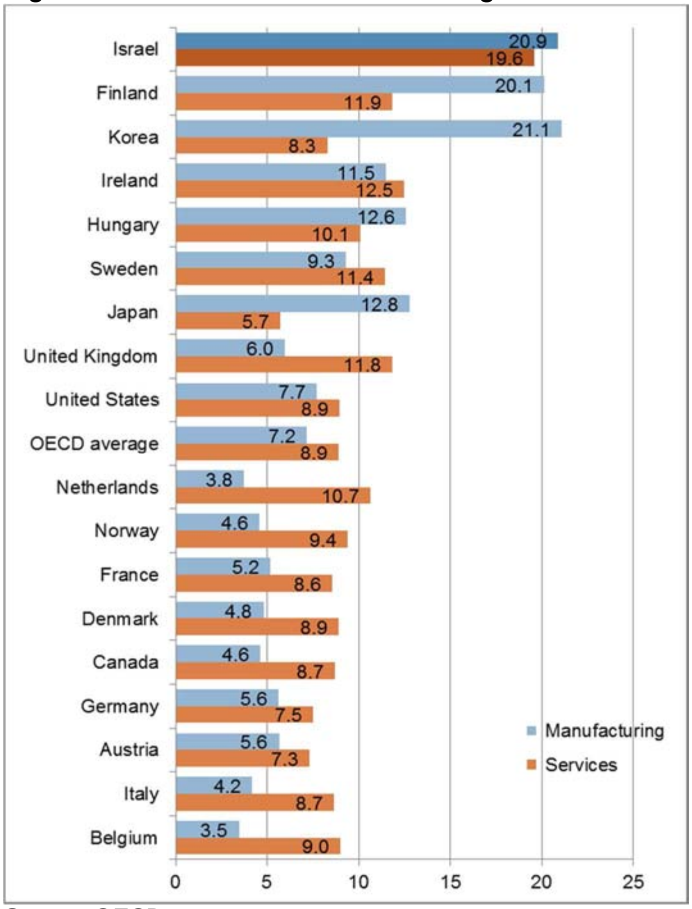
Figure 3.3: ICT Value Added and Share of ICT in GDP and Business Output, (NIS millions, 2005 prices), 1997–2009



Source: Central Bureau of Statistics

By international standards, too, Israel is a leader in the relative size of its ICT sector. The next graph shows the contribution of ICT (manufacturing and services) in GDP value added by international comparison.

Figure 3.4: Share of ICT Manufacturing and ICT Services Value Added (%), 2006

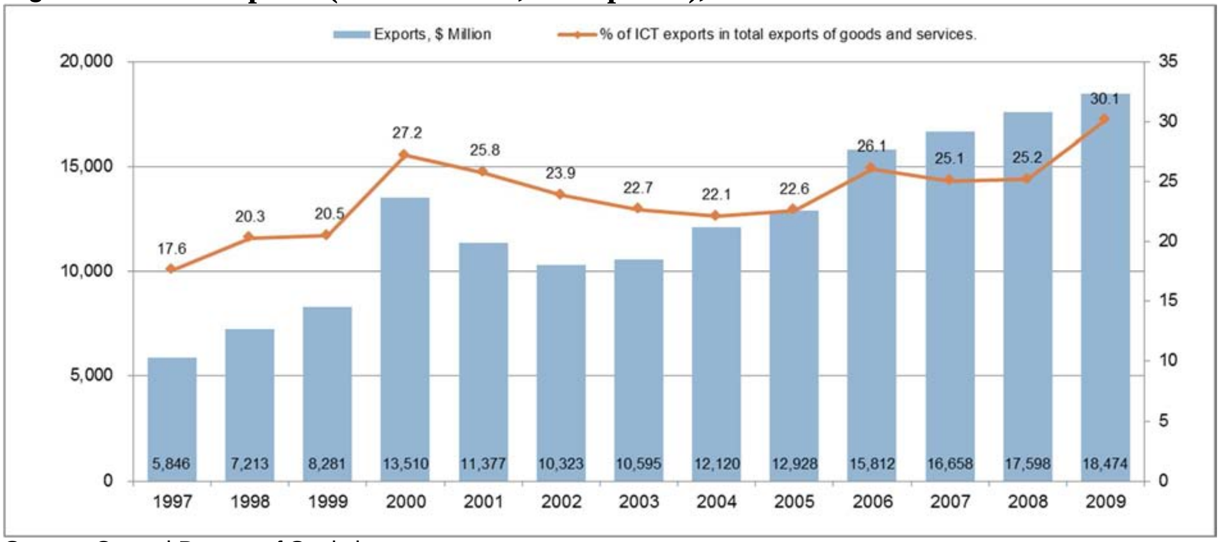


Source: OECD.

3.3 ICT Exports

Another indicator of the major contribution of ICT to the Israeli economy is exports. In 2009, ICT exports were worth USD 18,474 (2005 prices), roughly one-fourth of total exports and up 200 percent over the past decade (from USD 5,846 in 1997).

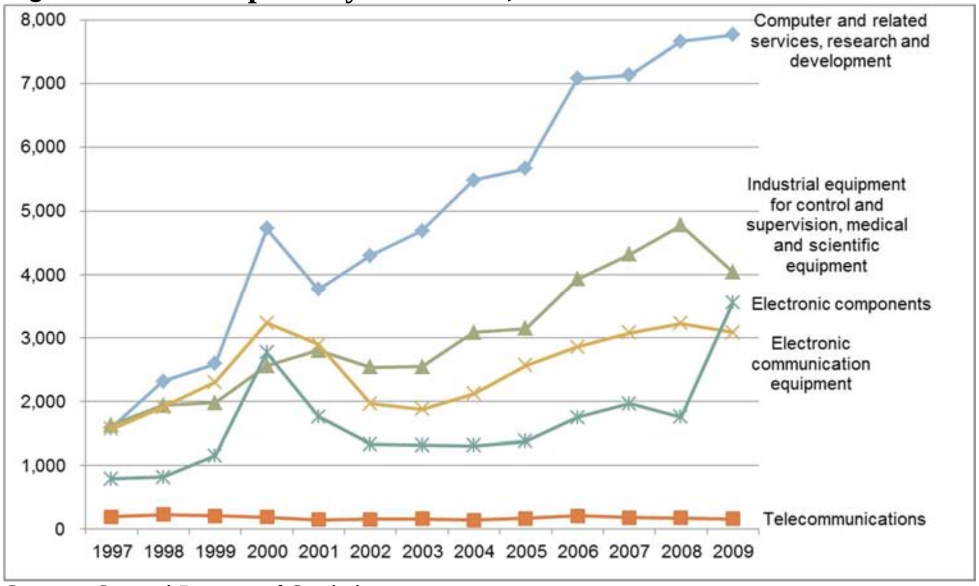
Figure 3.5: ICT Exports (USD millions, 2005 prices), 1997–2009



Source: Central Bureau of Statistics.

The next graph presents the distribution of exports by branch. The computer and related services and research and development branch made the greatest contribution to ICT exports, at 43 percent of total ICT exports. In the past decade, the exports of this branch have increased by 385 percent. Exports of the electronic communication equipment branch, in contrast, have hardly changed and even declined in 2008–2009, both in monetary terms and in share of total ICT exports. All branches show evidence of the crisis of the early 2000s. From 2002 onward, a perceptible recovery took place in computer, research, and development services; manufacturing industrial equipment for control and supervision, medical and scientific equipment; and electronic communications equipment. The electronic-components branch did not manage to recover by 2007 but posted a 100 percent increase in 2009.

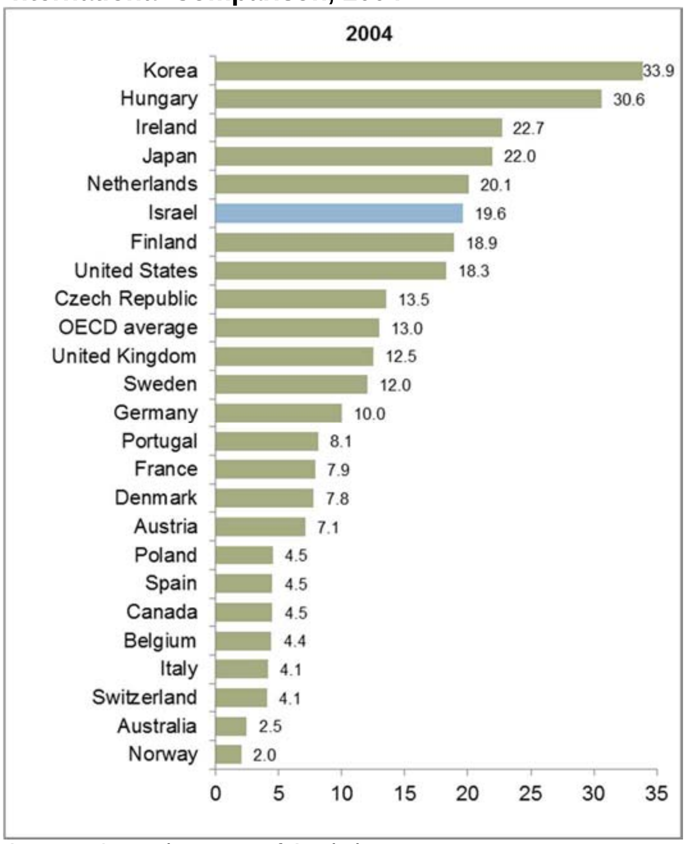
Figure 3.6: ICT Exports by Industries, 1997–2009



Source: Central Bureau of Statistics.

Figure 3.7 shows the share of exports of ICT goods (excluding services) in total exports of goods by international comparison. As may be seen, Israel ranks high in the table but trails countries such as Mexico and Hungary. The reason is that these countries sustain the manufacture and export of ICT goods due to their relatively cheap labor force.

Figure 3.7: Exports of ICT Goods as Share of Total Merchandise Exports, International Comparison, 2004

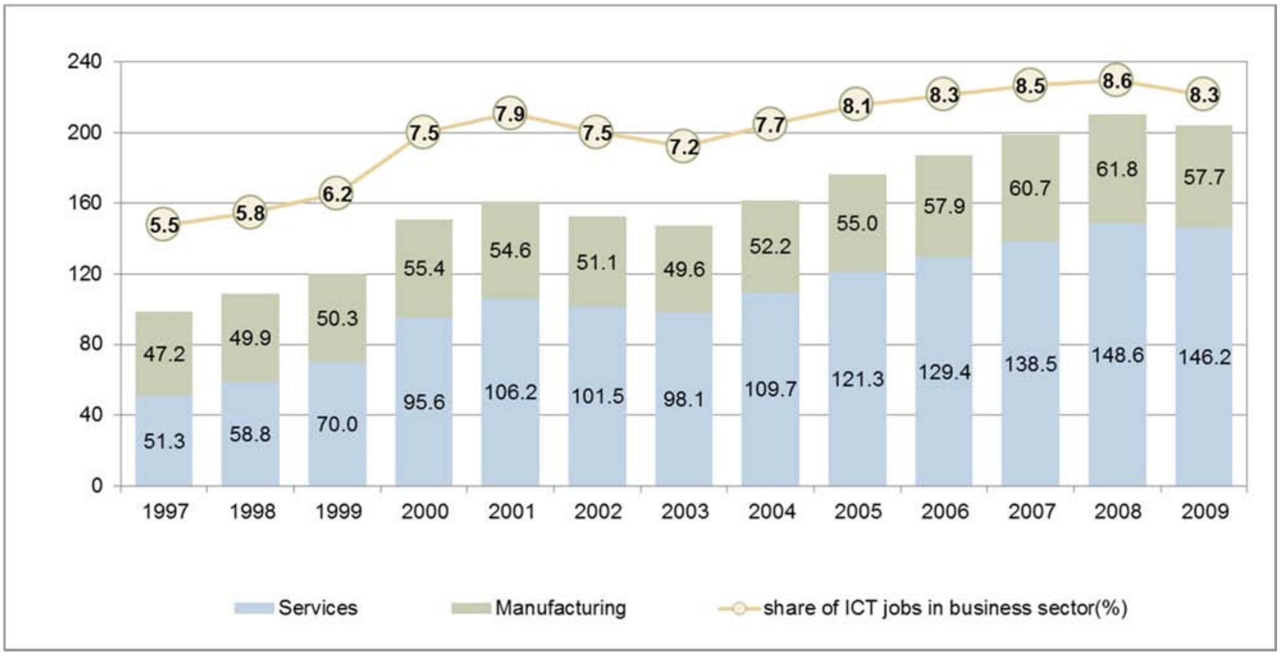


Source: Central Bureau of Statistics.

3.4 ICT Employment

ICT is an important source of employment growth. Figure 3.8 reports total jobs in ICT industries and their share in total business-sector jobs in 1997–2009. It may be seen that the number of jobs in ICT increased significantly during these years—from 99,000 to 204,000, up 107 percent. Most of the increase occurred in the ICT services industries, from 51,000 in 1997 to 146,000 in 2009. The services industries posted a 9.6 percent increase in annual average jobs during this time, as against 1.8 percent in the ICT manufacturing industries. Overall, ICT accounted for 8 percent of total business-sector jobs in 2009 as against 5.5 percent in 1997.

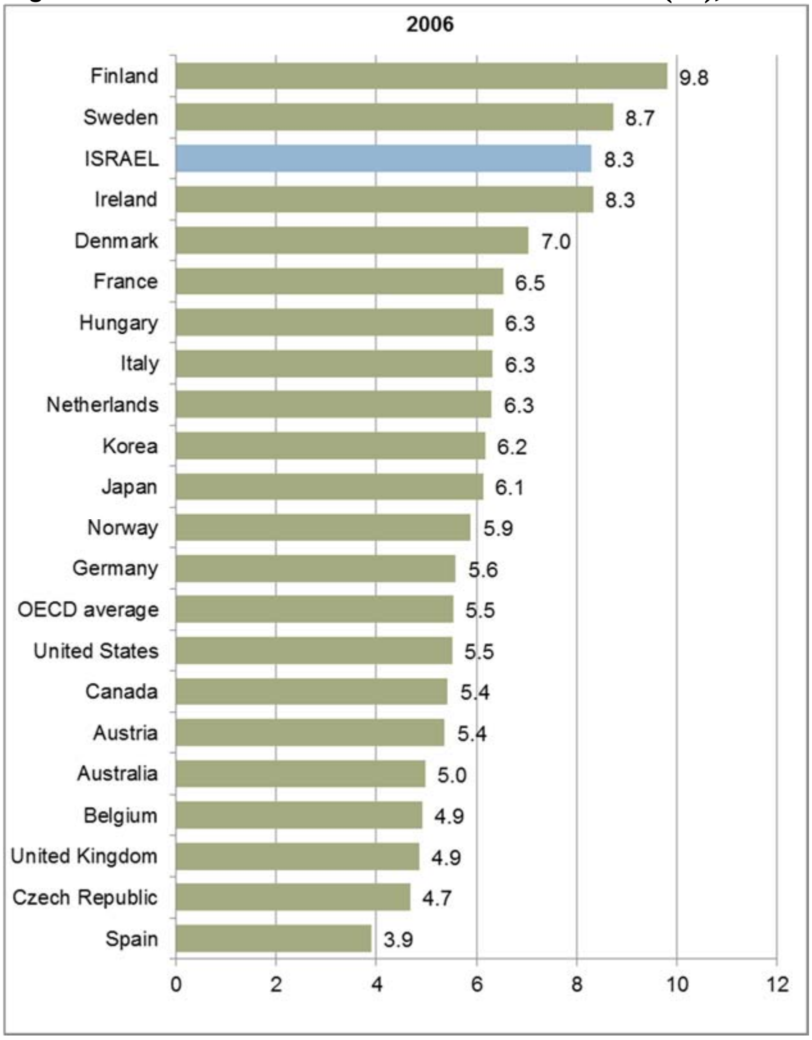
Figure 3.8: ICT Jobs (000's) and Share of ICT in Total Business-Sector Jobs (%), 1997–2009



Source: Central Bureau of Statistics.

Figure 3.9, presenting an international comparison on the basis of 2006 data, shows that Israel's ICT sector stands out in terms of employment by international comparison as well. The countries that had the largest number of ICT jobs (U.S., Japan, UK, and Germany) were not the leaders in ICT jobs relative to total business-sector jobs. The proportion of ICT jobs in business-sector jobs was highest in Finland (9.8 percent), Sweden (8.7 percent), Ireland (8.3 percent), and Israel (8.3 percent).

Figure 3.9: Share of ICT in Business-Sector Jobs (%), 2006



Sources: Central Bureau of Statistics, OECD.

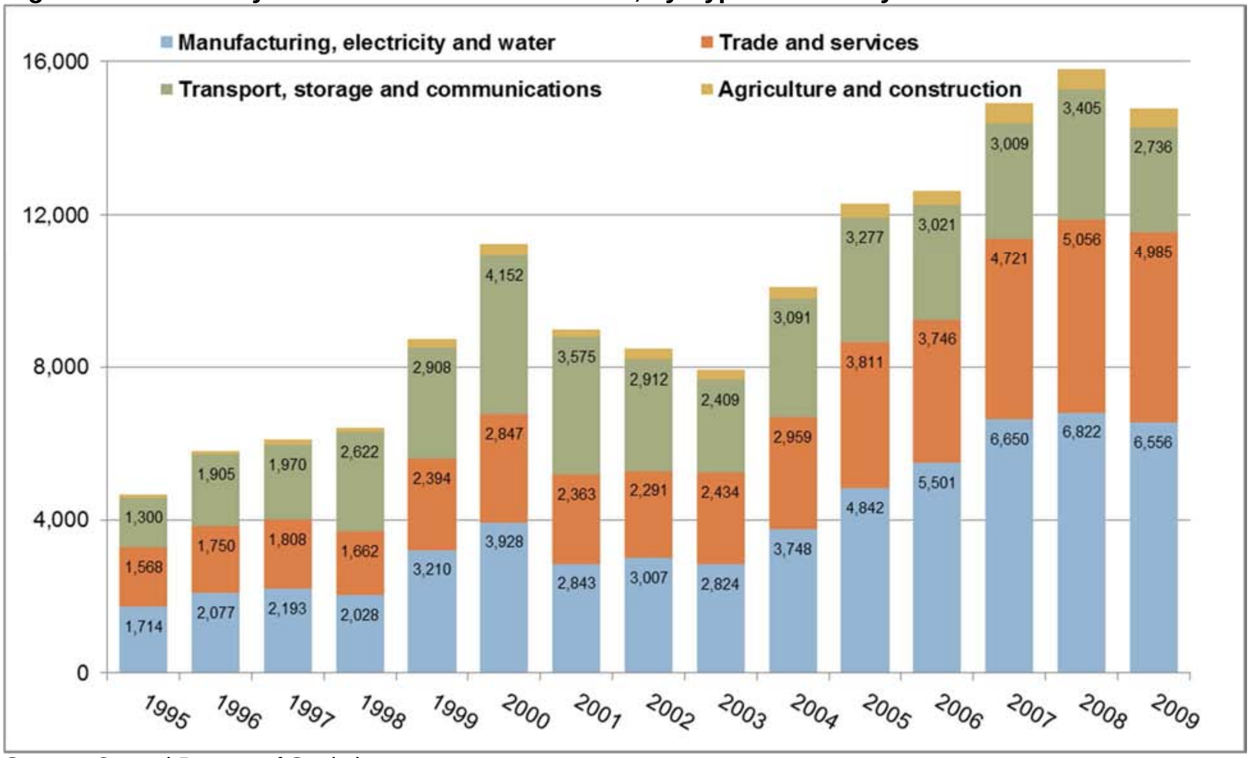
For additional indicators of wage and employment, see Chapter 6, "Economic Indicators of Science and Technology Activities," Subchapter 6.3, "Employment and Wages in High-Tech industries."

3.5 Investments in ICT Products, by Types of Industry

Another important aspect of ICT is other industries' investments in ICT products that constitute fixed assets for these industries. Investments in ICT products—information-technology equipment, communication equipment, and software—are crucial for the enhancement of productivity. According to the OECD, ICT investments are underestimated because they are included only if they can be physically isolated, a condition that makes it hard to measure software investments above all but also investments in the upgrading of existing equipment. Equipment and software investment is immensely important for the economy's growth; it boosts and renews capital and allows new technologies to be integrated into production processes.

Figure 3.10 presents various industries' investments in ICT products in 1995–2009. In the latter year, total investments in ICT products were NIS 14,775 million (in 2005 prices), up 200 percent from 1995. In 1995, the manufacturing, electricity, and water industry accounted for 36 percent of this investment; its share increased to 44 percent in 2009. The share of investment by the transport, storage, and communications industry, in contrast, rose from 28 percent in 1995 to 40 percent in 2001 and fell back to 18 percent in 2009. The average share of trade and services was unchanged at 30 percent and that of agriculture and construction accounted for less than 3 percent over the years.

Figure 3.10: Industry Investments in ICT Products, by Type of Industry



Source: Central Bureau of Statistics.

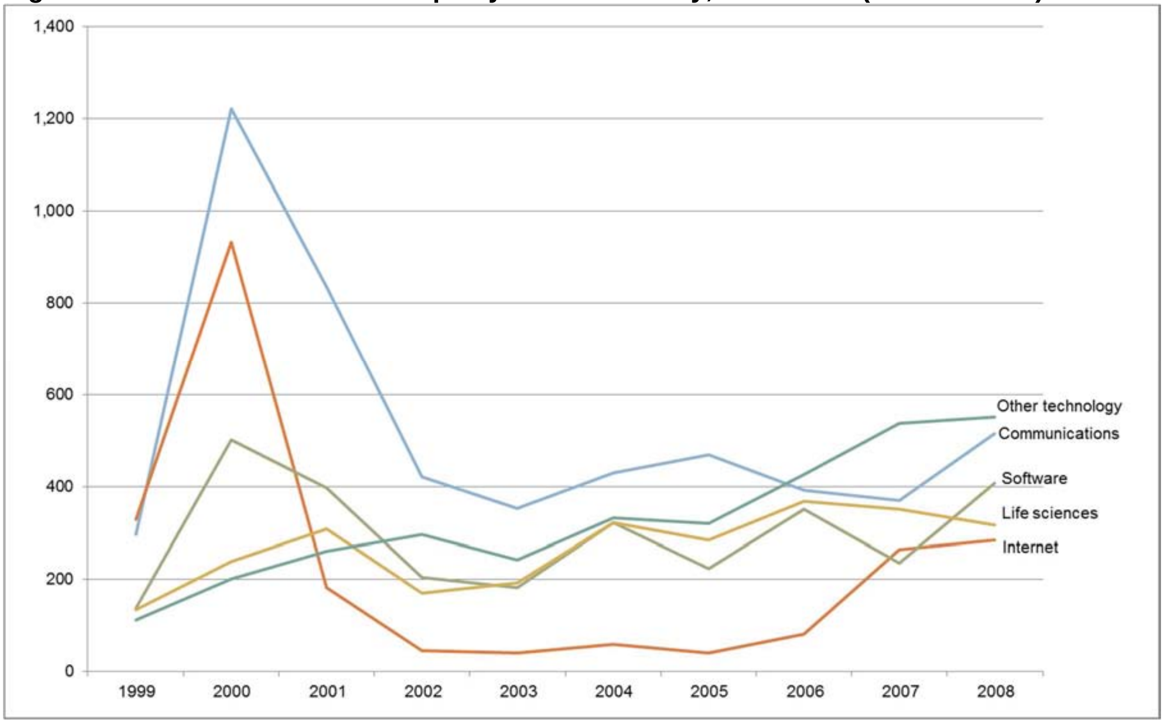
For additional indicators of ICT capital, see Chapter 4, "Capital Inputs in and Government Assistance for Scientific and Technological R&D," Subchapter 4.1.1, "ICT Capital."

3.6 Venture Capital Investments in ICT

The next graph shows total investment of venture capital in Israeli startups. Investment in startups crested in 2000 and 85 percent of it was made in areas related to ICT: software, communications, and Internet. The data clearly reflect the bursting of the "high-tech bubble" by 2003 and the recovery that began in 2004.

From 2002 onward, VC investments in ICT fell from 85 percent of the total in 2000 to 58 percent in 2008; most of the change took place in the Internet field. Concurrently, VC investments in life sciences and other technologies increased.

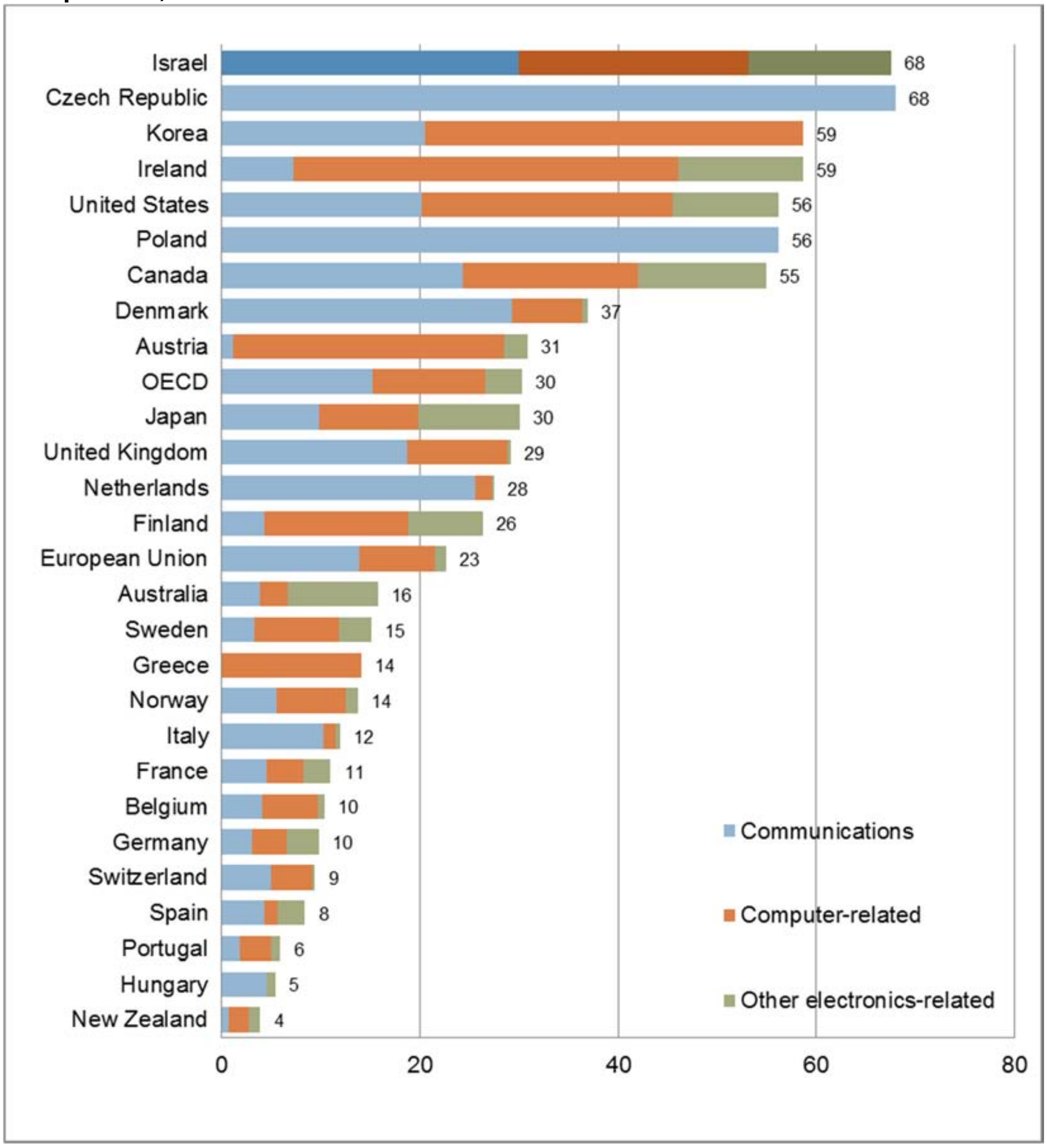
Figure 3.11: Investments in Startups by Area of Activity, 1999–2008 (USD millions)



Source: Central Bureau of Statistics.

It is crucial to measure VC investments in ICT industries in order to estimate the performance and contribution of ICT to economic growth. VC investments in ICT are parsed into three fields: communications, computer-related, and other electronics-related. In the past few years, ICT industries have been the recipients of a large fraction of total VC investment. Figure 3.12 shows this proportion by international comparison in 2006. In Israel and the Czech Republic, 68 percent of total VC investment went to ICT. In South Korea, Ireland, the U.S., Canada, and Poland, the share exceeded 50 percent. In Poland, notably, VC investments in ICT are made in communications only.

Figure 3.12: Venture Capital ICT Investment in Total VC Investment: International Comparison, 2006



Source: OECD Venture Capital Database, 2008.

For additional indicators of VC investment, see Chapter 8, "Globalization," Subchapter 8.4.2, "Startups."

4. Capital Inputs in and Government Assistance for Scientific and Technological R&D

- **Israel's technological capital stock (a.k.a. ICT capital) has grown twice as rapidly as total capital stock in the past decade but still represents only 8.5 percent of total capital stock, low by the standards of leading OECD countries (2008).**
- **The software constituent of ICT capital stock accounted for 43.3 percent of the total (2008).**
- **Venture-capital funds raised USD 1,122 million in 2009, the smallest amount since 2003 and 46 percent less than in 2008.**
- **The OCS-MOITAL budget was NIS 1,286 million in 2010, down 25 percent from 2009 (NIS 1,690 million).**
- **Sixty percent of total resource allocations from OCS-MOITAL in 2009 accrued to R&D projects in the ICT field (including software) as against 74 percent in 2001.**

4.1 Technological Capital

It is conventional to divide aggregate production factors into capital, labor, and materials. Capital includes all fixed assets, including machinery and equipment, that are used for the production of goods and services. The immense technological developments that have taken place in the fields of automation, communication, and information have created a new subcategory: capital equipment into which advanced technology has been assimilated. Indeed, many of the technological improvements that are leverage a major increases in labor productivity are available to producers of various goods and services in the form of sophisticated machinery and equipment such as CAD/CAM; control, supervision, and communication systems; automated systems for management of trade, inventory, and customer relations; and so on. Because technological capital plays such an important role in total productivity and economic growth, the National Accounts data systems have been treating the measurement of general capital inputs and technological capital inputs separately in recent years, in order to better understand the factors that affect economic growth.

4.1.1 ICT Capital

Capital stock is defined as total fixed assets that have not yet used up their economic life. In recent years, it has been conventional to divide this aggregate into ICT capital stock and other capital stock. ICT capital stock comprises the following:

- stock of instruments used for electronic communications and information processing.
- stock of electronic instruments that are used for the detection, measurement, recording, and/or control of miscellaneous processes;
- software.

The indicator of ICT capital stock as a share of total capital stock mirrors the extent of the economy's use of advanced technologies. Studies show that investment in ICT capital is one of the most important factors in the support of growth.

Israel's ICT capital stock has been increasing more rapidly than its total capital stock. Thus, total capital stock increased by 33.2 percent between 2000 and 2008 (from NIS 856 billion to NIS 1,140 billion) whereas ICT capital stock grew twice as fast, by 65.4 percent (from NIS 65.5 billion to NIS 108.5 billion).

Noteworthy changes have occurred in software stock. This constituent of ICT capital has been growing more rapidly than all other constituents of ICT stock: by 86.5 percent (from NIS 25 billion to NIS 47 billion) between 2000 and 2008. As Table 4.1 shows, the share of software in ICT capital stock has been rising steadily since 2001 (after a dip in 2000) except for some leveling-off in 2007–2008.

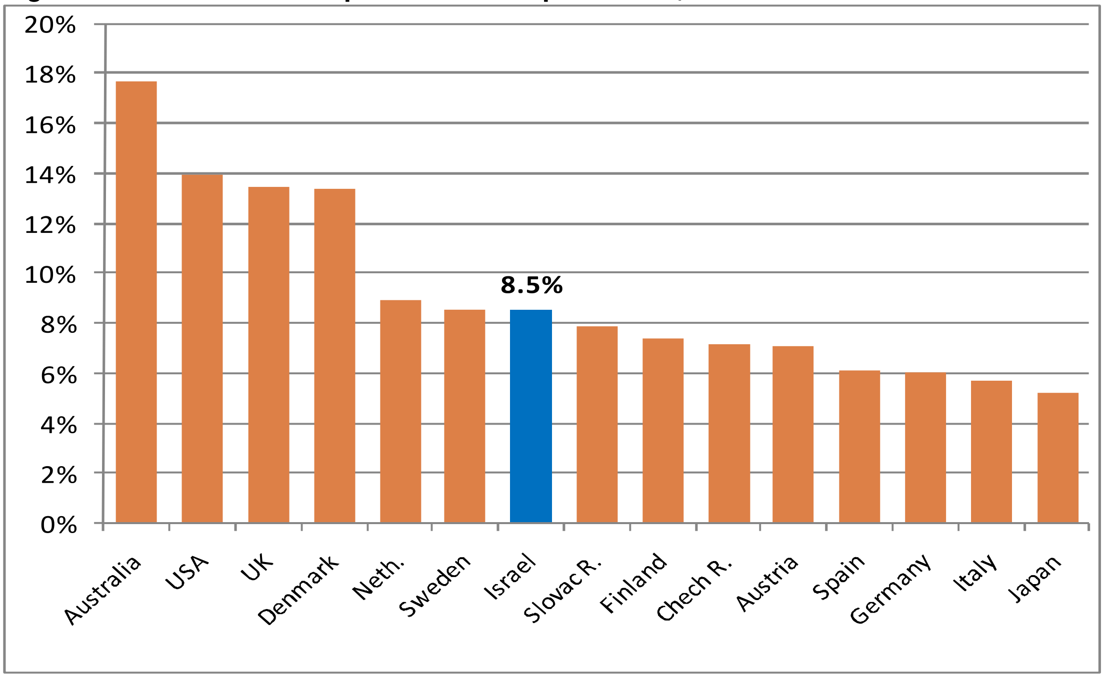
Table 4.1: Total ICT Capital Stock Value and Software Stock Value, 2000–2008 (NIS millions, 2005 prices)

Year	Total ICT capital stock	Software stock	Share of software in total ICT capital stock
2000	65,614	25,173	38.4%
2001	72,204	26,780	37.1%
2002	76,008	28,365	37.3%
2003	78,069	29,774	38.1%
2004	78,386	30,904	39.4%
2005	80,452	32,758	40.7%
2006	85,578	35,915	42.0%
2007	92,967	40,576	43.6%
2008	108,543	46,956	43.3%

Source: Central Bureau of Statistics

Despite the rapid rate of increase, the share of ICT capital in Israel's total capital stock remains relatively small: 8.5 percent in 2007, as against almost twice the proportion in Australia (17.6 percent) (Figure 4.1). Since Israel is considered a country that specializes in ICT, this apparently indicates that ICT capital is poorly assimilated in many domestic industries.

Figure 4.1: Share of ICT Capital in Total Capital Stock, 2007



Note: the data for Japan and the Slovak Republic pertain to 2006.
Sources: Central Bureau of Statistics, EU Klems.

Indeed, Figure 4.2 shows major disparities among domestic industries in their share of ICT capital in total capital stock. By using an international comparison, we may identify the fields in which Israel lags behind the rest of the world in the use of advanced technologies.

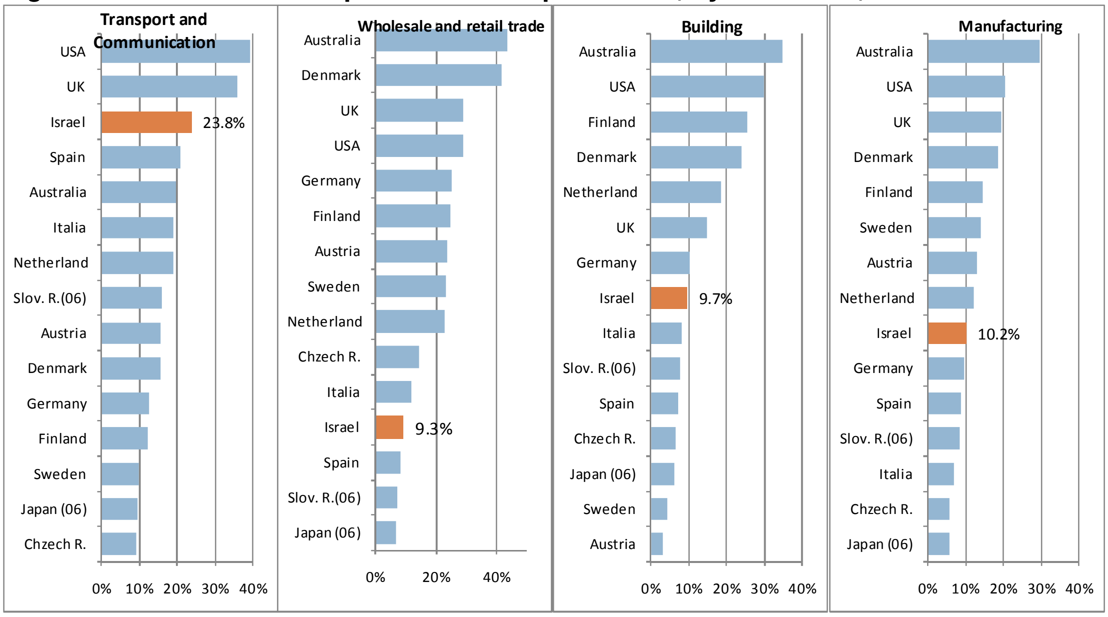
As the graph indicates, Israel ranks in a "bad place in the middle" in utilization of ICT capital by its manufacturing and building industries. In countries such as Australia, the U.S., the UK, and Denmark, ICT capital accounts for 20–30 percent of gross capital stock in manufacturing and building, as against around 10 percent in Israel.

In the service industries, Israel is one of the least advanced countries. Only 9.3 percent of services capital stock is ITC capital, as against 43.5 percent in Australia, 41 percent in Denmark, and 29 percent in the UK and the U.S.

In its transport and communication industries, however, Israel is among the leaders in its proportion of ICT capital. This class includes manufacturers of ICT equipment, reinforcing the proposition that Israel's use of advanced technologies is typified by severe polarity and wider disparities among industries than the OECD average.

Just the same, it should be noted that the differences among industries in the assimilation of ICT capital have been narrowing over time.

Figure 4.2: Share of ICT Capital in Total Capital Stock, by Industries, 2007

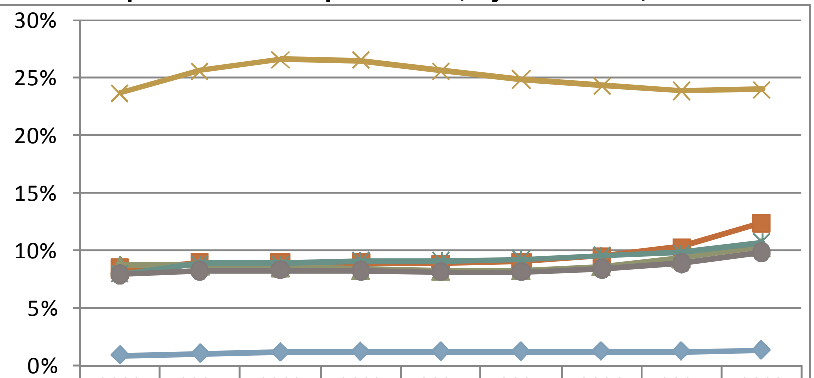


Notes: 1. The data for Israel are based on CBS estimators
2. The data for Japan and Slovenia pertain to 2006.
Sources: Central Bureau of Statistics, EU Klems

As Figure 4.3 shows, the gaps have been narrowing since 2002 for two reasons: a steady increase in the share of ICT capital in most industries and also, and mainly, a decline in this index in transport and communication.

Additional data (e.g., Section 3.5 in the ICT chapter) show that most industries have been increasing their purchases of ICT products (including capital goods). Below in this chapter, further evidence of the decrease in ICT activity the narrowing of disparities among industries in the utilization of ICT in Israel is provided.

Figure 4.3: Share of ICT Capital in Total Capital Stock, by Industries, 2000–2008



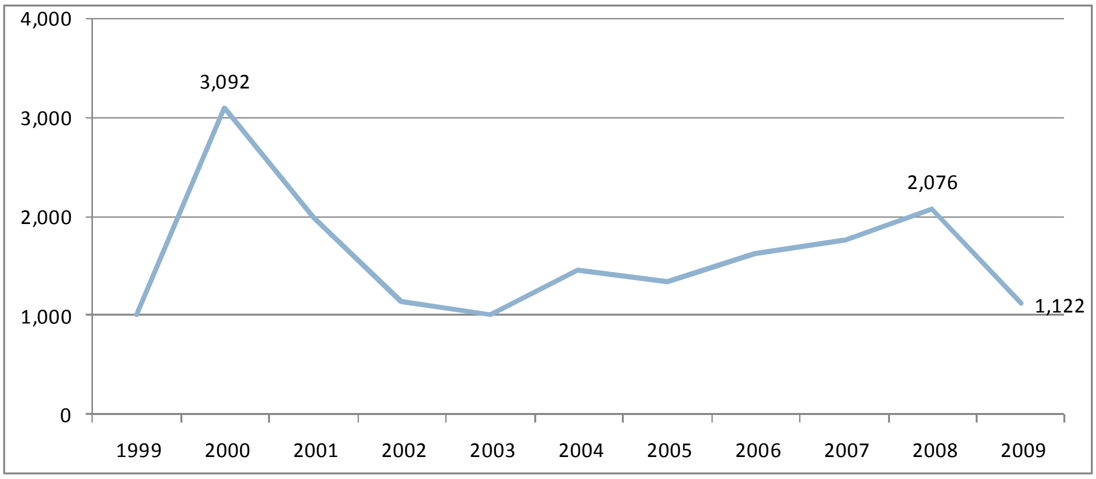
	2000	2001	2002	2003	2004	2005	2006	2007	2008
AGRICULTURE	0.8%	1.0%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%
MANUFACTURING	8.3%	8.8%	8.9%	8.9%	8.8%	8.9%	9.4%	10.2%	12.3%
SERVICES	8.7%	8.7%	8.5%	8.3%	8.2%	8.2%	8.6%	9.3%	10.3%
TRANSPORT & COMM.	23.6%	25.5%	26.5%	26.5%	25.6%	24.8%	24.3%	23.8%	23.9%
BUILDING	7.9%	8.8%	8.8%	9.0%	9.0%	9.1%	9.4%	9.7%	10.7%
TOTAL	7.8%	8.2%	8.2%	8.2%	8.1%	8.1%	8.3%	8.8%	9.8%

Notes: 1. The data for Israel are based on CBS estimators
Source: Central Bureau of Statistics

4.2 Venture Capital

The venture-capital market was badly hit by the dotcom crisis. Within three years, the amount of capital raised by Israeli firms fell from a record USD 3,096 million in 2000 to USD 1,011 million in 2003. The market rebounded from then until 2009 but remained far from its pre-crisis attainments. The new crisis in 2009 caused the VC market to slump again (Figure 4.4).

Figure 4.4: Venture Capital Raised by Israeli High-Tech Companies (USD millions), 1999–2009



Source: IVC Research Center.

The crisis also affected the distribution of VC investments by industries (Table 4.2). Investment in Internet companies plunged from 30 percent of total investment in 2000 to 9 percent in 2001 and 4 percent in 2002. Even after the market recovered, VC investment in this class of industries rebounded to only 14 percent of total VC investment in 2008.

Another important phenomenon in recent years is the relative decrease in VC investment in communication firms—from a peak of 42 percent in 2001 to 25 percent in 2008. Overall, the share of VC investments in ICT industries (Communication + Internet) decreased from 69 percent in 2000 to 39 percent in 2008. For further details, see Chapter 3, "Information and Communication Technologies (ICT)."

Table 4.2: Israel Venture Capital Fund Investments in Israeli Companies, by Industry (%), 1999–2008

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Communication	29%	39%	42%	37%	35%	29%	35%	24%	21%	25%
Internet	33%	30%	9%	4%	4%	4%	3%	5%	15%	14%
Software	14%	16%	20%	18%	18%	22%	17%	22%	13%	20%
Life sciences	13%	8%	16%	15%	19%	22%	21%	23%	20%	15%
Others	11%	6%	13%	26%	24%	23%	24%	26%	31%	27%

Sources: Central Bureau of Statistics, IVC Research Center.

Table 4.3 reveals another important change since the 2000 crisis: a shift in the composition of firms that receive VC investment capital in terms of their stages of development. In 2000, 56 percent of total VC investment was made in firms in their early stages of product development, if not in the seed stage. By 2004, the share of firms in these stages fell to 32 percent. Their fraction of VC investment began to rebound in 2005 and came to 41 percent in 2008.

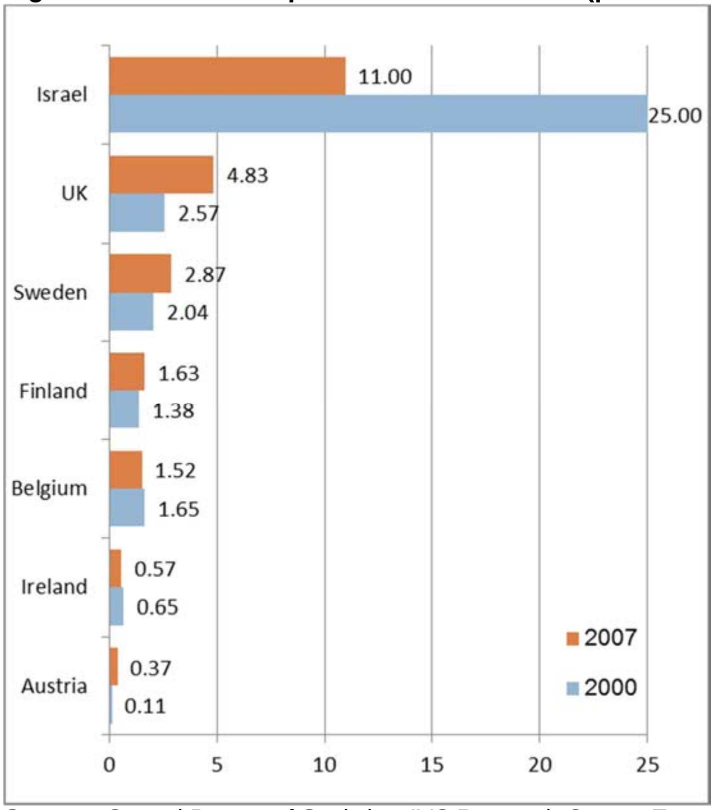
Table 4.3: Israel Venture Capital Fund Investments in Israeli Companies, by Stage (pct.), 1999–2008

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Seed	9%	17%	7%	4%	9%	7%	8%	9%	9%	5%
Early	39%	39%	44%	42%	39%	25%	28%	31%	32%	36%
Mid	30%	29%	31%	46%	46%	56%	53%	42%	38%	38%
Late	22%	15%	18%	8%	6%	12%	11%	19%	22%	21%

Sources: Central Bureau of Statistics, IVC Research Center

Israel's VC market was more severely affected by the dotcom crisis than corresponding markets in other countries (Figure 4.5). Investments by Israeli VC funds fell from 2.5 percent of GDP in 2000 to only 1.1 percent in 2007 (down 56 percent). Most corresponding markets in other countries gathered strength since the crisis; in 2007, investment in them (in percent of GDP) exceeded the 2000 level. Nevertheless, the Israeli VC market remains much larger than its counterparts elsewhere.

Figure 4.5: Venture Capital Fund Investments (pro mille of GDP), 2000, 2007



Sources: Central Bureau of Statistics; IVC Research Center; European Innovation Scoreboards 2001/8

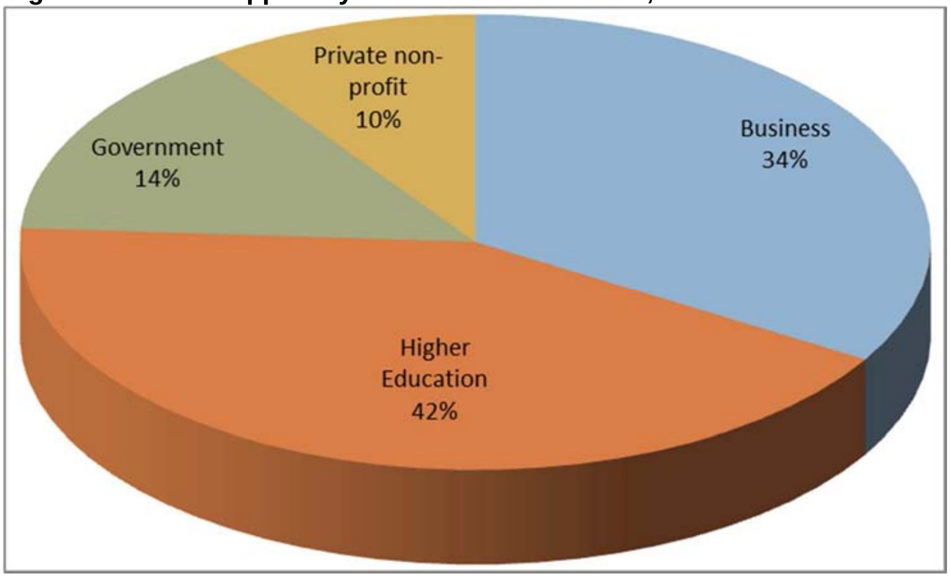
4.3 Government Support

Government policy has an important if not decisive effect on the growth of the economy and/or of selected industries. In Israel, government supports and encourages R&D in several ways: direct support of R&D projects from the Office of the Chief Scientist of the Ministry of Industry[18], Trade, and Labor (OCS-MOITAL), tax benefits for recognized R&D expenditures per approval of OCS-MOITAL, and funding of R&D for government purposes at academic and civilian research institutes. The Encouragement of Industrial Research and Development Law recognizes R&D investments in specified industries for tax purposes. Also, domestic high-tech companies, like those in other industries, enjoy tax benefits under export and capital-investment encouragement policies and in additional ways.

Due to the lack of data on the extent of the indirect benefits, especially those relating to tax relief, the discussion in this chapter focuses on budgeted grant and subvention programs.

Figure 4.6 presents the apportionment of budget support by performing sector. One may see that higher education receives 42 percent of the total subvention and the business sector receives 34 percent. Private nonprofits also obtain an appreciable share of the budget support (10 percent). Importantly, only some of the R&D budgets are revealed in the state budget[19]; the actual subvention is larger and may be apportioned differently than the budget support.

Figure 4.6: R&D Support by Sector of Performance, 2008



Source: Central Bureau of Statistics

[18] Other government ministries also operate Chief Scientists, but their activity relatively small to the activities of the Chief Scientist Ministry of Industry (see Section 4.3.1)

[19] This topic is discussed in detail on pp. 34–38 of the Israel National Council for Research and Development report for 2008 and 2009.

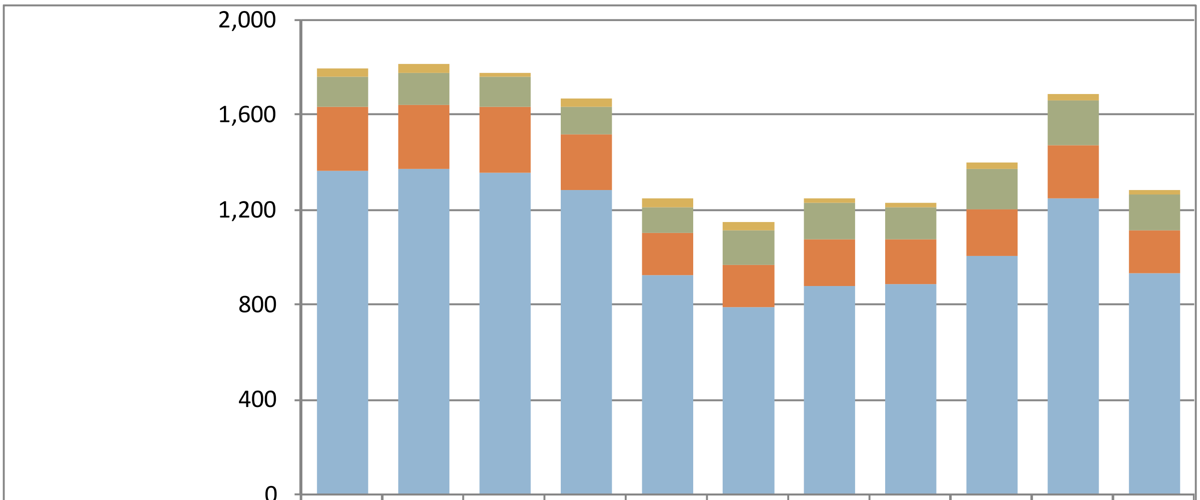
4.3.1 Encouragement of Industrial R&D via OCS-MOITAL

The main vehicle of government support for R&D in Israel is subventioning via OCS-MOITAL. OCS-MOITAL activity is regulated under the Encouragement of Industrial Research and Development Law, passed in 1984 (and amended in many ways since then) for the following purposes:

- creating jobs in manufacturing and assuring the intake of scientific and technological personnel;
- creating excess return;
- expanding the country's technological and scientific infrastructure and human resources;
- improving the national balance of payments by manufacturing and exporting domestically developed science-intensive products.

The Law sets conditions for the awarding of grants, loans, and tax exemptions, reductions, and relief, on the basis of approved programs that serve the purpose listed above.[20] OCS gets its budget from two main sources: government transfers and royalties paid by previous OCS grantees.

Figure 4.7: Total Budget of OCS-MOITAL for All Support Programs, NIS millions, 2000–2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Others	33	33	15	40	36	31	19	17	26	31	20
Technological Incubators	127	135	129	118	113	141	147	135	175	186	150
MAGNET	274	270	275	234	183	183	205	190	190	227	183
Industrial R&D	1,361	1,373	1,358	1,282	920	790	875	889	1,009	1,246	933

Source: Final Report on OCS-MOITAL Activity in 2009.

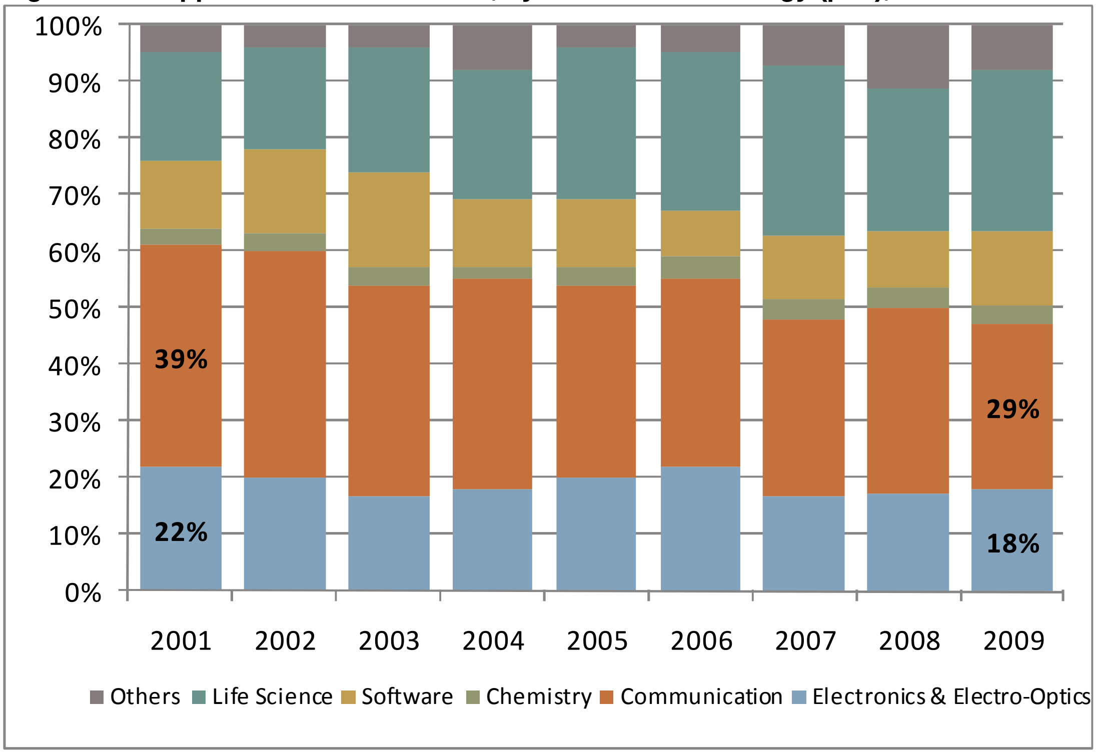
[20] Quoted from report of the Knesset Research and Information Center, "Assistance Programs for Industrial R&D," submitted on Nov. 14, 2005.

Figure 4.7 shows the scope of OCS-MOITAL support and its apportionment by programs. Most activity takes place on three paths:

- R&D Fund—funding of business R&D that is performed by private firms;
- MAGNET—consortia for the cooperative development of technologies, with the participation of several manufacturing firms and academic research institutes in a given field;
- Technological Incubators—a program that helps to establish startups based on new technologies in research stages.

The OCS budget has been developing in accordance with trend noted in previous subchapters but at a one-year lag. Thus, it attained its highest level in 2001 (NIS 1,811 million), declined from then until 2005 (NIS 1,141 million), and has been trending up since then but not back to its early 2000s level. Another trend observable in Figure 4.7 is an increase in the proportion of OCS funding that accrues to the technological incubator program.

Figure 4.8: Support from OCS-MOITAL, by Fields of Technology (pct.), 2001–2009



Source: Final Report on OCS-MOITAL Activity in 2009.

Figure 4.8, which analyzes the OCS-MOITAL grants by fields of technology, shows that the largest share of support is aimed at ICT research (electro-optics and communication) even though support for these industries has been following a clear and deliberate downward trend, from 61 percent of total grants in 2001 to 47 percent in 2009. Concurrently, OCS-MOITAL increased its participation in life-science research, from 18 percent of the total budget in 2002 to 30 percent in 2007 and 28 percent in 2009.

The “Others” category in Figure 4.8 includes grants for traditional industries, in which OCS-MOITAL has been encouraging R&D in recent years. Apart from product-development grants through the R&D Fund, OCS-MOITAL subventions strategic consultancy, encourages the placement of high-tech workers in traditional industries, encourages international cooperation in this field, and operates additional assistance programs. Since 2006, NIS 262 million has been awarded to 130 firms under all programs for the encouragement of R&D in traditional industries. The peak year of this activity was 2009, when NIS 87.6 million was granted to eighty-three firms.

Table 4.4 shows the distribution of grants from the R&D Fund by size of grantee firm. The most conspicuous trend in recent years is an increase in the extent of support for small firms (those that have less than USD 1 million in annual sales revenue). Grants to these firms more than doubled between 2005 and 2008—from 25 percent to 55 percent of the total. Concurrently, the share of grants to firms with sales revenue of USD 1 million–USD 20 million fell from 31 percent to 15 percent and that of grants to firms with more than USD 70 million in sales contracted from 31 percent to 16 percent. The trend changed in 2009: the emphasis shifted back to support for SMEs (less than USD 20 million in sales revenue) and large firms also received an increase in support.

Table 4.4: OCS Support by Sales Revenue of Supported Firms (pct.), 2003–2009

	2003	2004	2005	2006	2007	2008	2009
< USD 1 million	37%	34%	25%	34%	41%	55%	43%
USD 1 million–USD 20 million	27%	27%	31%	24%	21%	15%	29%
USD 20 million–USD 70 million	10%	10%	13%	14%	16%	14%	10%
USD 70 million–USD 100 million	4%	5%	6%	1%	1%	1%	1%
> USD 100 million	22%	24%	25%	27%	21%	15%	17%

Source: Final Report on OCS-MOITAL Activity in 2009.

5. Scientific and Technological Human Capital

- **Forty-four percent of Israel's working-age population has secondary or more schooling (2007), one of the highest rates among OECD countries.**
- **Some 50 percent of Israeli twelfth-graders qualify for matriculation certificates; 44 percent pass university entrance requirements (2007). 16 percent take the five-credit matriculation exam**
- **Israel ranks very low on international tests in education: twenty-fourth among forty-nine countries on the latest TIMSS exam in mathematics (falling five ranks from the previous exam) and thirty-ninth among fifty-eight participating countries on the PISA exams (2006).**
- **Roughly one-third of first-year degree students major in life sciences and 17 percent major in engineering and architecture.**
- **In 2008/9, 8700 students completed bachelor's degree in science and engineering study of which 56 percent in engineering and architecture, 21 percent in mathematics, statistics, and computer sciences; 15 percent in biological sciences; and 7 percent in physical sciences.**
- **Israel's teaching and research staff had 9,736 members in 2008/09, almost unchanged in the past decade. The shortage of senior academic staff is growing as the existing staff ages. Thus, 46 percent of senior university academic staff is over age 55, far beyond the rate in other developed countries .**
- **In Israel, 53,000 people hold R&D posts in the business sector (2008) and more than 60 percent of the jobs are in R&D and computer and related services.**
- **Some 26 percent of business-sector employees in Israel work in R&D (2007), a much higher share than in most developed countries.**

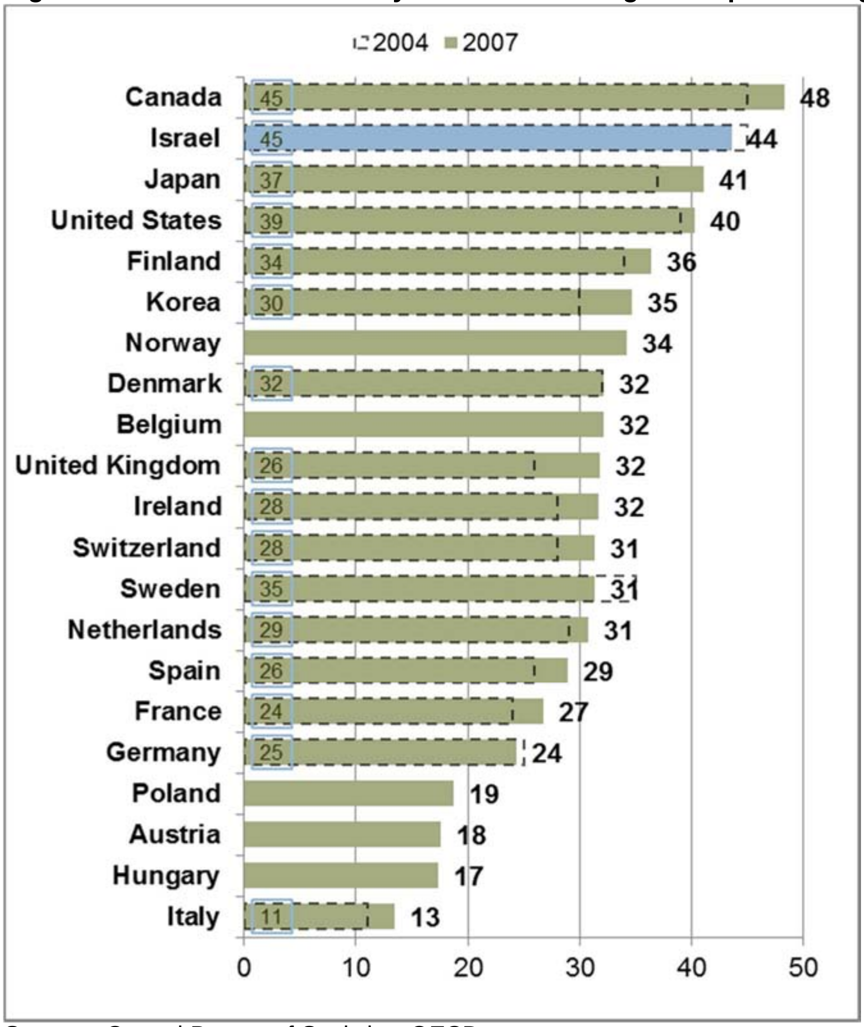
The pool of scientific and technological human capital is a crucial component of R&D activity in Israel and figures definitively in cementing the country's standing in scientific research, which, in turn, is a major engine of economic growth. The human-capital pool is composed of current human capital and a reserve in which the state invests, in the coin of education and higher schooling, in order to assure quality human capital in the future. Most basic research takes place in the higher-education system and is crucial to the development of the economy and tomorrow's research labor force. Israel's higher-education system is esteemed for its past achievements domestically and abroad. Since it takes many years to observe changes in human capital, indicators of the human-capital reserves are immensely important for Israel's continued position at the cutting edge of knowledge and progress.

This chapter analyzes indicators of human capital that are internationally comparable. In our previous publication, we presented data on university graduates and persons employed in R&D, e.g., the number of researchers employed in the business sector, university graduates in areas of science and technology, and the proportion of women in the job market and the classroom. Israel's strength and resilience in global competition depend on the graduates of its education system and their scientific and technological training; therefore, this publication adds indicators that are representative of the country's reserve of scientific and technological personnel. Specifically, we added data about high-school students, e.g., the share of scientific and technological subjects that they take, the proportion of students who excel in them, and the national level of science and mathematics studies as mirrored in international tests such as PISA and TIMSS.

An accepted indicator of a country's human-capital potential is the level of schooling among its population at large. Figure 5.1 shows the proportion of the 25–64 age cohort that has tertiary (post-secondary or higher) schooling.[21] In Israel in 2007, 44 percent of the population had post-secondary or higher schooling—a high percentage by international standards, surpassing countries such as the U.S. (40 percent), Japan (41 percent), and Finland (36 percent). Relative to 2004, this index moved up in all countries other than Israel, Germany, and Sweden.

[21] Israel's post-secondary and higher settings of education are universities (seven), academic colleges, teacher-training institutes, technological training centers supervised by the Ministry of Labor, and "Grades 13–14" at six-year secondary schools.

Figure 5.1: Incidence of Tertiary Education among the Population Aged 25–64, 2007



Sources: Central Bureau of Statistics, OECD.

To determine whether Israel is fulfilling its potential in terms of this indicator, we should ask whether the large proportion of well-schooled members of the population is reflected in the employment market in the form of jobs that are suited to this labor force. Examining these jobs, we need to differentiate between two types of occupations that require tertiary schooling[22]:

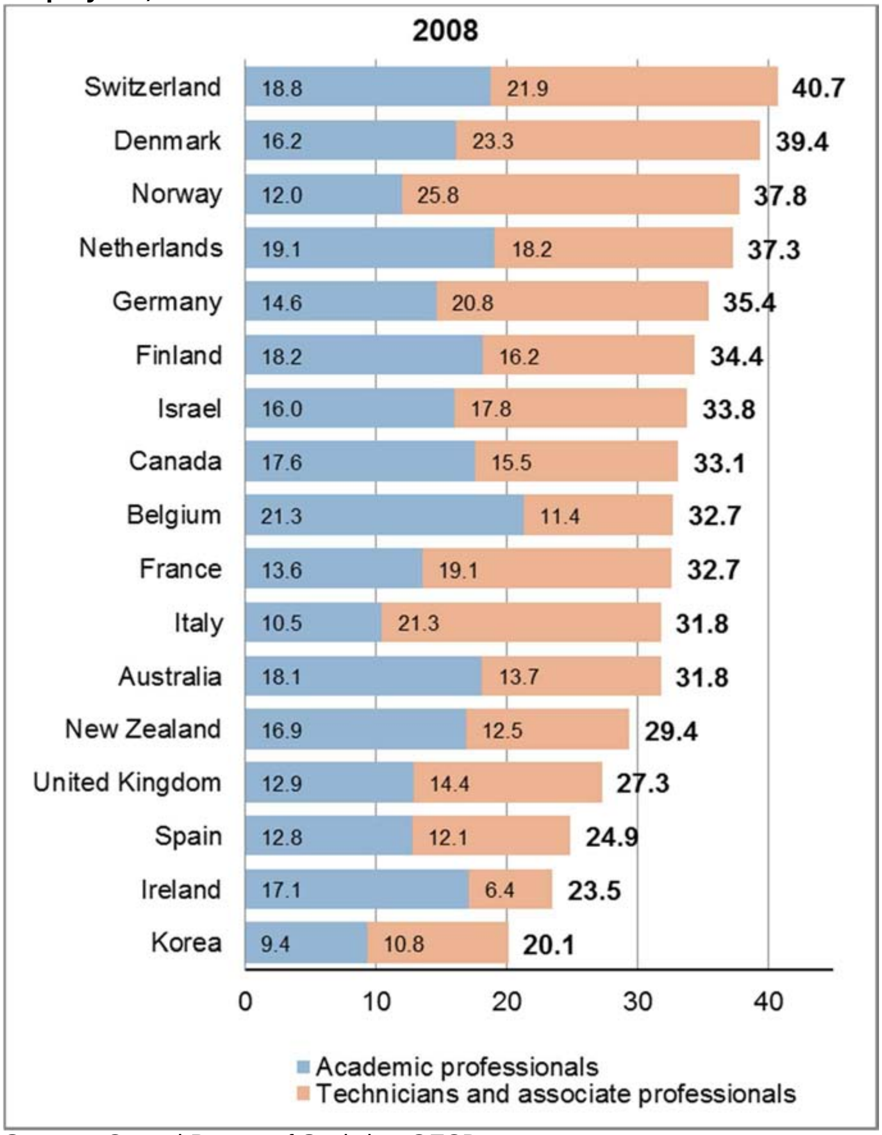
- **academic professions**—comprised of professions that require the kind of higher schooling that is acquired at universities and other academic institutions (e.g., biologists, systems analysts, electrical engineers, mechanical engineers, economists, lawyers, doctors, accountants, and teachers and education workers in junior-high and senior-high schools).

[22] Central Bureau of Statistics, *Standard Classification of Occupations 1994,* Technical Publication 64.

- **Associate and technician professions**—comprised of vocations that parallel the "academic professions" classification but require tertiary schooling that is non-university/non-academic. This classification includes:
    - practical engineers and technicians who hold auxiliary positions in research, planning, and performance of work in fields such as science (chemistry, physics, computers, life sciences, etc.), production, electricity and electronics, communications, engineering and building—by using scientific ideas and theories. The purview of their work is narrower than that of engineers and architects, who engage in the planning and management of research. Practical engineers, technicians, and associate professionals (e.g., practical engineers and technicians in the fields of electronics, programming, machinery, manufacturing and management, graphic art, nursing, teachers, etc.).
    - associate professionals: primary teachers, preschool teachers, professional and other instructors, bookkeepers, journalists, personal-care workers, optometrists, opticians, and other paramedics.
    - artists and theater and cinema workers;
    - athletes and referees in sports competitions;
    - photographers, pilots, marine officers, clergy, and other workers with tertiary schooling.

Figure 5.2 presents an international comparison of the percent of employed persons who work in academic, associate, and technical professions. In Israel, despite the large share of the population that has higher schooling, only 33.8 percent of employed persons work in academic, associate, and technical professions—a weak position compared with countries that have a lower share of well-schooled labor, such as Switzerland (40.7 percent), Germany (35.4 percent), and Finland (34.4 percent).

Figure 5.2: Academic, Associate, and Technical Professionals as a Percentage of Total Employees, 2008



Sources: Central Bureau of Statistics, OECD.

Below in this chapter, we take a closer look at Israel's human capital as reflected in employment, academia, and the economy at large.

5.1 Secondary Schooling

The past two decades have been termed the "knowledge era" for good reason. Investment in scientific and technological education and training of quality human resources are a *sine qua non* for growth and participation in the knowledge-based global economy.

The human-capital chapter in our previous publication, *Science, Technology and Innovation Indicators in Israel: An International Comparison, 2007,* included data reflecting the state of higher education and R&D human capital in Israel, such as the number of recipients of advanced degrees, academic staff, persons employed in

R&D, etc. The current report also presents data "one step back," i.e., data on the pool of Israeli high-school students that has the potential of advancing to technological and scientific studies in comparison with their counterparts in other countries, as reflected *inter alia* in international tests such as PISA and TIMSS.

5.1.1 <u>Eligibility for Matriculation Certificate</u>

According to Adva Center publications, only 80 percent of the twelfth-grade age group, on average, has actually attended twelfth grade in the past decade. In 2008, the proportion was 79.2 percent. In 2008, 24,198 youngsters of this age did not attend twelfth grad; among them, 60 percent were Jews who attended haredi ("ultra-Orthodox) settings, 15 percent attended nothing, and 20 percent were Palestinians from Eastern Jerusalem who took the Jordanian curriculum.[23]

According to the Central Bureau of Statistics, 99,447 youngsters attended twelfth grade in 2008, up 24 percent from 1996. Some 16.6 percent of them did not take matriculation exams. Only 44 percent of twelfth-graders in 2008—approximately 44,000 of nearly 100,000 students—earned matriculation certificates that met university entrance requirements. (The entrance requirements include, in addition to eligibility for a matriculation certificate, passing grades in mathematics at the three-credit level, in English at the four-credit level, and in one other "intensified" subject.) These data were basically unchanged from 1996, when the share of those meeting university entrance requirements was 40 percent (32,000 of 80,000 twelfth-graders.) Notably, since 2001 students have been allowed to take matriculation exams in mathematics and English at repeat opportunities as well; this has boosted the certificate eligibility rates.

Only some of those who meet university entrance requirements belong to the potential pool of students of science and technology because this group includes students who earn three credits in mathematics who, by and large, cannot be admitted to engineering and science programs. (Below are data on persons tested at an "intensified" level in individual scientific subjects and university requirements for technological subjects.) However, even students who do not meet the university entrance requirements may gain admission to higher studies at the academic colleges, which have easier entrance requirements. Such students may also make up the requirements later on by taking missing matriculation exams and/or improving earlier scores. According to CBS data, almost one-third of matriculation examinees in 1998 who did not meet the requirements for a matriculation certificate when they

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[23] Ettie Connor-Attias and Hala Abu-Khala, "Matriculation-Certificate Eligibility by Localities, 2007–2008" http://www.adva.org/uploaded/Bagrut2008.pdf

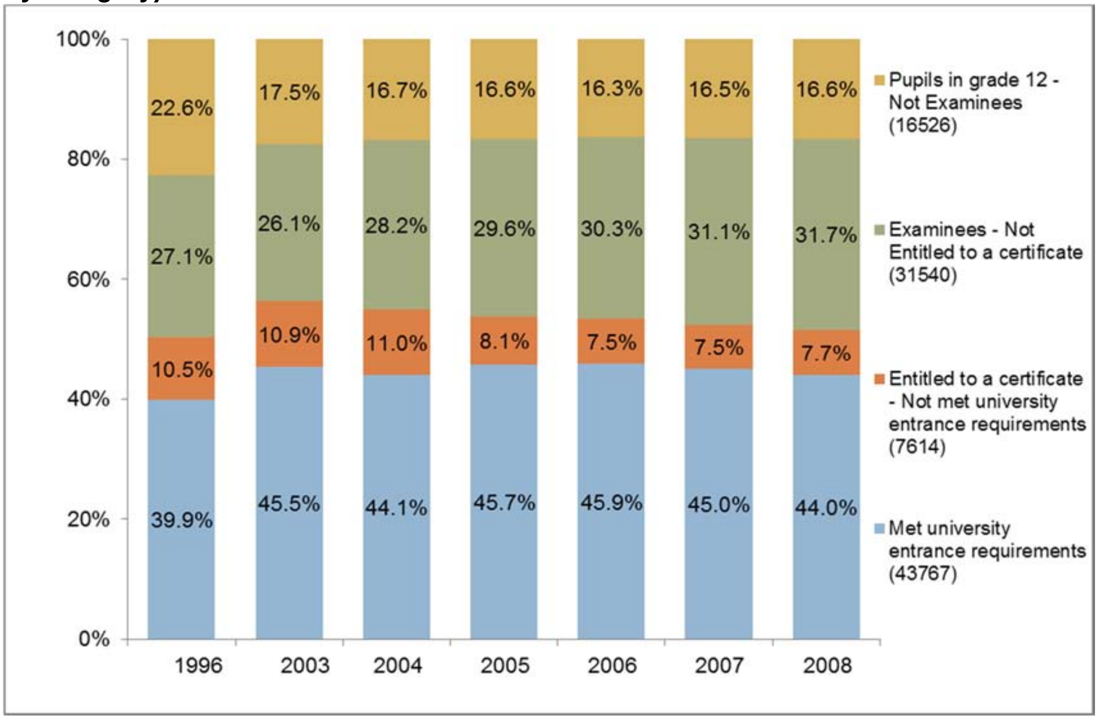
completed their studies made up the missing exams in 1999–2006 by taking secondary exams and earned matriculation certificates. This raised the proportion of certificate-eligibles among examinees from the 1997/98 group from 63 percent in 1998 to 76 percent in 2006. However, the fraction of certificate-eligibles who met university entrance requirements remained higher among those who earned their certificates upon the completion of their studies (in 1998) than among those who made up missing requirements: 82 percent as against 64 percent.[24]

Table 5.1: Twelfth-Grade Students, Matriculation Examinees, Examinees Entitled to a Matriculation Certificate, and Matriculates Who Meet University Entrance Requirements, 1996–2008

	Twelfth-grade students	Examinees	Entitled to a certificate	Met university entrance requirements
1996	80,139	62,044	40,340	31,959
2003	96,444	79,574	54,378	43,853
2004	100,351	83,551	55,249	44,245
2005	97,304	81,172	52,383	44,503
2006	98,557	82,513	52,650	45,237
2007	101,472	84,779	53,250	45,680
2008	99,447	82,921	51,381	43,767

Sources: Central Bureau of Statistics

Figure 5.3: Share of Matriculation Examinees and Examinees Entitled to a Certificate as Percentage of Twelfth-Graders (in parentheses: number of students in 2008, by category)



Source: Central Bureau of Statistics.

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[24] Source: CBS, Press Release, Nov. 7, 2007: "One-third of matriculation examinees in 1998 who did not meet testing requirements upon completion of studies finished matriculation within eight years."

The Israeli education system has three tracks of study: academic, technological,[25] and agricultural. In the past, there was a clear distinction among them. The academic track was identified with the most proficient pupils, those who had the potential of earning matriculation certificates that would meet university entrance requirements. Technological education provided training for work in high-tech environments and based itself extensively on science. Vocational education focused on giving over technical skills and training for working life. Today, the concepts are somewhat blurred and may be used to describe similar systems.

Table 5.2: Twelfth-Graders, Matriculation Examinees, and Those Entitled to a Certificate, by Track, 2007

	Twelfth-grade students	Thereof: examinees	Eligible for certificate		Met university entrance requirements	
			% of students	% of examinees	% of students	% of examinees
Total *	**101,472**	**83.5%**	**52.5%**	**62.8%**	**45.0%**	**85.8%**
Academic track	66,693	82.4%	55.4%	67.2%	48.0%	86.7%
Technological track	32,733	87.8%	48.0%	54.7%	40.2%	83.8%
Engineering majors	10,836	97.8%	75.0%	76.7%	70.0%	93.3%
Technological majors	14,186	83.5%	38.6%	46.2%	30.9%	80.1%
Vocational majors	7,711	81.5%	27.3%	33.5%	15.4%	56.3%
Agricultural track	1,115	96.8%	55.1%	56.9%	44.6%	80.9%

* The total includes students enrolled in no specific track or in an unknown track.
Source: Central Bureau of Statistics.

5.1.2 Matriculation by Subjects

Mathematics and English are compulsory subjects for a matriculation certificate; the percent of examinees who take them has been high at 85–95 percent over the years. If we narrow the inquiry to mathematics examinees at the five-credit level, on the assumption that this group represents the potential pool of future students of science and technology, the share is very low—only 16 percent in 2007. The proportion of outstanding students (those scoring 85+) among those tested in mathematics at the five-credit level is even smaller, at only 9.2 percent in 2007.

The elective subjects of biology, physics, and chemistry are aptly named: they are elective. Therefore, a large majority of students who take them (in 2008: 84.7 percent of those in biology, 69.2 percent of those in physics, and 78.9 percent of those in chemistry) do so as "intensified" subjects and take the matriculation exams at the five-credit level. However, the proportion of matriculation examinees who take these

[25] The technological track comprises three classes of majors: **engineering majors** including mechanical engineering, electronics engineering, computer engineering, biotechnology, etc.; **technological majors** including control and energy systems, CAM systems, construction engineering and architecture, manufacturing and management, design arts, communication technologies, media and advertising, marine systems, etc.; and **vocational majors** include business management, healthcare systems, education, tourism and leisure, lodging, etc.

subjects is small: 11.1 percent in chemistry, 13.4 percent in physics, and 19.4 percent in biology.

The tables below show the proportion of matriculation examinees in selected subjects among all examinees, their distribution by number of credits, and the share of outstanding students among them (scores of 85+) at the five-credit level in 2008 and as compared with selected years.

Table 5.3: Share of Matriculation Examinees in Selected Subjects among All Examinees

	Math	English	Biology	Physics	Chemistry
2008	89.1%	85.1%	19.4%	13.4%	11.1%
2007	93.5%	88.1%	19.4%	13.2%	10.8%
2006	91.0%	85.7%	18.4%	12.5%	10.2%
2005	86.5%	86.2%	16.6%	10.6%	10.0%
2000	87.4%	90.8%	15.3%	11.3%	10.1%
1999	87.7%	92.5%	16.1%	11.0%	11.0%
1997	85.4%	92.2%	16.6%	12.0%	12.8%

Source: Central Bureau of Statistics.

Table 5.4: Distribution of Matriculation Examinees in Selected Subjects, by Credits

2008					
3 credits	60.8%	22.9%	15.0%	29.6%	20.9%
4 credits	23.4%	36.4%	0.3%	1.2%	0.2%
5 credits	15.8%	40.7%	84.7%	69.2%	78.9%
5 credits, selected years					
	Math	**English**	**Biology**	**Physics**	**Chemistry**
2007	16.0%	41.4%	86.9%	70.8%	75.1%
2006	16.6%	41.4%	86.1%	72.3%	74.3%
2005	17.6%	41.0%	89.1%	84.5%	77.9%
2000	16.0%	41.8%	87.0%	84.5%	80.9%
1999	15.9%	40.8%	84.4%	84.9%	78.8%
1997	16.9%	40.4%	80.6%	86.6%	78.2%

Source: Central Bureau of Statistics.

Table 5.5: Share of Outstanding* Matriculation Examinees at 5 Credits among All Examinees in Subject

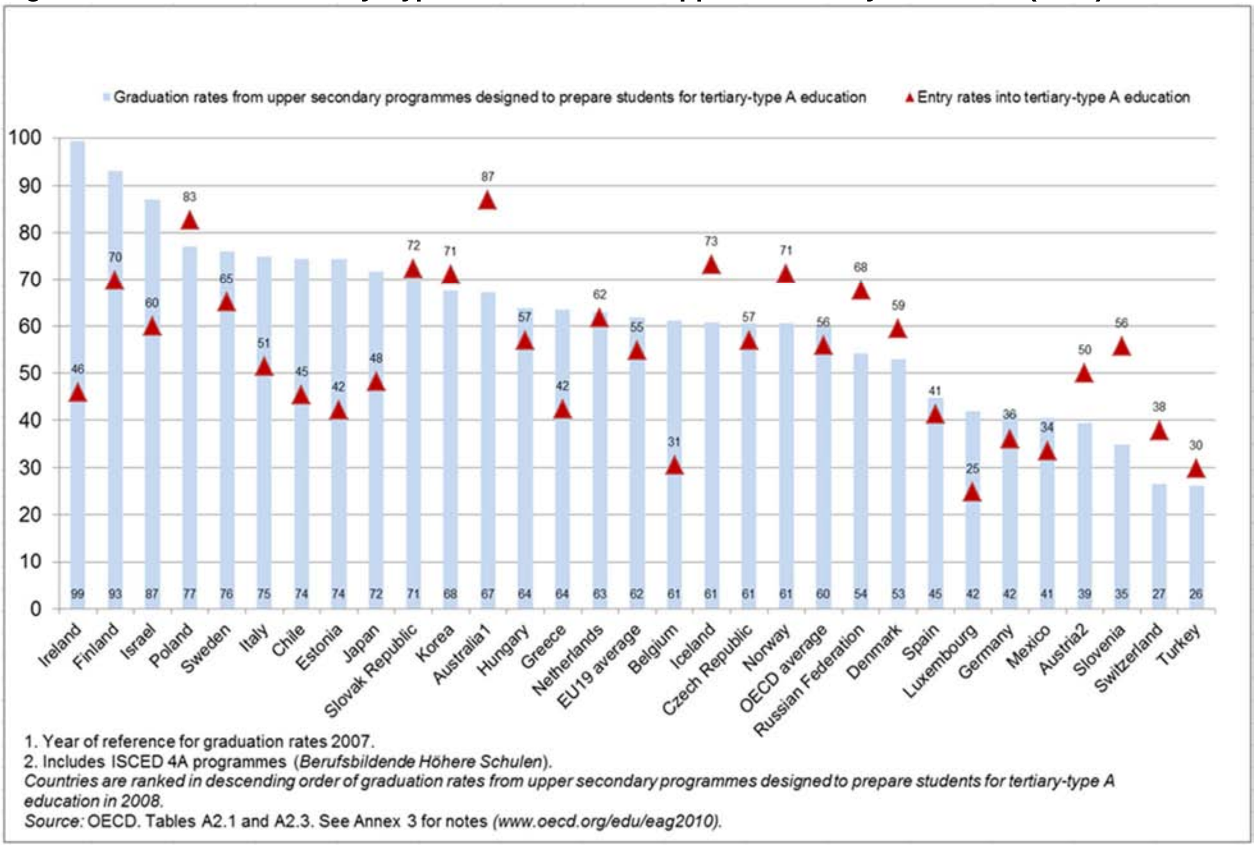
	Math	English	Biology	Physics	Chemistry
1998	8.90%	24.1%	40.8%	50.6%	45.7%
1997	9.2%	25.6%	40.3%	39.0%	43.9%
1996	10.5%	27.1%	40.4%	40.2%	39.1%
1995	12.1%	24.0%	41.6%	55.8%	47.0%

* 85+ score.
Source: Central Bureau of Statistics.

5.2 International Comparison

International comparisons in education are problematic because each country has a different education system. To create a basis for comparison nevertheless, the OECD presents low-cutoff data. The next graph, for example, presents two kinds of data for 2008 from the OECD publication *Education at a Glance 2010*: the percent of high-school graduates in Israel, i.e., those who finished twelfth grade (as distinct from those who received matriculation certificates), and the proportion of twelfth-grade graduates who enrolled in higher (academic) studies in 2008. The graph shows that Israel is among the leading countries in twelfth-grade graduates (87 percent). However, the proportion of these graduates who qualified for a matriculation certificate was 53 percent, of whom even a smaller share (46 percent) met university entrance requirements. The fraction of Israeli twelfth-grade students who began higher studies in 2008 was similar to the OECD average (56 percent).

Figure 5.4: Access to Tertiary-Type A Education for Upper Secondary Graduates (2008)



Source: OECD.

5.2.1 <u>Comparison by Means of International Tests</u>

One of the most important developments in measuring success in different education systems is international comparison by means of the TIMSS test, which examines international trends in science and mathematics studies, or the PISA test, which probes achievements of students in different countries in science, reading, and mathematics. By both standards, Israel ranks below the world average.

The TIMSS Test

TIMSS (Trends in International Mathematics and Science Study) is a quadrennial international test that measures achievements in mathematics and science in order to compare different countries' scholastic achievements and track their changes over the years. The test was initiated, is administered, and is analyzed by the IEA (International Association for the Evaluation of Educational Achievement), an independent international society for the evaluation of scholastic achievements that examines education systems using an international-comparison approach. It is headquartered at Boston College and its members are leading researchers and educators in diverse countries including Israel.

The TIMMS achievement tests are administered along with background questionnaires that ask pupils, teachers, school principals, and senior education-system officials in each country to provide information on a range of variables that affect the level of scholastic achievements. The tests are administered in Grades 4 and 8 in mathematics and science. Four such exams have been given thus far, in 1995, 1999, 2003, and 2007; the next is scheduled for 2011.

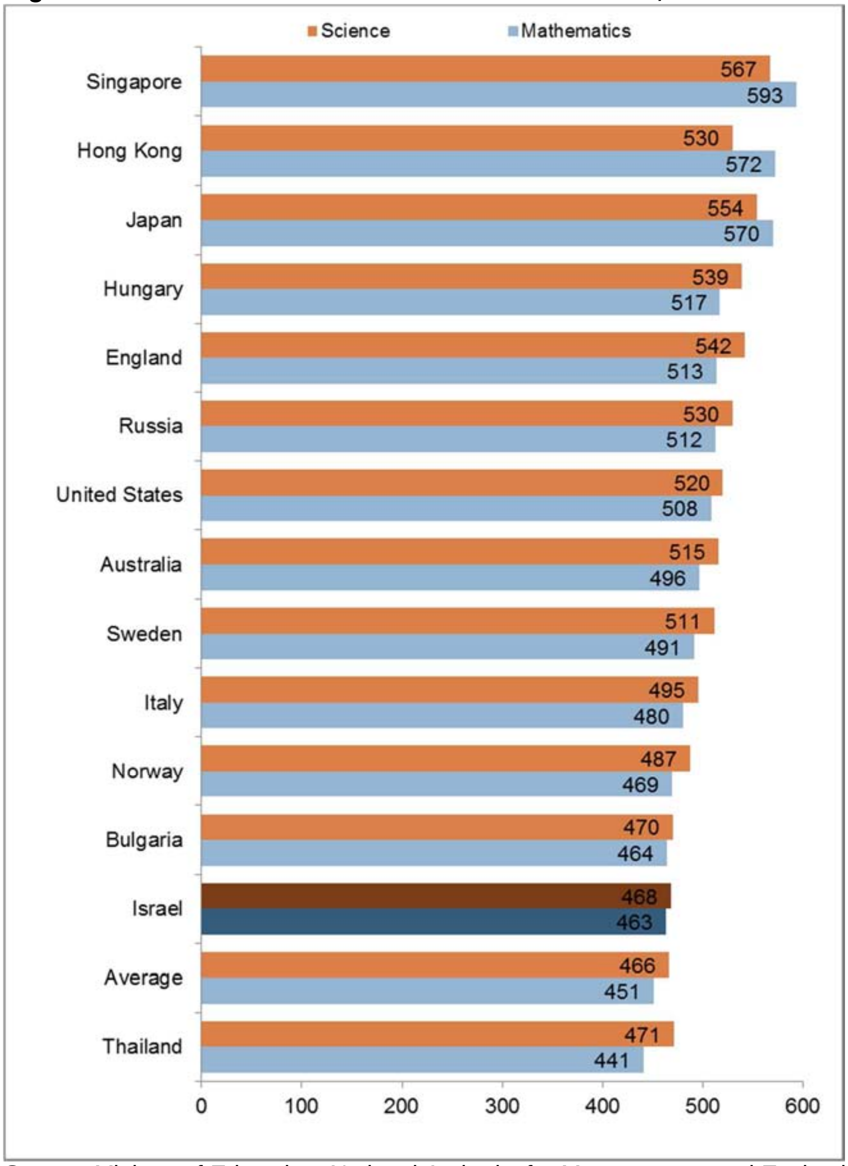
In the latest TIMSS (2007), Israel ranked twenty-fourth among forty-nine countries in mathematics and twenty-fifth in science. The achievements of Israel's pupils have clearly been declining in recent years. In mathematics, Israel fell by five ranks between 2003 and 2007, from nineteenth to twenty-fourth. In science, the loss was smaller at only two ranks: from twenty-third to twenty-fifth.

The world champions in this respect were Taiwan, South Korea, and Singapore. Bulgaria ranked above Israel; Ukraine ranked below. Australia was in fourteenth place, the U.S. in ninth, and Russia in eighth. Given that the ranking in international achievements is meant to reflect the level of Israel's education system and the quality of its alumni, Israel needs to apply a policy that will improve its pupils' achievements on these exams.

5.2.1.1 Mathematics and Science Scores (TIMSS 2007 Research)

In 2007, Israel's pupils had an average score in mathematics of 463 (as against 451 on international average), similar to Norway (469), Cyprus (465), and Bulgaria (464). Israel's achievements in science closely approximated the international average (468 vs. 466).

Figure 5.5: TIMSS Mathematics and Science Scores, 2007



Source: Ministry of Education, National Authority for Measurement and Evaluation in Education (RAMA)

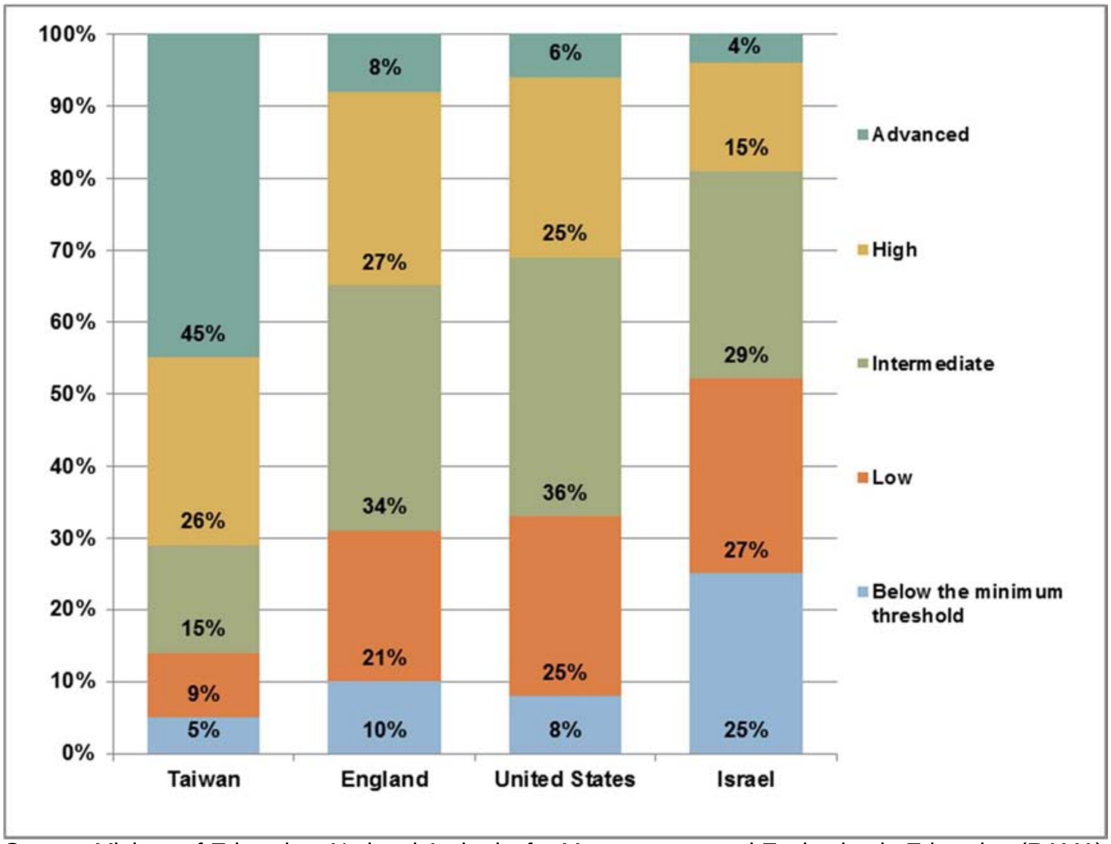
To describe eighth graders' achievements on the scale of the mathematics and science scores, four thresholds on the international scale of scores were defined: "Advanced" (625), "High" (550), "Intermediate" (475) and "Low" (400).

In the highest-achieving countries, a relatively large share of pupils surpasses the "Advanced" threshold and a relatively low percent falls below the "low" threshold. In Taiwan, for example—the leader in mathematics achievements—45 percent of the pupils surpassed the "Advanced" threshold (≥625) and 5 percent of pupils failed to reach the "Low" threshold (<400). In the U.S., by comparison, the proportions were 6 percent and 8 percent, respectively.

In Israel, only 4 percent of pupils crossed the "advanced" threshold in mathematics (>625) and 25 percent fell below the "Low" threshold (≤400). In the sciences, the proportions were only 5 percent and 25 percent, respectively. The latter percentage is much higher than in the U.S. (8 percent) and the UK (10 percent).

Israel's achievements on the 2007 TIMMS (eighth-grade science and mathematics) are poor by the standards of developed countries and need to be improved, both by reducing the failure rate and by increasing the share of outstanding performers.[26]

Figure 5.6: Distribution of Israeli Pupils by Achievement Thresholds, Mathematics, TIMSS 2007



Source: Ministry of Education, National Authority for Measurement and Evaluation in Education (RAMA)

5.2.1.2 PISA

PISA (Program for International Student Assessment) tests are administered by the OECD and many countries from all over the world take part in them. (Fifty-seven did so in 2006.) The program tests literacy among fifteen-year-olds in three respects—reading, mathematics, and science—and examines the extent to which students approaching the end of their compulsory schooling (in most countries) acquired general cognitive tools and comprehension of the topics examined so that they may cope well and effectively with their surroundings. PISA does not necessarily test the extent to which they acquired specific knowledge and contents that a specific

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[26] http://cms.education.gov.il/EducationCMS/Units/Rama/MivchanimBenLeumiyim/TIMMS_2007_1.htm

curriculum expects them to have. For this reason, the PISA questions probe knowledge from a practical perspective: knowledge that is crucial for the "adult world," capabilities for life, and the ability to solve complex problems that require integration of different areas of knowledge, with emphasis on skills.

PISA is administered in a three-year cycle. All three areas of knowledge (reading, mathematics, and science) are examined once every three years, but one of them is given special emphasis each time. Israel took part in the 2000 PISA, in which reading literacy was emphasized; skipped the 2003 exams; participated in the 2006 PISA, in which scientific literacy was stressed; and participated in the 2009 PISA program, in which reading literacy was emphasized. The results of the last-mentioned exams are due to appear in late 2010. Israel is expected to take part in the 2012 PISA.[27]

In the 2006 exams, Israel ranked thirty-ninth among fifty-eight participating countries. Its overall score, 445 points, was 50 points under the OECD average. Israel was under the OECD average in all fields examined: by 46 points in science, 56 in mathematics, and 53 in reading.

Table 5.6: PISA 2006—Results for Israel and Selected Countries

	Average	Science	Mathematics	Reading
Finland	553	563	548	547
Korea	542	522	547	556
Canada	529	534	527	527
Japan	517	531	523	498
Switzerland	513	512	530	499
Belgium	511	510	520	501
Ireland	509	508	501	517
Germany	505	516	504	495
United Kingdom	502	515	495	495
Denmark	501	496	513	494
OECD Average	496	500	498	492
United States	482	489	474	0
Israel	445	454	442	439
Turkey	432	424	424	447

Source: OECD.

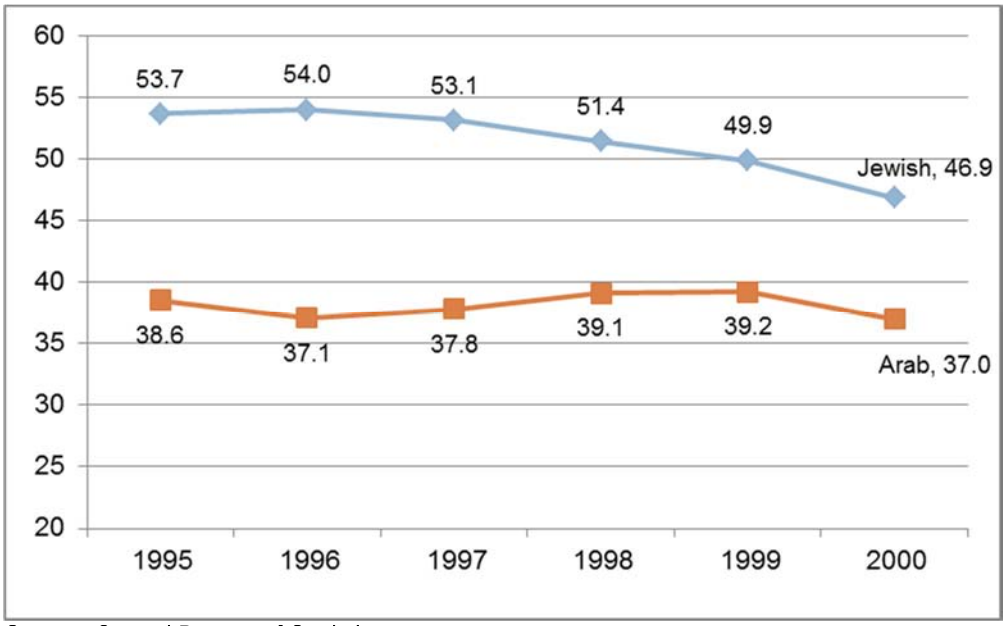
5.3 The Psychometric Exam

In 2009, the Central Bureau of Statistics performed two studies relating to the psychometric exam; these are the sources of the data that follow. We focus on indicators that illustrate the relation between high-school graduates and the psychometric exam. The following graph shows the percent of examinees in the Jewish and Arab school systems who took the psychometric exam within six years of

[27] http://cms.education.gov.il/EducationCMS/Units/Rama/MivchanimBenLeumiyim/OdotPisa.htm

finishing high school, among all high-school graduates in 1995–2000. About half of those who finished twelfth grade in the Jewish system in 2000 took the psychometric exam at least once between 2000 and 2005, as did 40 percent of alumni of the Arab system. Between 1996 and 2000, the share of graduates of the Jewish system who took the psychometric exam fell by 7 percentage points (from 54 percent to 46.9 percent in the respective years). Since the psychometric exam is by-and-large a *sine qua non* for admission to academic studies, especially in universities, this decrease may signal a decline in high-school students' intention of going on to higher studies. In the Arab system in 1995–2000, there was hardly any change in the percent of psychometric examinees among high-school graduates, at 38 percent on average.

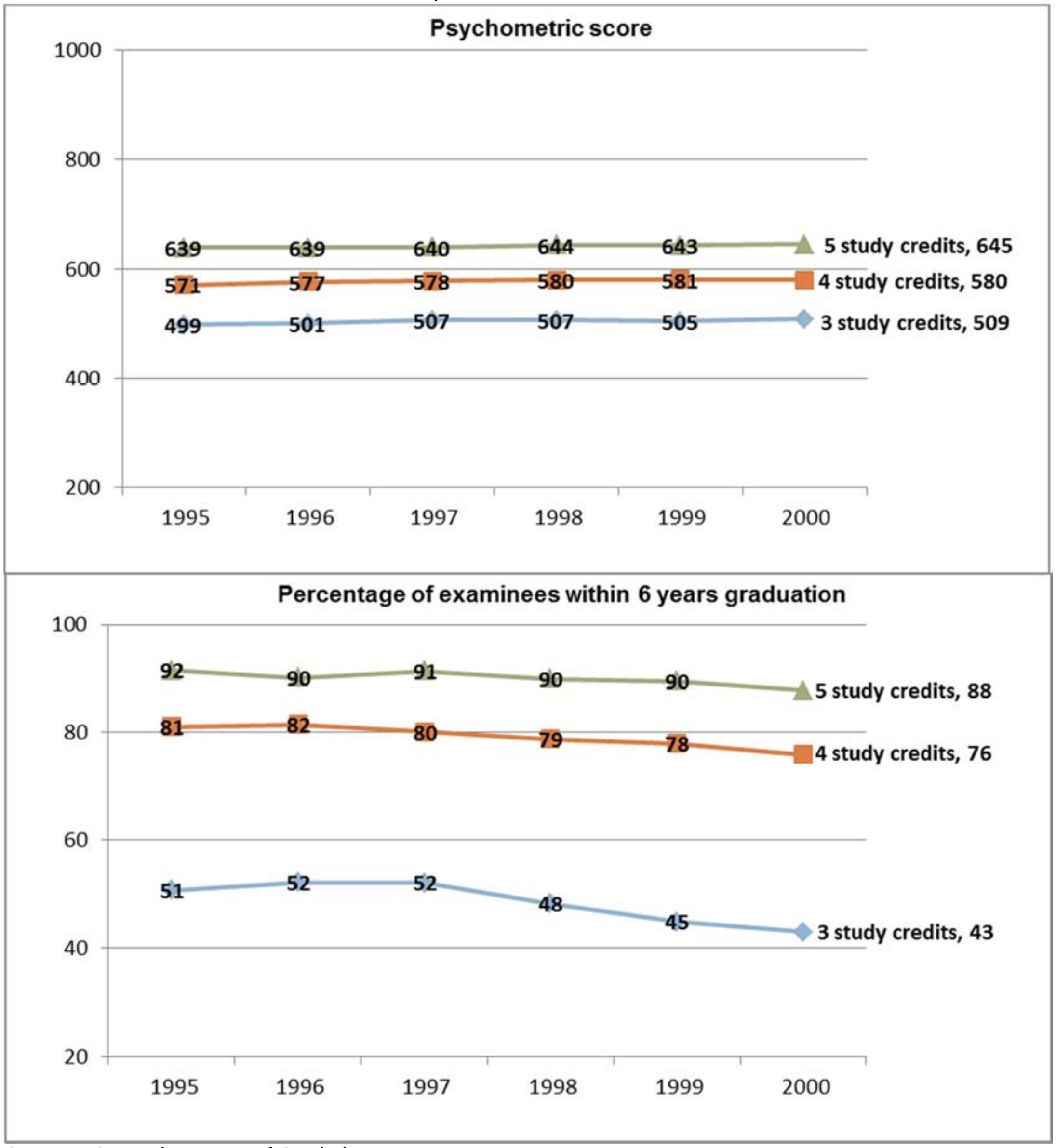
Figure 5.7: Psychometric Examinees as a Percentage of 12th-Grade Students, 1995–2000



Source: Central Bureau of Statistics.

The next graph tracks the relation between the percent of examinees and their scores on the psychometric test and the number of matriculation credits in mathematics. It turns out that there is a positive and significant statistical relation between students who passed the five-credit mathematics exam and percent of psychometric examinees (R^2=0.91, p=0.001) as well as their psychometric score (R^2=0.99, p=0.001). In other words, between 1995 and 2000, 90 percent of all students who passed the mathematics matriculation exam at the five-credit level took the psychometric exam, as against 50 percent of students who passed the mathematics matriculation exam at the three-credit level.

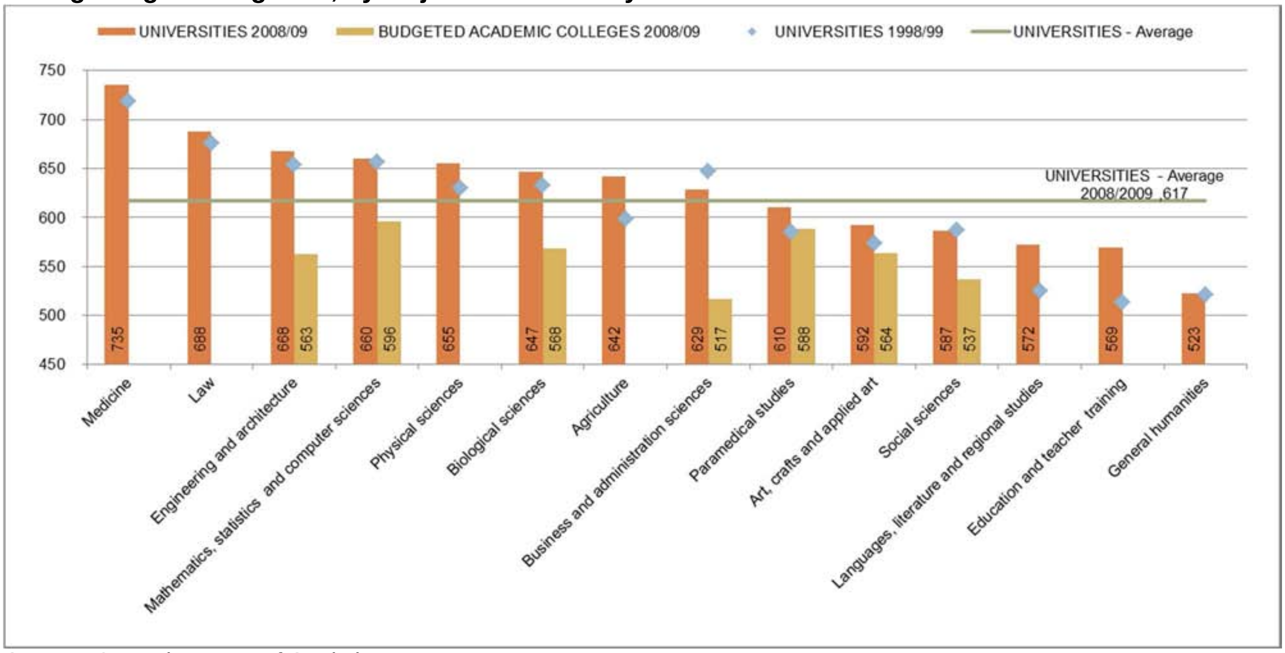
Figure 5.8: Percent of Psychometric Examinees and Their Scores, by Level of Matriculation Exam in Mathematics, 1995–2000



Source: Central Bureau of Statistics.

The next graph presents the average psychometric scores of students in their first year of degree studies, by major fields of study. In a comparison of 1998/99 with 2008/09, the psychometric score increased in all majors except business and administration sciences and social sciences. The largest differences were in education and teacher training (10 percent), languages, literature, and regional studies (8 percent), and agriculture (7 percent). The highest average scores were in medicine (735), law (688), and engineering and architecture (668).

Figure 5.9: Average Psychometric Scores of 1st-Year Students in University and College Degree Programs, by Major Field of Study

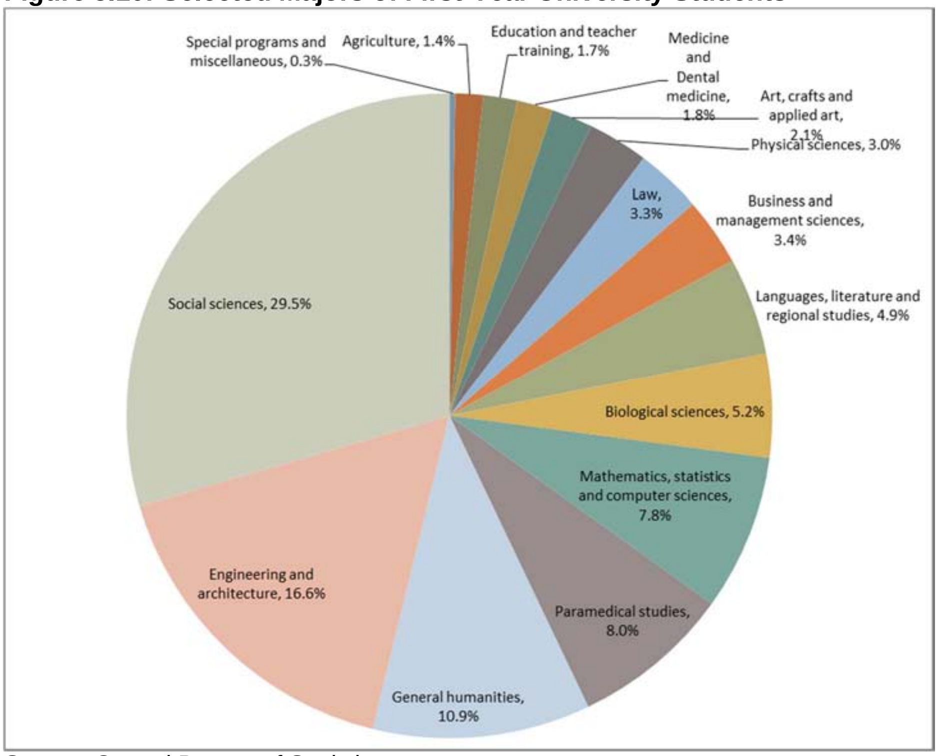


Source: Central Bureau of Statistics.

5.4 <u>First-Year Degree Students</u>

There were 23,391 first-year students in Israel's universities in 2008/09. The next graph shows their distribution by majors. About one-third chose majors in the social sciences, 10 percent in the general humanities, and 16 percent in engineering and architecture.

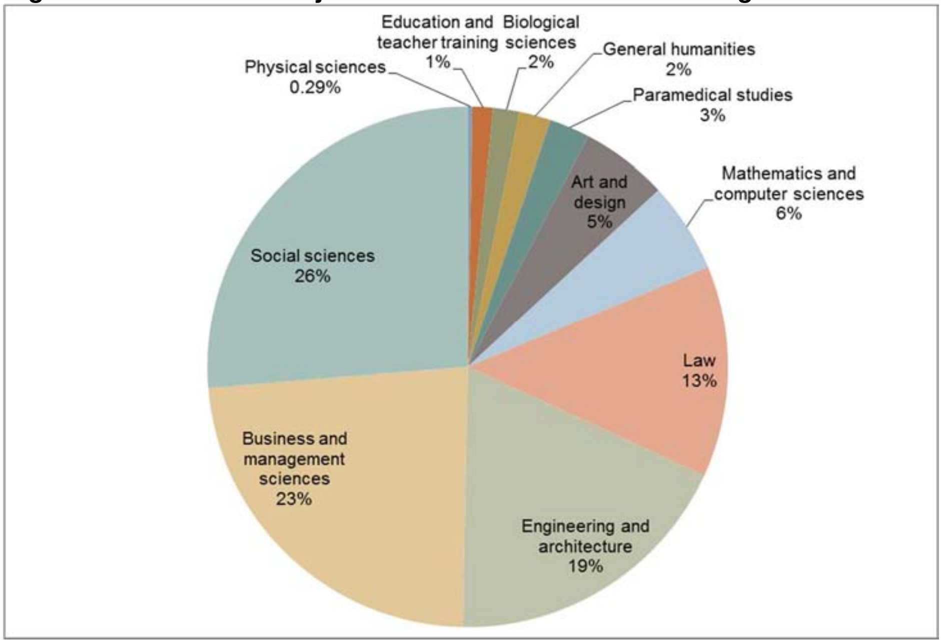
Figure 5.10: Selected Majors of First-Year University Students



Source: Central Bureau of Statistics.

Israel's academic colleges had 27,767 first-year students in 2008/09. Figure 5.11 shows their segmentation by major fields of study. The breakdown at the colleges resembles that at the universities: 26 percent majoring in social sciences, 23 percent in business and management sciences, and only 19 percent in engineering and architecture.

Figure 5.11: Selected Majors of First-Year Academic-College Students



Source: Central Bureau of Statistics.

5.5 Higher Education

5.5.1 Degree Recipients in Science and Engineering

This section examines the trends in degree recipients at Israeli universities, focusing on science and technology (S&T). The OECD's *Canberra Manual,* which sets rules for the measurement of human resources in S&T,[28] defines seven fields of study as related to S&T: life sciences, engineering, medicine, agriculture, social sciences, humanities, and other. The first five are core to S&T human capital. OECD and EU publications[29] relate to graduates in science and engineering (S&E) as the pool of R&D human capital. These fields of study include life sciences, physical sciences, mathematics, statistics, computers, engineering, manufacturing, and architecture and building.

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[28] OECD, *"Canberra Manual"—Manual on the Measurement of Human Resources Devoted to S&T,* Paris, 1995, p. 21.

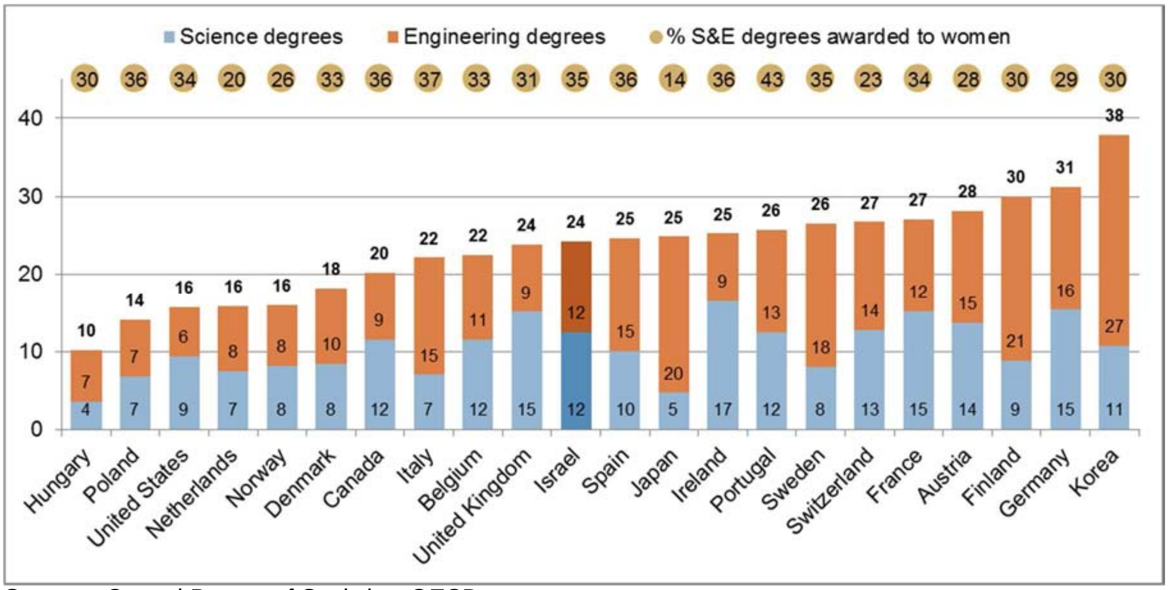
[29] European Commission, *Third European Report on Science and Technology Indicators 2003,* Brussels, 2003, p. 435.

The Israel Central Bureau of Statistics sorts the science-and-engineering fields of study into two categories: mathematics and natural sciences (including mathematics, statistics, computer sciences, physical sciences, and biological sciences) and engineering and architecture. The definitions are similar enough to allow international comparison at a reasonable level of confidence. First we present first-, second-, and third-degree graduates in the aforementioned fields of study that are core to R&D human resources.

Notably, until 1990, Israel's higher-education system was based almost exclusively on universities. This changed in the 1990s as a large number of academic colleges joined the roster of higher-education institute, allowing easier access to higher education for new population groups. The data in this chapter pertain to the universities and the colleges, some showing the total for universities and colleges together and others separating the two.

In June 2005, 24.3 percent of new degrees in Israel were in S&E. In comparison with the countries listed in the next graph, Israel ranked low in this respect but surpassed countries such as the U.S. (18.5 percent), Belgium (19.3 percent), and Denmark (19.8 percent). The share of women among recipients of S&E degrees was 35 percent in Israel, similar to other developed countries shown in the graph.

Figure 5.12: Science and Engineering Degrees as Percentage of Total New Degrees, 2005



Sources: Central Bureau of Statistics, OECD.

The next table present data about new first, second, and third degrees in S&E from universities and other higher-education institutes from 1994/95 to 2008/09 in Israel. Due to the change that took place in the higher-education system, the number of new degrees increased by 115 percent during this time.

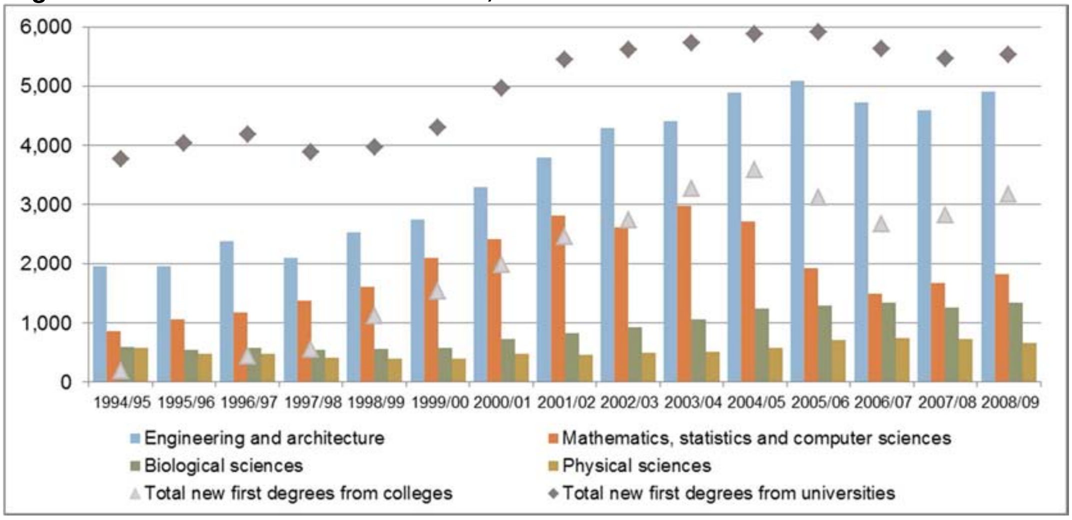
Table 5.7: New First, Second, and Third Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2008/09

	Engineering and architecture			Mathematics, statistics and computer sciences			Biological sciences			Physical sciences			Multidisciplinary sciences		Total			
	First degree	Second degree	Third degree	First degree	Second degree	Third degree	First degree	Second degree	Third degree	First degree	Second degree	Third degree	First degree	Second degree	First degree	Second degree	Third degree	Total
1994/95	1,944	467	75	855	158	42	585	275	157	566	213	102	11		**3,961**	**1,113**	**376**	**5,450**
1995/96	1,948	532	69	1,061	121	52	545	327	163	468	227	131	4		**4,026**	**1,207**	**415**	**5,648**
1996/97	2,381	630	76	1,179	139	47	572	319	148	482	200	128	8		**4,622**	**1,288**	**399**	**6,309**
1997/98	2,107	439	103	1,362	162	51	542	293	163	407	184	144	12		**4,430**	**1,078**	**461**	**5,969**
1998/99	2,530	405	77	1,595	175	58	564	331	142	387	169	129	14		**5,090**	**1,080**	**406**	**6,576**
1999/00	2,749	432	70	2,103	173	60	567	329	198	385	160	133	10		**5,814**	**1,094**	**461**	**7,369**
2000/01	3,301	434	60	2,408	196	56	728	330	216	474	159	137	13		**6,924**	**1,119**	**469**	**8,512**
2001/02	3,790	468	55	2,820	224	54	822	431	191	460	146	146	13		**7,905**	**1,269**	**446**	**9,620**
2002/03	4,292	555	80	2,614	259	63	927	454	269	492	206	145	19		**8,344**	**1,474**	**557**	**10,375**
2003/04	4,415	610	87	2,982	354	57	1,056	493	273	501	220	153	33		**8,987**	**1,677**	**570**	**11,234**
2004/05	4,893	727	86	2,718	356	73	1,232	539	255	570	281	158	45		**9,458**	**1,903**	**572**	**11,933**
2005/06	5,095	819	98	1,917	406	76	1,281	683	253	706	308	136	21	34	**9,020**	**2,250**	**563**	**11,833**
2006/07	4,728	788	93	1,488	443	93	1,336	672	293	739	323	146	20	35	**8,311**	**2,261**	**625**	**11,197**
2007/08	4,588	844	135	1,665	427	114	1,257	688	307	725	355	170	33		**8,268**	**2,314**	**726**	**11,308**
2008/09	4,906	906	132	1,811	430	112	1,332	654	289	651	359	155			**8,700**	**2,349**	**688**	**11,737**

Source: Central Bureau of Statistics.

Figure 5.13 shows new first degrees in S&E from universities and other higher-education institutes (colleges and the Open University of Israel) in 1994/95–2008/09. Among the fields of study, the increase in new first degrees was greatest in mathematics, statistics, and computer sciences. Degrees in engineering and architecture and biological sciences also increased during this time. No change occurred in physics. The share of universities in the awarding of first degrees fell from 90 percent in 1996/97 to 63 percent in 2008/09.

Figure 5.13: New First, Second, and Third Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2008/09[a]

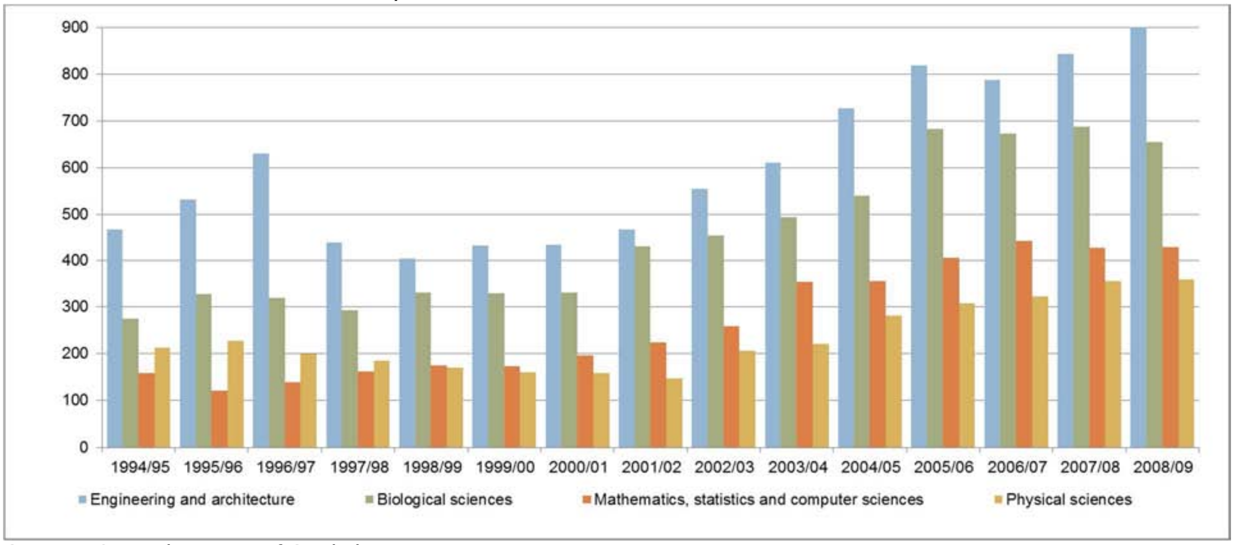


Note a. The data for 1995/96 do not include colleges.
Source: Central Bureau of Statistics.

Total new second degrees in S&E have been increasing by 6.5 percent on annual average (Table 5.7). The trend of the increase, however, has not been steady over the years. Between 1994 and 2000, there was a mixed trend in which increases and decreases cancelled each other out. From 2001 to 2005, rapid growth (14 percent per year) ensued. The main increase in new second degrees occurred in two fields of study: mathematics, statistics, and computer sciences (8.5 percent on annual average) and biological sciences (7 percent). In physical sciences and engineering and architecture, there was a decrease in 1997/98–2001/02 and a strong upturn starting in 2002/03.

It is very important to distinguish between two types of second degrees: those that require theses and those that do not. Only a second degree including a thesis allows its holder to go on to a Ph.D. According to CBS publications, while the absolute number of new second degrees with theses increased between 1991 and 2006, the share of such degrees among all new second degrees declined in all fields of knowledge.

Figure 5.14: New Second Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2008/09



Source: Central Bureau of Statistics.

In Israel, only research universities offer Ph.D. studies. The number of doctoral students in all fields of study has been growing rapidly in recent years, from 3,910 in 1990/91 to 9,835 in 2005/06—up 152 percent—and so, consequently, has the number of new doctoral degrees, from 450 in 1990/91 to 1,206 in 2005/06—up 168 percent.[30]

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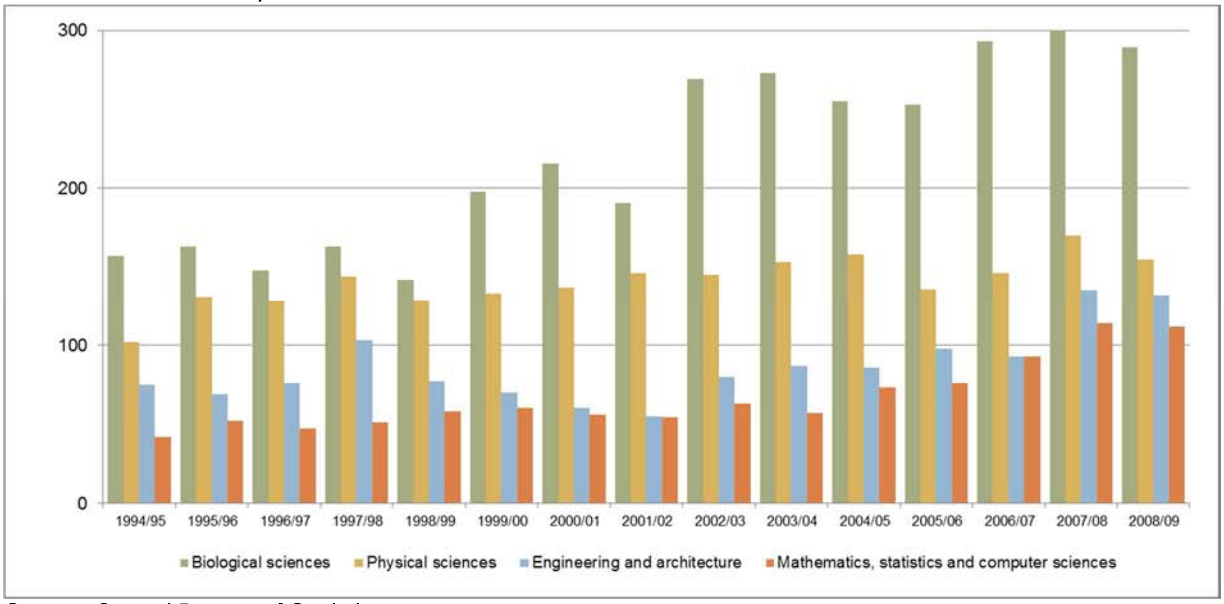
[30] Shlomo Hershkowitz, ***"The Place of Research Universities in Israel's Expanding Higher-Education System,"*** 2006.

Figure 15.5, parsing new doctoral degrees by the S&E fields of study, shows a different trend from that in first and second degrees. In first and second degrees, a majority of graduates are in engineering and architecture. In third degrees, in contrast, the share of biological sciences stands out strongly, accounting for half of the total increase in recipients of doctoral degrees in S&E in recent years. In the other fields of study, the upturn has been very small and the number of graduates has been at a standstill.

Figure 5.15: New Third Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2008/09



Source: Central Bureau of Statistics.

5.5.2 <u>Academic Staff</u>

University staff is an important if not definitive factor in the advancement of university research in Israel. It is also responsible for the quality of curricula and, in this sense, for the quality of graduates of higher-education institutions—who, as stated, are core to the national pool of human resources. The university teaching and research staff is divided into the following ranks:

- **senior academic staff,** including rank-and-file professors, associate professors, senior lecturers, and lecturers;
- **junior academic staff,** including senior instructors (doctoral students), assistants, and teaching and research assistants;
- **other academic staff,** mainly external teachers.

Table 5.8 tracks the size of university research staff (not including colleges) over a seventeen-year period (1991/92 to 2007/08) in terms of full-time equivalents (monthly average) and distribution across the ranks listed above. During the relevant years, the teaching and research staff increased by 24 percent (1.9 percent per year on average) or by 2,009 staff members in net terms. Most of the increase, however, traced to increases in junior academic staff (32 percent) and other staff (58 percent); less than one-fourth of the expansion originated in growth of senior academic staff (only 8 percent). As a result, the proportion of senior staff in total teaching and research staff declined from 57 percent to 49 percent, even though senior academic staff is perceived as the leader in terms of both research and knowledge and experience in teaching. Furthermore, in 2003–2008, the size of staff decreased at all ranks.

Table 5.8: University Academic Staff by Rank, 1991/92–2008/09

		Senior academic staff					Junior academic staff				Other
	Total	Professor	Associate professor	Senior lecturer	Lecturer	**Total**	Instructor (senior)	Assistant	Teaching and research assistants	**Total**	**Total**
1991/92	8,110	1,219	1,161	1,350	860	**4,590**	95	1,465		**1,560**	1,960
1992/93	**8,589**	1,286	1,172	1,370	858	**4,686**	93	1,569		**1,662**	2,241
1993/94	**9,131**	1,364	1,147	1,380	865	**4,756**	113	1,631		**1,744**	2,631
1994/95	**9,233**	1,396	1,151	1,344	880	**4,771**	96	618	1,172	**1,886**	2,576
1995/96	**9,529**	1,455	1,136	1,366	898	**4,855**	200	825	966	**1,991**	2,683
1996/97	**9,546**	1,507	1,169	1,366	885	**4,927**	110	941	875	**1,926**	2,693
1997/98	**9,881**	1,560	1,165	1,361	865	**4,951**	141	862	1,081	**2,084**	2,619
1998/99	**9,851**	1,603	1,186	1,397	890	**5,076**	150	1,026	1,005	**2,181**	2,594
1999/00	**10,171**	1,619	1,215	1,428	889	**5,151**	250	896	1,265	**2,411**	2,571
2000/01	**10,275**	1,620	1,225	1,440	892	**5,177**	233	921	1,327	**2,481**	2,640
2001/02	**10,395**	1,598	1,219	1,432	918	**5,167**	235	930	1,327	**2,492**	2,958
2002/03	**10,408**	1,594	1,218	1,407	938	**5,157**	195	922	1,265	**2,382**	2,838
2003/04	**9,849**	1,510	1,192	1,405	902	**5,009**	143	880	1,082	**2,105**	2,735
2004/05	**9,609**	1,510	1,155	1,410	871	**4,946**	109	819	1,067	**1,995**	2,668
2005/06	**9,680**	1,480	1,161	1,410	887	**4,937**	101	884	1,009	**1,994**	2,749
2006/07	**9,768**	1,458	1,191	1,390	896	**4,935**	100	904	1,002	**2,006**	2,827
2007/08	**10,119**	1,457	1,203	1,395	905	**4,960**	99	897	1,067	**2,063**	3,096
2008/09	**9,736**	1,458	1,227	1,408	891	**4,985**	88	902	1,122	**2,112**	2,640
Average growth	**1.1%**	**1.1%**	**0.3%**	**0.2%**	**0.2%**	**0.5%**	**-0.5%**	**1.9%**		**1.8%**	**1.8%**

Source: PGC.

A study by Prof. Uri Kirsch for the Neaman Institute[31] posts several red flags around Israel's institutions of higher study:

- Hiring of new academic staff at the universities has been slumping badly even though the pool of potential candidates has been growing. The ratio

[31] Uri Kirsch, *Higher-Education Policy in Israel—Accessibility, Quality and Excellence with Limited Resources,* Samuel Neaman Institute, 2010.

of senior staff member per student is an important parameter in determining teaching quality because it reflects the number of students relative to staff members. As Tables 5.7 and 5.8 show, the student population has been rising in recent years while the number of academic staff members has not changed. Consequently, according to Kirsch's data, the ratio of students (for first and second degrees) to senior academic staff rose steadily and uninterruptedly by 50 percent between 1990 and 2005, at 16.2 and 24.2 in the respective years. Due to the major cutbacks in public budgeting of higher education and the universities' financial crises, the number of full-time posts for senior academic staff members declined in absolute terms by more than 300 in 2001–2005 and the trend has not yet been arrested. Consequently, the research universities have been hiring fewer staff members that have been retiring.

- Because senior academic staff is not being hired in adequate numbers, the long-term process of aging among academic staff has been accelerating to levels that far exceed those in other developed countries, with all the dangers that this implies for the capabilities of university research in Israel. According to the Central Bureau of Statistics, 46 percent of senior academic staff members at university were over age 55 in 2008/09. It is claimed today that there are too few staff members in the age group that is considered creative. Furthermore, large numbers of retirements are expected in the next few years and the pool of replacements is inadequate.

Another parameter that should be examined is the dearth of women among senior academic staff. According to the Central Bureau of Statistics, women accounted for only 29.9 percent of university senior staff and 35.1 percent of college senior staff in 2008/09.

5.6 The Business Sector

In the previous section, we surveyed the higher-education sector in a way that allowed us to gauge the human resources that are being trained for innovative activity and those that engage in academic research. Here we present data on human resources employed in the business sector, where most R&D takes place.

According to the *Frascati Manual* definitions,[32] on which the data in this chapter are structured, R&D employees include those employed directly in R&D and those who provide direct services for R&D, such as R&D managers and administrative workers. The *Manual* distinguishes among three main categories:

- **researchers:** employees involved in the production of new knowledge, product development, and new processes; development of systems; and R&D project management. This group includes people with academic schooling and students who have not yet completed their academic studies but hold positions that require an academic degree;
- **technicians:** employees who have a technical background and skills in engineering or exact sciences, i.e., practical engineer/technician certification or equivalent training;
- **others:** including all administrative employees directly connected with R&D projects.

There are two ways of enumerating R&D employees: by headcount and by number of full-time posts. The international comparison that follows uses the latter metric and not the former in order to neutralize the effect of part-time R&D employees.

In Israel, employees in the business sector include those in the various fields of manufacturing (10–39), computer and related services (72), and research and development (73).[33] The table below presents total R&D employee posts in Israel's business sector in 1999–2008. During the years at issue, the number of employee posts increased by 47 percent (from 36,000 in 1999 to 53,000 in 2008); more than 60 percent of the posts were in research and development and computer and related services.

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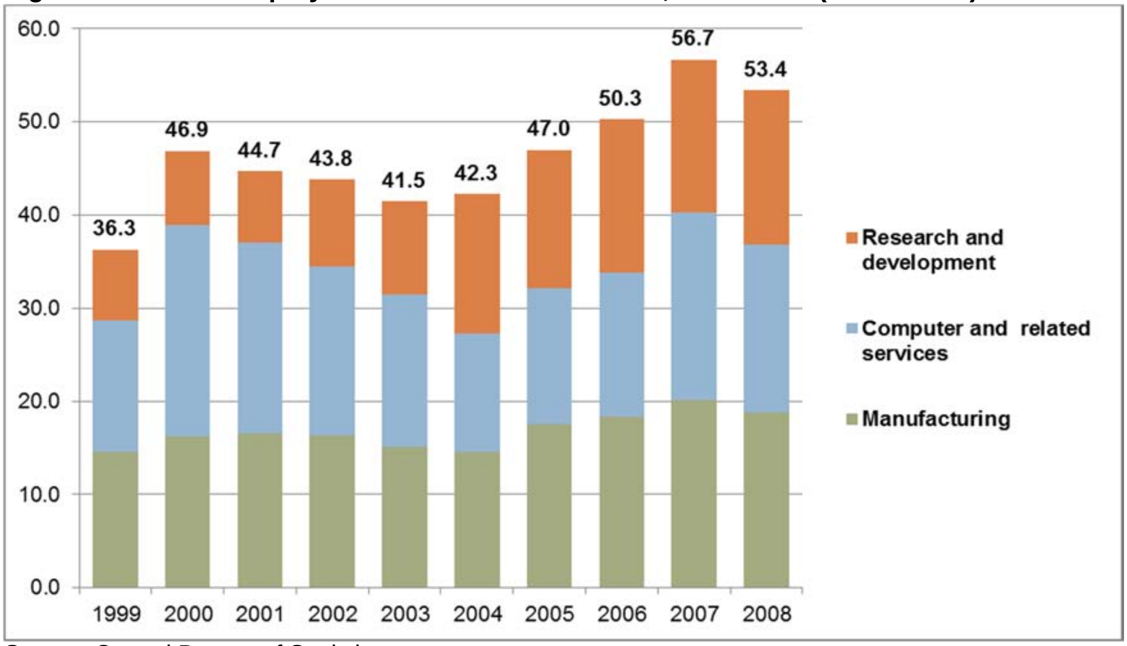
[32] OECD, *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development,* Paris, 2002.

[33] Central Bureau of Statistics, *Standard Industrial Classification of All Economic Activities 1993,* Jerusalem, 1993.

Figure 5.16: R&D Employees in the Business Sector, 1999–2008 (Thousands)



Source: Central Bureau of Statistics.

Table 5.9: R&D Employees (Full-Time Equivalents) in Companies Practicing R&D in the Business Sector, Thousands, 1997–2007

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	CAGR
Japan	586	613	605	582	562	556	581	587	610	619	620	0.56%
Germany	286	288	307	312	307	303	298	299	305	312	322	1.18%
France	166	168	172	178	185	191	193	201	195	208	213	2.52%
Korea	90	78	84	87	117	121	128	133	153	172	185	7.40%
United Kingdom	137	148	153	145	154	158	156	150	145	149	163	1.75%
Canada	83	86	91	105	116	118	127	138	142	147	148	5.97%
Italy	61	61	60	64	65	70	68	68	71	80	94	4.32%
Spain	30	35	38	47	46	56	65	71	75	83	88	11.30%
Sweden	44		44		49		48	47	56	58	56	2.46%
Israel	24	28	36	41	39	38	38	38	41	44	50	7.46%
Belgium	28	29	31	33	35	32	31	31	32	33	34	1.91%
Finland	22	25	28	29	30	30	32	33	32	33	32	3.66%
Denmark	20	21	22	24	26	28	27	28	28	29	31	4.52%
Singapore	8	9	10	10	10	11	13	15	17	18	19	9.10%
Poland	23	22	20	19	17	9	11	13	14	14	15	-4.24%
Ireland	7	8	8	9	9	9	9	10	10	11	11	4.63%
EU27	966	988	1,021	1,049	1,070	1,081	1,083	1,100	1,126	1,184	1,238	2.51%

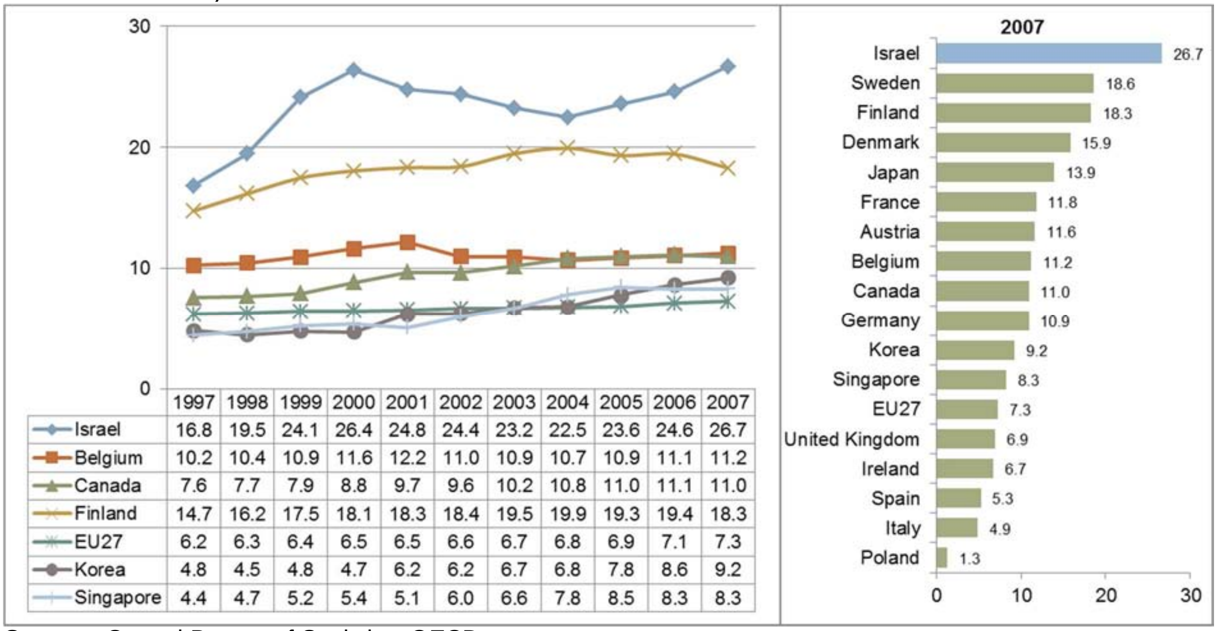
Note: the compound annual growth rate is calculated as follows:

$$CAGR = \left(\frac{Ending\ value}{Beginning\ value}\right)^{\frac{1}{\#of\ years}} - 1$$

Sources: Central Bureau of Statistics, OECD.

The data in the table above are expressed in thousands and do not reflect Israel's size relative to other countries. To perform an international comparison, the effect of country size must be neutralized. Figure 5.17 does this by presenting the share of R&D employees in total business-sector employment in selected countries. In this respect, Israel is the leader far and away. The trend in Israel is divided into two periods: 1997–2000, when a steep increase occurred due to the rapid development of the domestic high-tech industry (the “bubble” period), and a precipitous downturn in 2001–2004. Israel and Finland consistently posted the highest growth rates in this indicator (2.1 percent in 2004), approached by Sweden (1.9 percent). Countries that resemble Israel in size, such as Ireland and Belgium, showed much lower percentages.

Figure 5.17: Total Business Enterprise R&D Personnel per Thousand Employed in the Business Sector, 1997–2007[a]

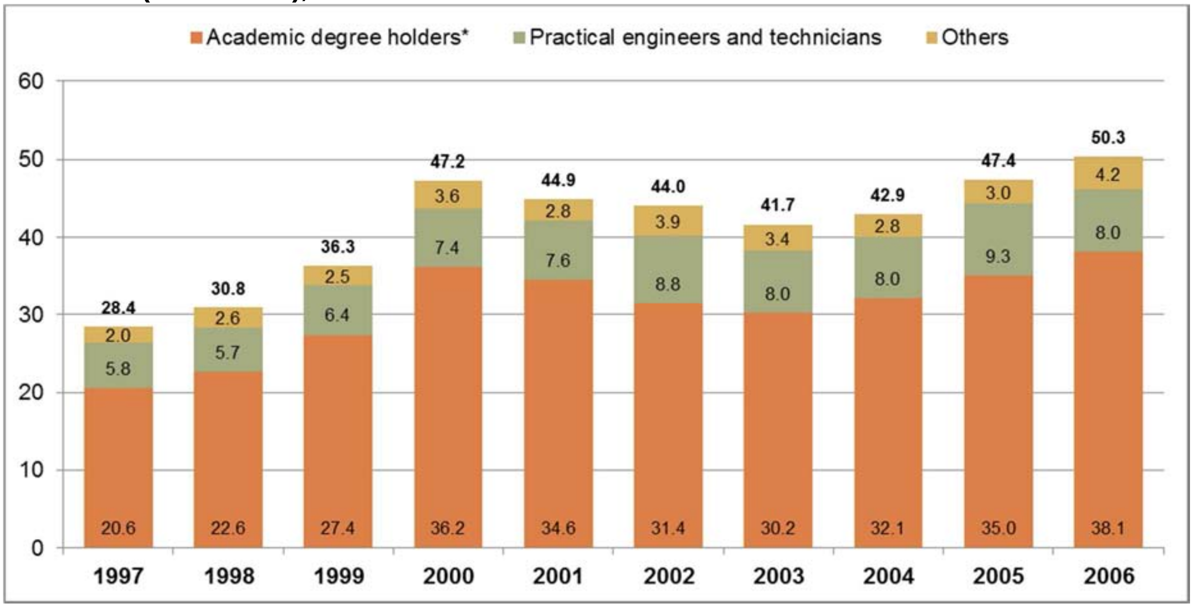


	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Israel	16.8	19.5	24.1	26.4	24.8	24.4	23.2	22.5	23.6	24.6	26.7
Belgium	10.2	10.4	10.9	11.6	12.2	11.0	10.9	10.7	10.9	11.1	11.2
Canada	7.6	7.7	7.9	8.8	9.7	9.6	10.2	10.8	11.0	11.1	11.0
Finland	14.7	16.2	17.5	18.1	18.3	18.4	19.5	19.9	19.3	19.4	18.3
EU27	6.2	6.3	6.4	6.5	6.5	6.6	6.7	6.8	6.9	7.1	7.3
Korea	4.8	4.5	4.8	4.7	6.2	6.2	6.7	6.8	7.8	8.6	9.2
Singapore	4.4	4.7	5.2	5.4	5.1	6.0	6.6	7.8	8.5	8.3	8.3

Sources: Central Bureau of Statistics, OECD.

Figure 5.18 parses R&D employment in Israel in 1997–2006 by the three categories listed at the beginning of this section. Although the ratio among the categories was relatively constant over the years, the number of persons employed increased from 28,000 to 50,000 between 1997 and 2006, up 77 percent.

Figure 5.18: Number of R&D Employees (Head Count) in Business Sector, by Education (Thousands), 1997–2006



* Academic degree = first, second, and third.
Sources: Central Bureau of Statistics, OECD.

5.7 Women in Science and Technology

Women's participation in the creation of knowledge infrastructure is an important indicator because it mirrors the extent of the utilization of women's potential in total national human capital. The detection of gender disparities in participation may provide a point of departure for the examination of S&T policy alternatives that would aim for better utilization of human capital for S&T activity.

First we present an international comparison of women's education relative to men's in order to examine the extent of women's potential in human capital. To facilitate the comparison, the levels of education are sorted into categories in accordance with the 1997 International Standard Classification of Education (ISCED). We chose to present an international comparison of Ph.D. graduates because a relatively large proportion of such personnel engage in research and the creation of knowledge infrastructures.

Figure 5.19 compares the share of women among holders of advanced research degrees[34] in various countries in 2006. The graph shows that Israel is one of the world's leaders in this respect. Together with Finland, Italy, and Ireland, it has achieved gender equality in the awarding of doctoral degrees. Importantly, however, this comparison relates to all Ph.D.'s and not only to those in S&E (due to lack of data).

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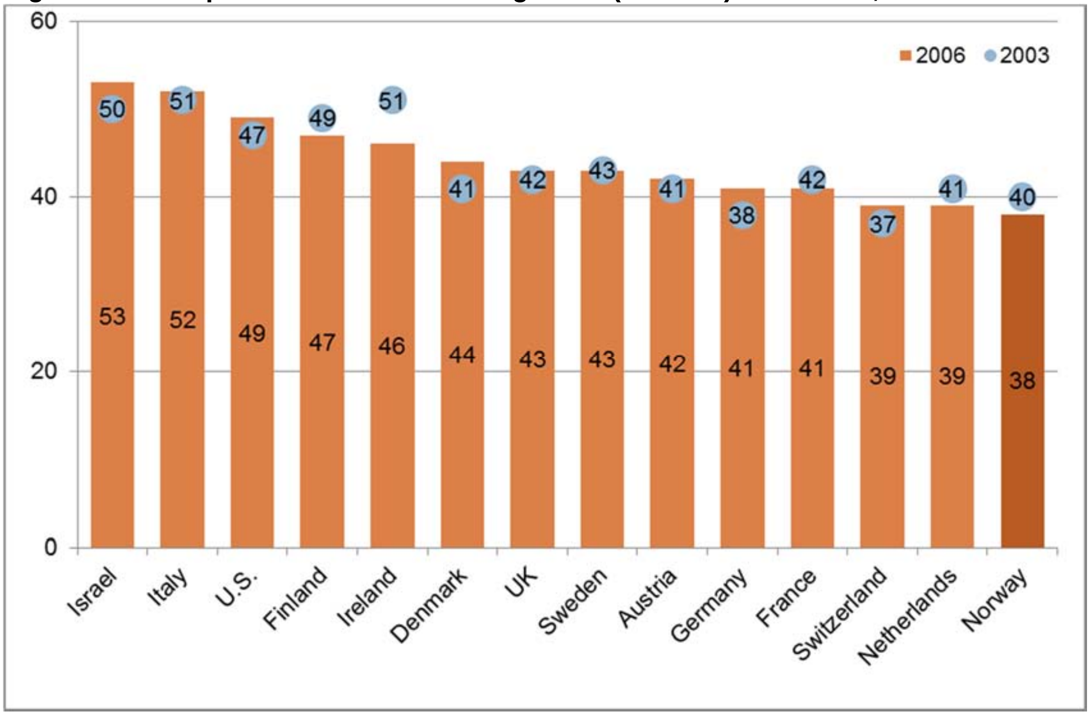
[34] Defined in ISCED as tertiary education (second stage), ISCED-6.

Figure 5.19: Proportion of Women among Ph.D. (ISCED 6) Graduates, 2006



Sources: Central Bureau of Statistics, OECD.

We now focus on the number of women in S&E in Israel. Table 5.10 presents the number of women university graduates in Israel on the basis of S&E degrees earned between 1994/95 and 2008/09.

Between 1994 and 2008, the number of women who received first degrees in S&E fields increased by 115 percent, second degrees by 108 percent, and third degrees by 89 percent. In the last three years of the reporting period, the year-on-year percent changes in the number of women earning S&E degrees were negative or flat.

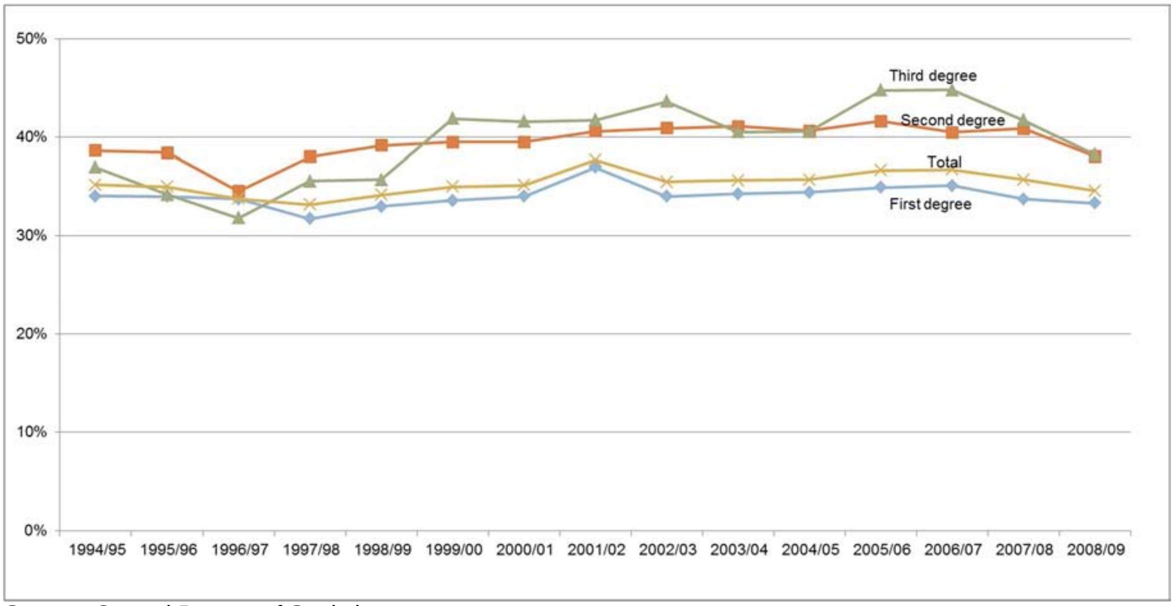
Table 5.9: Women Recipients of First, Second, and Third Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2007/08

	First degree	Second degree	Third degree	Total	Year-on-year change
1994/95	1,348	430	139	**1,917**	
1995/96	1,370	464	142	**1,976**	3%
1996/97	1,560	445	127	**2,132**	8%
1997/98	1,406	410	164	**1,980**	–7%
1998/99	1,679	423	145	**2,247**	13%
1999/00	1,953	432	193	**2,578**	15%
2000/01	2,354	442	195	**2,991**	16%
2001/02	2,922	515	186	**3,623**	21%
2002/03	2,837	603	243	**3,683**	2%
2003/04	3,082	689	231	**4,002**	9%
2004/05	3,255	773	232	**4,260**	6%
2005/06	3,149	936	252	**4,337**	2%
2006/07	2,919	915	280	**4,114**	-5%
2007/08	2,789	945	303	**4,037**	–2%
2008/09	2,900	894	263	**4,057**	0.5%

Source: Central Bureau of Statistics.

The increase does not denote an improvement in women's situation because the same change occurred in the population at large. To understand the trend among women relative to men, we need to examine the percent of women among total degree recipients. To accomplish this, Figure 5.20 shows the trend in the rate of women among recipients of new first, second, and third degrees in S&E fields between 1994/95 and 2008/09. During these years, even though the overall number of women recipients of degrees increased, the share of women among all new first and second degrees in S&E hardly changed. As for third degrees, there was an increase in 1997–2000, mild volatility from 2001 onward, and an average rate of 41 percent.

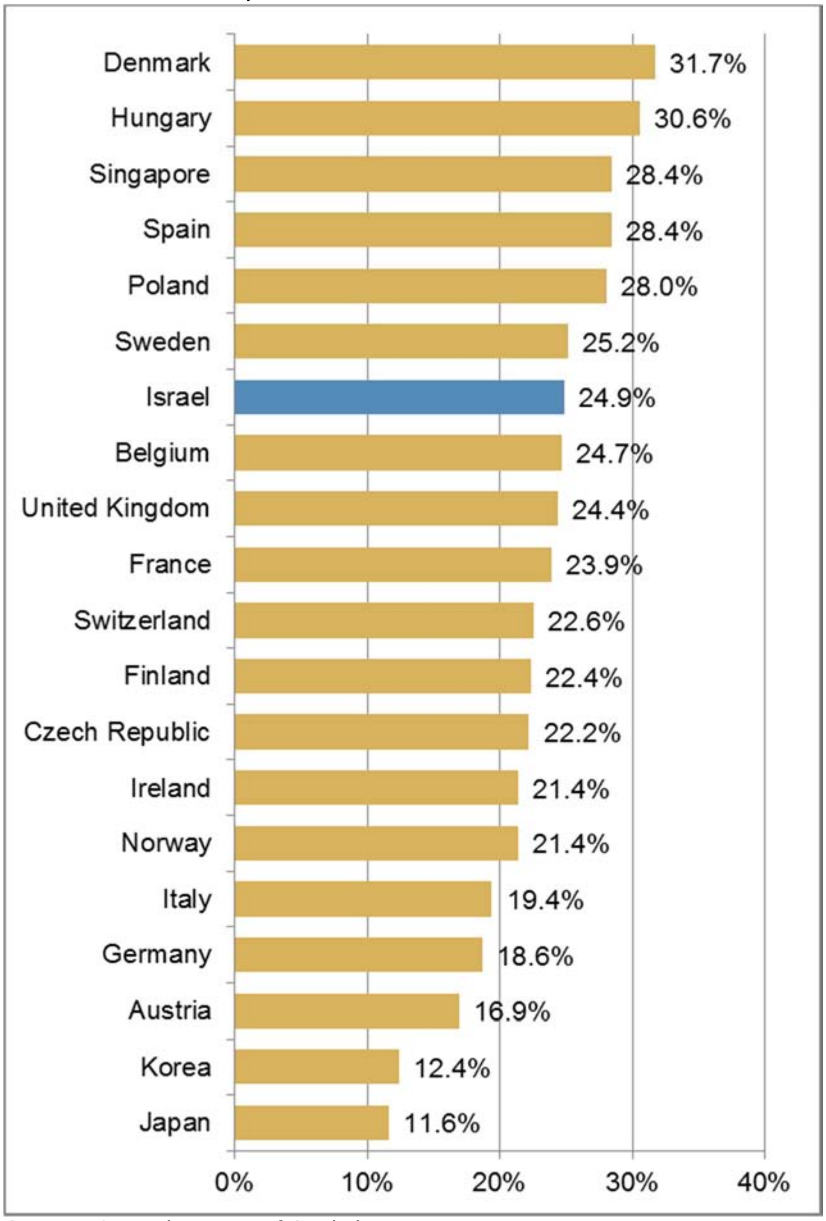
Figure 5.20: Share of Women among Recipients of First, Second, and Third Degrees in S&E from Universities and Other Higher-Education Institutions in Israel, 1994/95–2007/08



Source: Central Bureau of Statistics.

Figure 5.21 shows the representation of women among total R&D employees in the business sector. In Israel, the average share of women in R&D employment was constant at 25 percent between 1999 and 2006. Comparing this with the data presented above in this chapter, we note that Israel ranks well in this respect by international standards. While Israel does not rest at the top of the table and falls below countries such as Denmark (31.7 percent), Hungary (30 percent), and Singapore (28.4 percent), its rate resembles that of Belgium (24.7 percent), the UK (24.4 percent) and Sweden (25.2 percent).

Figure 5.21: Share of Women Employed in R&D (Head Count) in Total R&D Employees in Business Sector, 2006



Source: Central Bureau of Statistics.

6. Economic Indicators of Science and Technology Activity

- **High-tech industries contributed 4.8 percent to Israel's GDP and medium-high technology industries contributed 2.3 percent (2009).**
- **Per-employee production is 1.3 times the national average in high-tech industries and 1.9 times the national average in medium-high technology industries—the highest among OECD countries (2006).**
- **Per-employee production in R&D and computer and related services is 2.1 times the national average—the highest among OECD countries (2006).**
- **The average wage in high-tech industries and in service industries identified with high-tech was 1.9 times and 2.0 times the national average wage, respectively (2009)—again, the highest among OECD countries.**
- **In 2009, there were 268,000 employee posts in high-tech, 9.6 percent of all employee posts—159,000 in services and 109,000 in manufacturing.**

Economic growth in the modern era is based not only on investing more in physical and/or human capital but also on knowledge and technology that allow other resources to be used efficiently and effectively, i.e., improving total factor productivity (TFP). Israel must predicate its economic growth on improvements in productivity because its labor and capital resources are limited, as are the sources with which it may expand them steadily over time.

This chapter presents indicators that reflect the effect of technological progress on economic growth—both as an exogenous factor and via the traditional factors of capital and labor—and examines the share of knowledge-intensive industries in the Israeli economy.

Some of the indicators are presented on the basis of the classification of industries by technology intensity as proposed in 1997 by the OECD. This classification divides the relevant industries into four groups:

- **high-tech industries**—comprised of electronic and optical equipment (including medical equipment), control and supervision equipment, office machinery and computers, aircraft, and pharmaceuticals;
- **medium-high technology industries**— comprised of oil refining, petrochemicals excluding pharmaceuticals, machinery, electrical equipment and motors, and transport equipment excluding aircraft;

- **medium-low technology industries**—comprised of mining and quarrying, rubber and plastic, basic metals, metal products, ferrous and nonferrous minerals, and jewelry;
- **low-tech industries**—comprised of food, beverages, and tobacco; textiles; clothing; leather products; paper; printing; wood and its products; and furniture.

We also focus on two service industries that typically make extensive use of advanced technologies: research and development and computer and related services.

6.1 Product

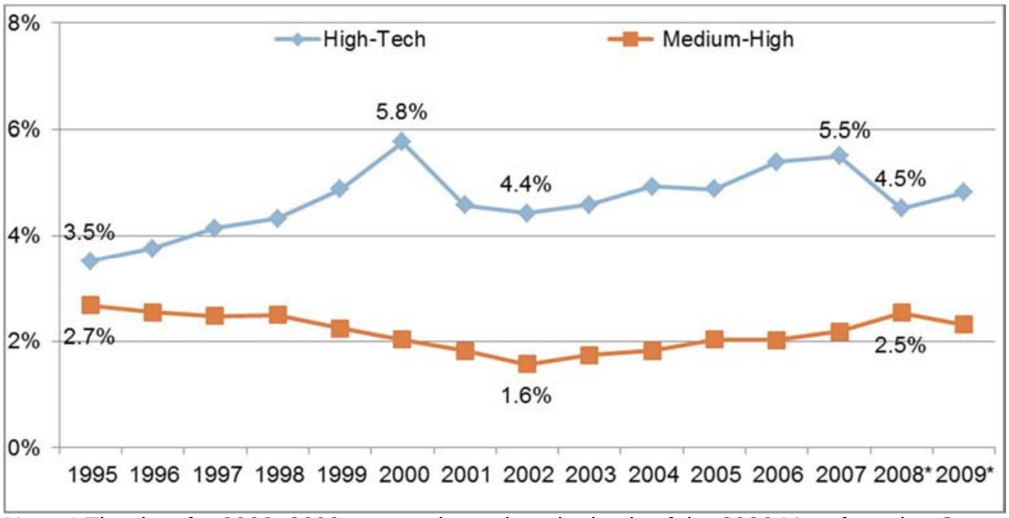
This section provides a macro-level analysis and examines the contribution of high-tech and medium-high technology industries to the aggregate indicators of Israel's economic output.

6.1.1 Share of High-Tech and Medium-High Technology Industries in GDP

The share of high-tech and medium-high technology industries in GDP increased between 1995 in 2008 but at different rates. The share of high-tech climbed from 3.5 percent in 1995 to 5.8 percent in 2000 and then, evidently under the influence of the "dotcom crisis," retreated to 4.4 percent in 2002. A net increase in 2002–2007 (from 4.4 percent to 5.5 percent) was followed by another retreat, to 4.5 percent of GDP in 2008. Preliminary data suggest that a slight increase occurred in 2009.

The contribution of medium-high technology industries to GDP was less volatile. The trend changed direction only once: in a downward direction from 1995 to 2002 (from 2.7 percent to 1.6 percent) and upward from 2002 on, to 2.5 percent of GDP in 2008 (Figure 6.1). Below we show that 2002 was a watershed year for Israel's medium-high technology industries.

Figure 6.1: Share of High-Tech and Medium-High Technology Industries in GDP, 1995–2007



Note: * The data for 2008–2009 were estimated on the basis of the 2006 Manufacturing Survey and changes in the manufacturing production index.
Source: Central Bureau of Statistics.

6.1.2 Share of Selected Industries in Business Product

Gross Domestic Product of the business sector (business product) is total GDP net of product of the government sector, municipal authorities, the National Institutions, nonprofit organizations, and housing services.

Table 6.1 presents the share of several knowledge-intensive manufacturing and service industries in business product. Commonalities exist in the development of all these industries. All of them increased their share in business product between 1995 and 2006, all encountered difficulties in 2000–2001, all experienced another crisis in 2003–2004, and most were perceptibly affected by the 2008 crisis. By implication, the factors that affect the growth of Israeli high-tech also affect these industries, but at different levels of intensity.

Table 6.1: Share of Knowledge Intensive Industries in Business Product

Year	Pharmaceuticals	Electronic components	Computer and related activities	R&D
1995	0.4%	0.7%	1.1%	0.2%
1996	0.5%	0.9%	1.4%	0.2%
1997	0.5%	0.8%	1.5%	0.3%
1998	0.5%	0.8%	2.1%	1.2%
1999	0.5%	1.1%	2.7%	1.7%
2000	0.4%	2.5%	2.9%	3.5%
2001	0.6%	1.5%	3.1%	2.7%
2002	1.0%	1.1%	3.8%	2.3%
2003	0.9%	1.3%	3.1%	2.1%
2004	1.3%	1.0%	3.3%	1.9%
2005	1.4%	0.9%	4.2%	2.4%
2006	1.9%	1.1%	4.9%	2.6%
2007	1.7%	1.2%	4.3%	2.5%
2008*	1.8%	0.8%	4.3%	2.4%
2009*	2.0%	1.1%	4.1%	2.2%

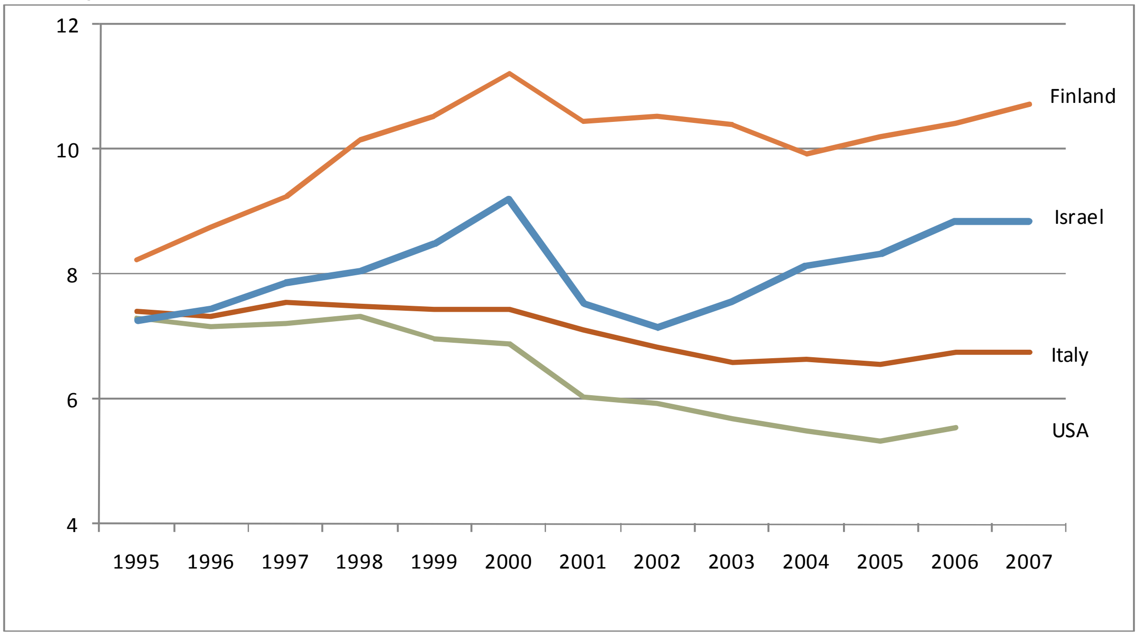
* The data for 2008–2009 were estimated on the basis of the 2006 Manufacturing Survey and changes in the manufacturing production index.
Source: Central Bureau of Statistics.

6.1.3 Share of High-Tech and Medium-High Technology Industries in Total Value Added

The value added of an economic industry is defined as the difference between the value of the industry's output and that of the inputs that the industry used. This indicator accurately reflects the contribution of the industry to the value of the products that it turns out. Consequently, the value added of the entire economy is equal to the value of all products that it manufactures, i.e., Gross Domestic Product in factor-input prices.

The share of high-tech and medium-high technology industries in Israel's total value added increased between 1995 and 2007 and came to almost 8 percent in the latter year. In contrast, some of the relevant industries in several G7 countries, e.g., the U.S. and Italy, posted downward trends during that time (Figure 6.2). Israel's rate of increase resembled that of Finland, an OECD member state that compares well with Israel both in size and as an economy that develops high technology.

Figure 6.2: Share of High-Tech and Medium-High Technology Industries in Total Value Added, 2007



Sources: Central Bureau of Statistics and OECD.Stat.

The contribution to value added of high-tech and medium-high technology industries is divided differently in Israel than in other countries. In all countries listed in Table 6.2, medium-high technology industries contribute more to value added than high-tech industries. Only Israel evinces the opposite relation, with high-tech contributing 5.81 percent of total national value added—the highest rate among all countries shown below.

Table 6.2: Share of High-Tech and Medium-High Technology Industries in Total Value Added, 2007

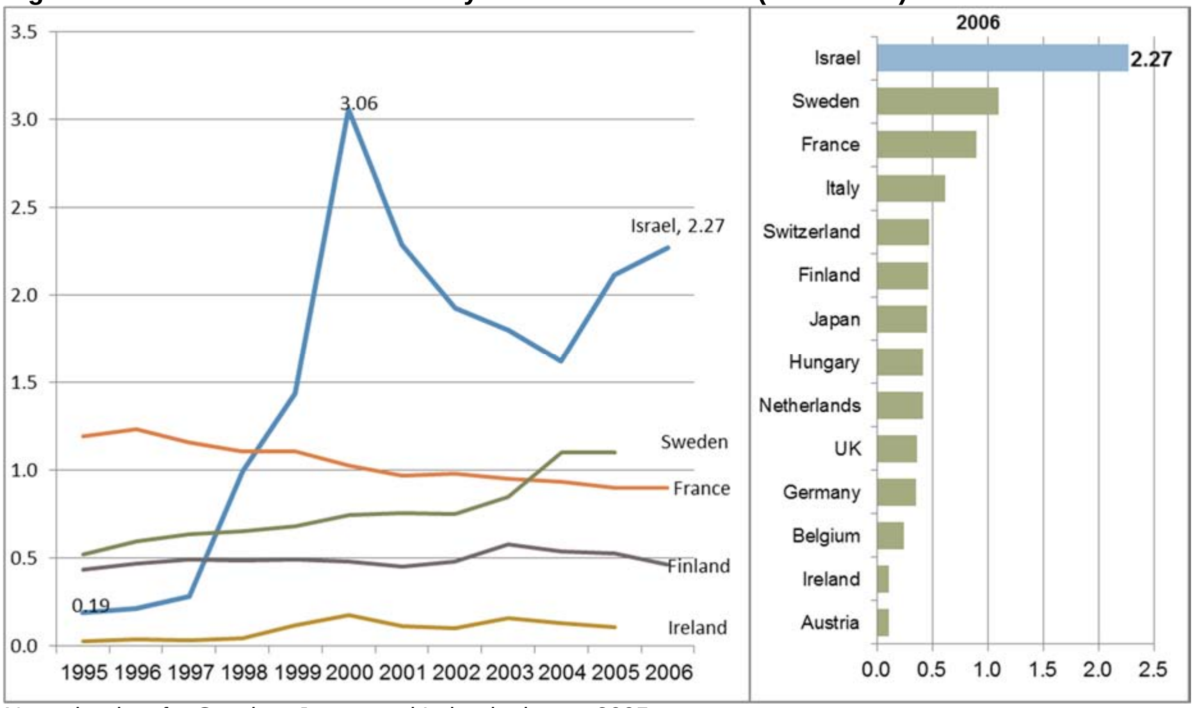
	High-tech	Medium-high tech	Total	High-tech/ medium-high tech. ratio
Germany	3.05	10.67	13.72	0.3
Finland	5.29	5.43	10.71	1.0
Sweden*	4.14	6.08	10.23	0.7
Austria	1.97	6.53	8.50	0.3
Israel	**5.50**	**2.18**	**7.68**	**2.5**
Italy	1.67	5.08	6.75	0.3
Belgium	2.03	4.43	6.46	0.5
Denmark	2.40	3.82	6.22	0.6
U.S.*	2.30	3.24	5.54	0.7
UK*	2.24	3.19	5.43	0.7
Netherlands	0.94	4.02	4.97	0.2
France	1.74	3.20	4.94	0.5
Iceland	0.57	0.76	1.33	0.7

Note: * Data for 2006.
Sources: Central Bureau of Statistics and OECD.Stat.

6.1.4 Share of the R&D Industry in Total Value Added

As noted above (Section 6.1.2), the contribution of R&D to GDP in Israel has grown considerably in the past decade. The country's R&D industry grew at a very rapid pace by international standards in 1997–2000 (Figure 6.3). Even after a contraction induced by the dotcom crisis, the share of R&D in Israel's total value added was the highest among all countries.

Figure 6.3: Share of the R&D Industry in Total Value Added (1995–2006)



Note: the data for Sweden, Japan, and Ireland relate to 2005.
Sources: Central Bureau of Statistics and OECD.Stat.

6.2 Indicators of Economic Growth and Productivity

The accepted model for the calculation of economic growth and productivity in OECD countries is Solow's model:

$$Y = AK^{\alpha}L^{\beta}$$

where:

Y—GDP

K—capital

L—labor

A—total factor productivity, a.k.a. technological level.

α, β—positive values.

According to this model, GDP may increase over time if an increase occurs in the inputs of capital and labor (K and L, respectively) and if improvements occur in technology, the quality of human resources, and the quality of the equipment included in the capital that allows a given quantity of capital and labor to generate production (= an increase in A). The growth rate is the rate of change in GDP (Y) over time.

This section relates to two growth indicators that are strongly associated with R&D and science and technology activity: total factor productivity (TFP) and labor productivity.

6.2.1 Increase in Total Factor Productivity

Between 2001 and 2007, Israel's TFP increased by 2.0% on annual average, outpacing most OECD countries (Figure 6.4). The annual changes in Israeli TFP, however, were typically more volatile than those in other countries. TFP is not measured directly; instead, it is estimated statistically on the basis of Solow's model (see above), labor-force data, and estimates—problematic in themselves—of capital services.

Figure 6.4: Total Factor Productivity Growth (pct.), 1996–2008

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Israel	-0.8	-2.7	0.5	-1.3	6.6	-3.1	-5.0	1.3	6.4	4.1	4.3	1.0	-0.5
Ireland	3.8	7.6	3.7	4.8	4.3	2.4	4.6	2.9	0.8	1.6	1.3	2.0	-2.2
Sweden	0.6	2.5	1.7	1.2	2.2	-0.2	2.9	2.9	3.0	2.1	2.3	-0.4	-2.6
Japan	1.0	1.1	-1.2	1.3	2.0	0.5	1.3	1.2	2.7	1.8	1.1	1.8	
U.S.	1.7	0.9	1.3	1.8	1.7	1.2	2.1	2.3	2.0	1.1	0.5	0.8	0.5

Sources: Central Bureau of Statistics and OECD.Stat.

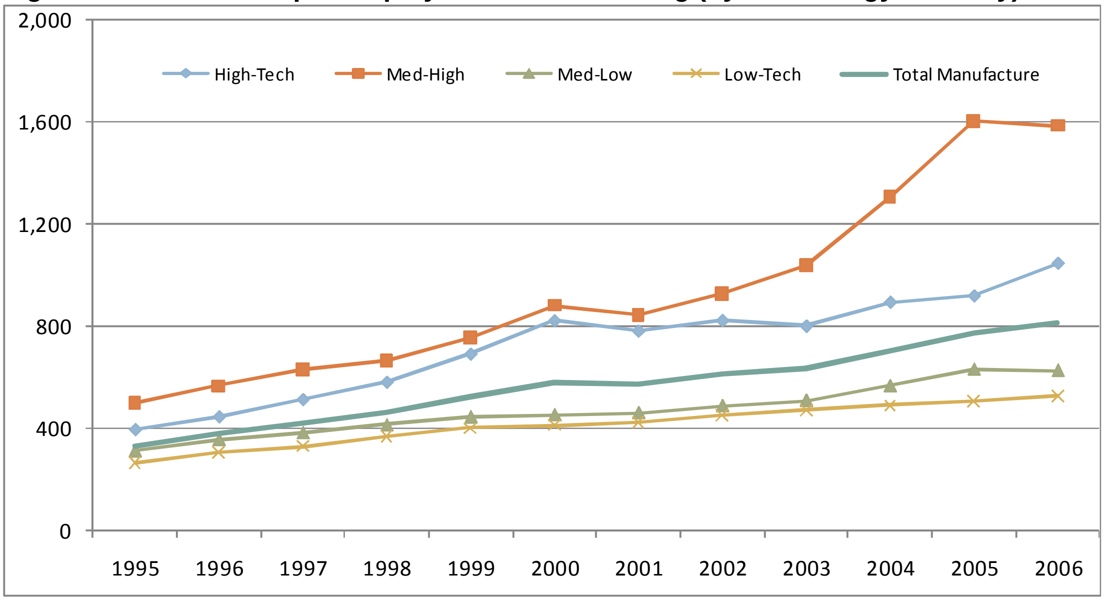
6.2.2 <u>Production per Employee</u>

Production per employee in an economic unit is defined as the value of goods and services produced by the unit divided by the number of persons that the unit employs.

6.2.2.1 Production per Employee in Israeli Industries, by Technology Intensity

Figure 6.5 charts trends the change in production per employee in manufacturing at large and in various industries by technology intensity. Production per employee was higher and grew faster in high-tech and medium-high technology industries than in others. Especially noteworthy is the spurt that occurred in production per employee in medium-high technology industries starting in 2002.

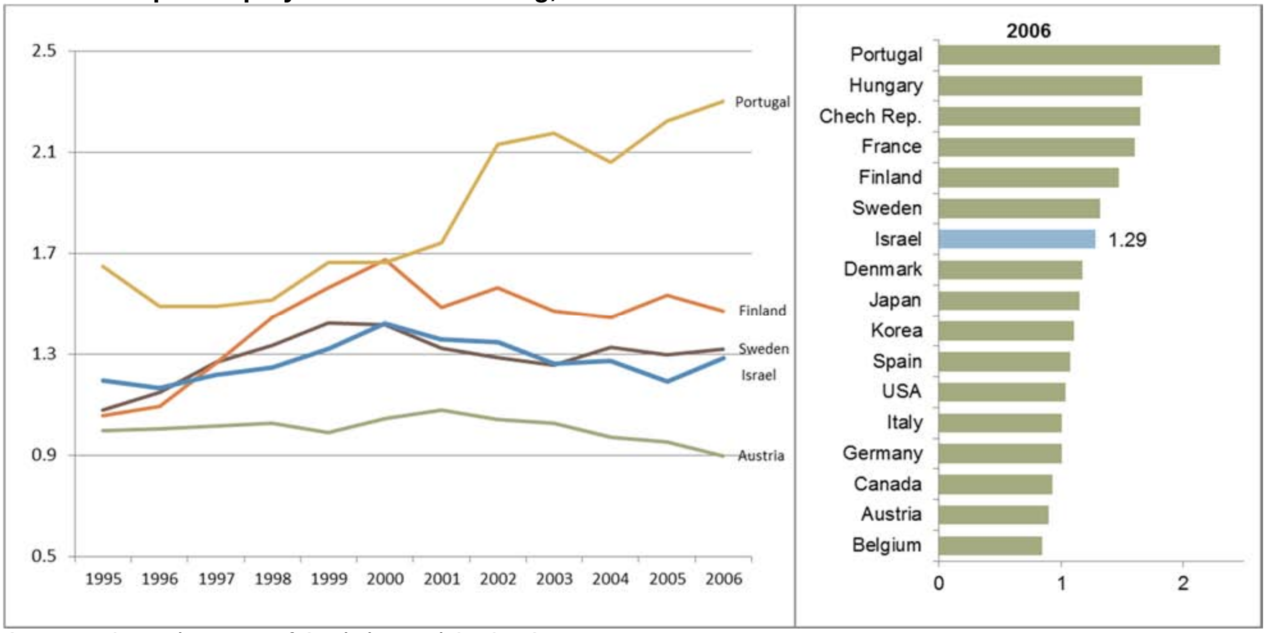
Figure 6.5: Production per Employee in Manufacturing (by Technology Intensity)



Source: Central Bureau of Statistics.

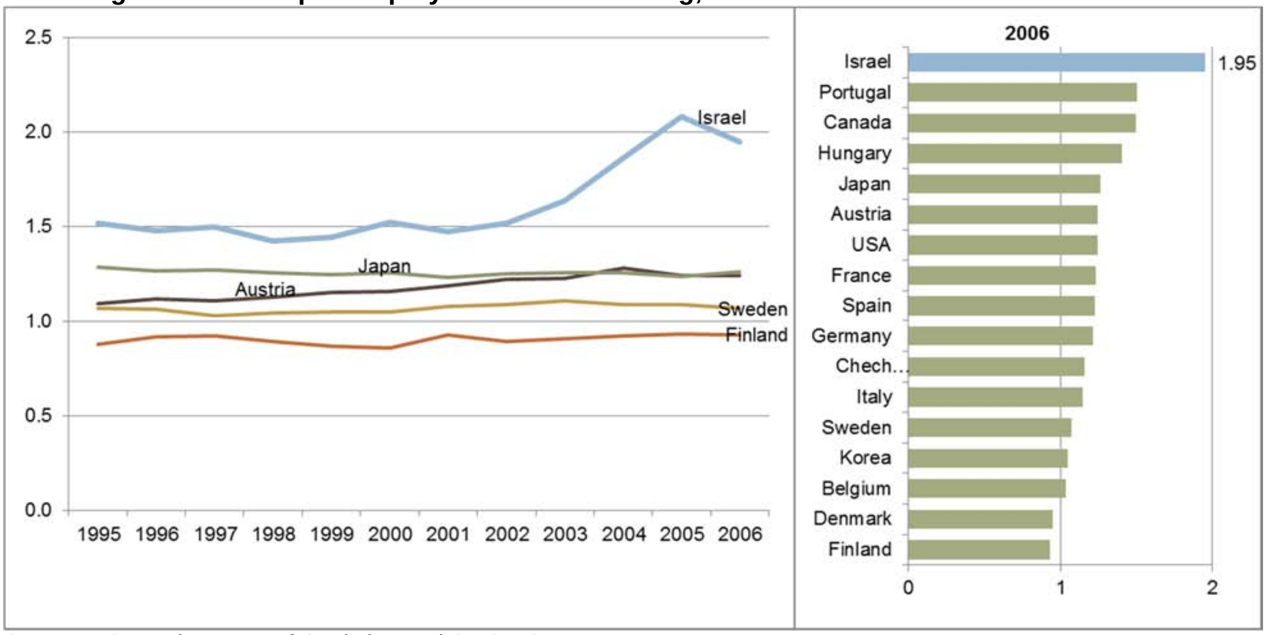
By international comparison, production per employee in high-tech industries has been developing similarly in Israel as in other countries (except Portugal). In medium-high-technology industries, however, the ratio of per-employee production to average per-employee production in manufacturing was high in Israel by the standards of developed countries throughout the 1995–2006 period. Furthermore, the big leap that Israel experienced in per-employee production in 2002–2005 was exceptional among OECD countries. These two phenomena may be related: the infrastructures that assured high per-employee production in medium-high technology industries also made it easier to adjust to the situation that followed the dotcom crisis. Production per employee in medium-high-technology industries increased in other countries as well, but at a much lower rate than Israel's.

Figure 6.6: Production per Employee in High-Tech Industries as Ratio of Average Production per Employee in Manufacturing, 1995–2006



Sources: Central Bureau of Statistics and OECD.Stat.

Figure 6.7: Production per Employee in Medium-High Technology Industries as Ratio of Average Production per Employee in Manufacturing, 1995–2006



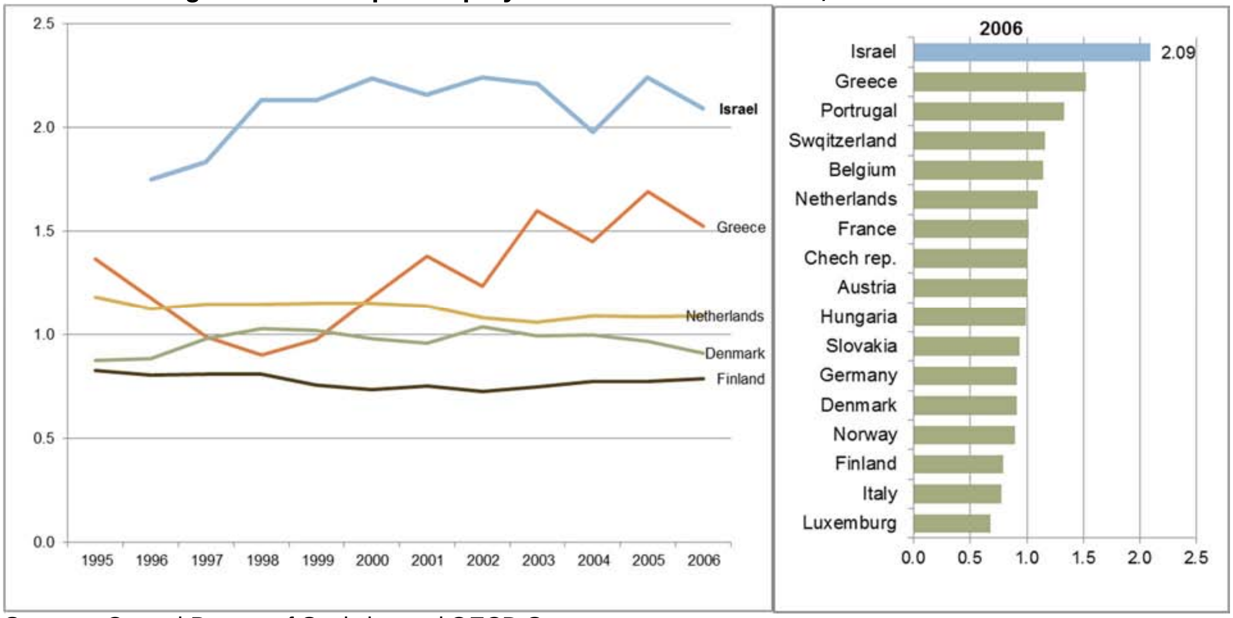
Sources: Central Bureau of Statistics and OECD.Stat.

6.2.2.2 Production per Employee in Selected Service Industries, Israel and OECD countries

Any attempt to calculate production in technology-intensive service industries encounters severe measurement problems that originate in the relatively large share of startups that have not begun to generate sales income. Another difficulty concerns how to distinguish between startups in R&D and those in computer and related services.

Despite these difficulties, it is possible to present a general picture of production per employee in technological service industries relative to average production in all business-service industries (Figure 6.8). The ratio of per-employee production in R&D and computer and related services to business-service industries at large was almost twice as high in Israel as in the peer countries throughout the 1995–2006 period.

Figure 6.8: Production per Employee in R&D and Computer and Related Services as Ratio of Average Production per Employee in Business Services, 1995–2006



Sources: Central Bureau of Statistics and OECD.Stat.

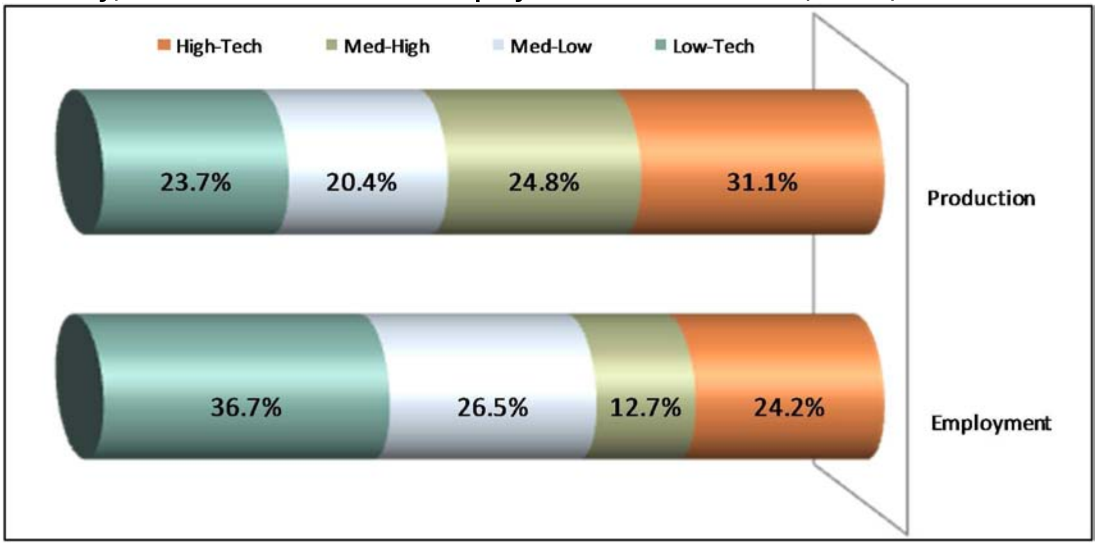
6.2.2.3 Production and Share of Employees in Manufacturing, by Technology Intensity, in Total Production and Employment in Manufacturing

Production per employee is an indicator of labor efficiency in various industries. To measure the contribution of the industries to total economic output, however, the production and employment data need to be calculated separately.

Figure 6.9 presents the distribution of production and employment in manufacturing by levels of technology intensity in 2006. Production was highest in high-tech and medium-high technology industries, at 31.1 percent and 24.8 percent of total manufacturing production, respectively. The same sectors, however, were also the smallest in terms of employment, at 24.2 percent and 12.7 percent of total manufacturing employment, respectively.

Again, the strong relation between production and employment in medium-high technology industries is visible. This sector employees only about one-eighth of manufacturing workers but generates almost one-fourth of total manufacturing production.

Figure 6.9: Production and Share of Employees in Manufacturing, by Technology Intensity, in Total Production and Employment in Manufactures, Israel, 2006



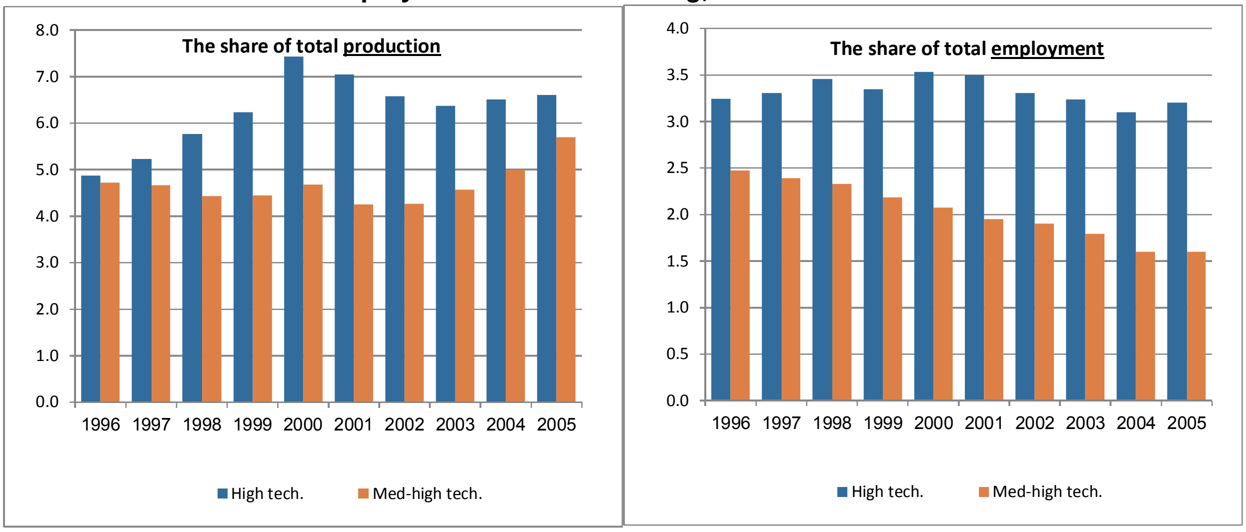
Source: Central Bureau of Statistics.

6.2.2.4 Share of High-Tech and Medium-High Technology Industries in Total National Production and Employment

Examining the share of production and employment in high-tech and medium-high technology industries in total national production and employment, we find much the same picture as that observed in previous sections of this chapter. The rates of both production and employment in high-tech industries began to decline in 2000 and continued to do so until the middle of the decade (Figure 6.10).

Conversely, the share of medium-high technology industries in total national production has been increasing since 2002 and is verging on that of high-tech, but these industries' share in employment has been declining steadily at least since 1996. In 2005, only 1.6 percent of employees countrywide worked in medium-high technology industries.

Figure 6.10: Share of High-Tech and Medium-High Technology Industries in Total National Production and Employment in Manufacturing, 1996–2005



Source: Central Bureau of Statistics.

As Table 6.3 shows, this is a very low percentage by the standards of developed countries. However, high-tech employees in Israel are 3.2 percent of total employees, the second-highest rate among OECD countries (surpassed only by S. Korea, at 3.21 percent).

Table 6.3: Share of High-Tech and Medium-High Technology Industries in Total Employment, Selected Countries, 2006

	High-tech	**Medium-High**	**Total**
Germany	1.86	7.10	**8.96**
S. Korea	3.21	5.32	**8.53**
Japan	2.20	5.10	**7.30**
Sweden	1.87	5.16	**7.02**
Finland	2.19	4.37	**6.56**
Denmark	1.53	3.70	**5.23**
Belgium	1.15	3.72	**4.86**
Israel	3.20	1.60	**4.80**
France	1.25	3.03	**4.28**
Spain	0.80	3.44	**4.24**
U.S.	1.32	2.21	**3.53**
Canada	0.95	2.51	**3.46**

Note: the data for Israel and Denmark relate to 2005.
Sources: Central Bureau of Statistics and OECD.Stat.

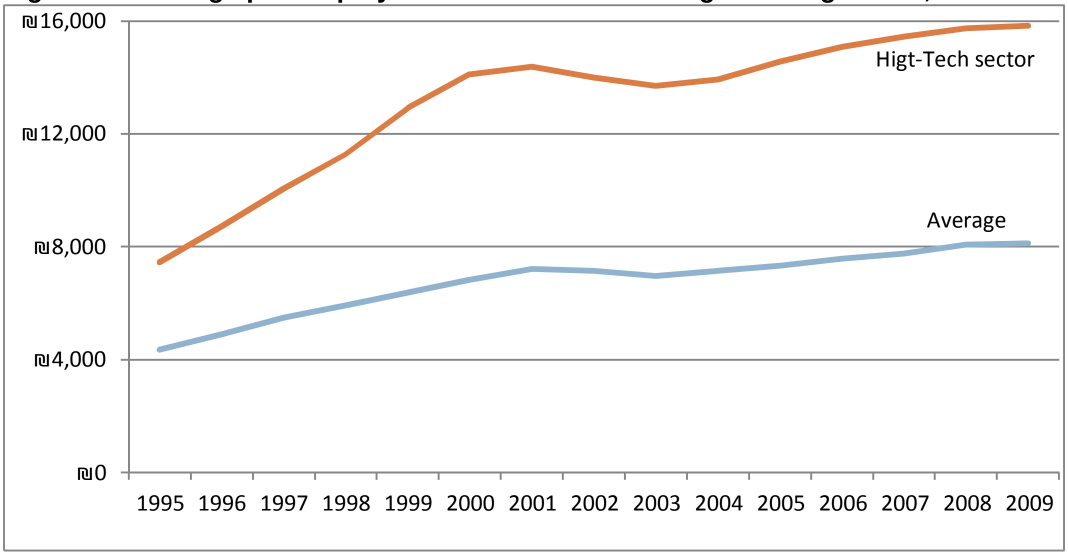
To sum up this section in two sentences, employment and production in Israeli high-tech are relatively strong and production per employee has been stable for years. In medium-high technology industries, employment is relatively small and falling and production has been rising steadily, signifying relatively high and rising rates of production per employee.

6.3 Employment and Wages in Technology-Intensive Industries

This section illustrates the singularity of Israel's technology-intensive industries (both manufacturing and services) in two respects: scale of employment and conditions of employment relative to the rest of the economy.

6.3.1 Gross Wage per Employee in High-Tech vs. National Average Wage

Figure 6.11: Wage per Employee Post—National Average and High-Tech, 1995–2009



Source: Central Bureau of Statistics.

Table 6.4: Wage per Employee Post—National Average and High-Tech, Manufacturing and Services, 1995–2009

	Natl. avg.	Hi-tech manufact.	Hi-tech services	ICT manufact.	ICT services	Hi-tech manufact.	Hi-tech services	ICT manufact.	ICT services
	NIS	NIS				Vs. national average wage			
1995	4,355	7,482	7,386			1.7	1.7		
1996	4,915	8,843	8,569			1.8	1.7		
1997	5,493	10,175	9,934			1.9	1.8		
1998	5,914	11,377	11,150			1.9	1.9		
1999	6,377	12,861	12,973			2.0	2.0		
2000	6,835	13,401	14,714			2.0	2.2		
2001	7,207	13,774	14,879	14,286	14,879	1.9	2.1	2.0	2.1
2002	7,147	13,991	13,995	14,398	13,995	2.0	2.0	2.0	2.0
2003	6,972	13,909	13,540	14,188	13,540	2.0	1.9	2.0	1.9
2004	7,145	13,962	13,928	14,612	13,926	2.0	1.9	2.0	1.9
2005	7,324	14,535	14,579	15,129	14,592	2.0	2.0	2.1	2.0
2006	7,576	14,991	15,161	15,592	15,161	2.0	2.0	2.1	2.0
2007	7,749	15,431	15,462	16,067	15,470	2.0	2.0	2.1	2.0
2008	8,075	15,478	15,937	16,012	15,932	1.9	2.0	2.0	2.0
2009	8,131	15,569	16,009	16,115	16,009	1.9	2.0	2.0	2.0

Source: Central Bureau of Statistics.

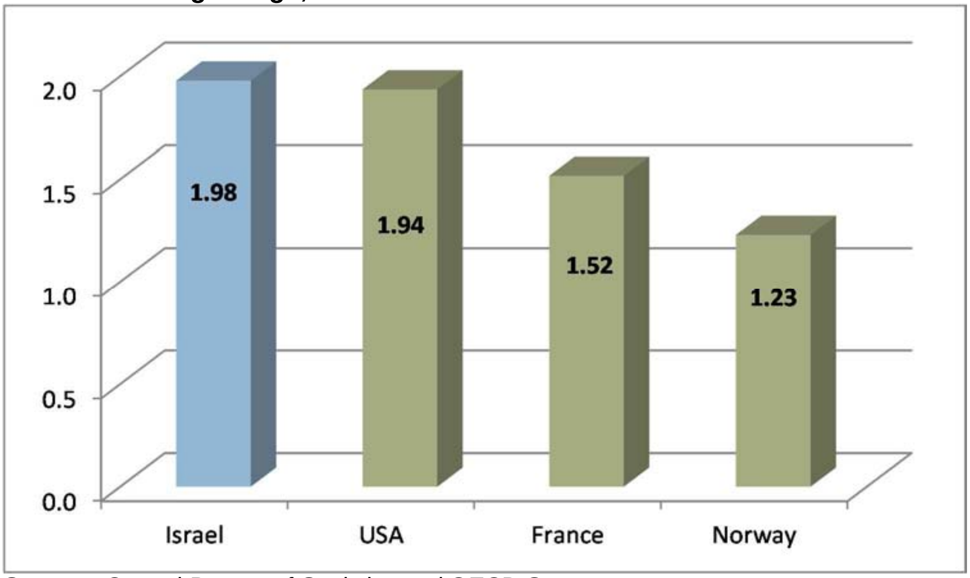
Wages rose more quickly in technology-intensive industries (manufacturing and services) than in the rest of the economy. Wages in high-tech have been almost double the national average since 1999. Although average wages are higher in ICT manufacturing industries than in services, in the broad aggregate of high-tech industries at large, services have paid slightly higher wages in recent years.

The data also show the pounding that the high-tech service industries absorbed in the 2001–2003 crisis. The ratio of average wage in these industries to the national average wage narrowed from 2.06 in 2001 to 1.96 in 2003 and did not level off at around 2.0 until 2006–2007. In the high-tech manufacturing industries, in contrast, the crisis was hardly manifested in wages; salaries in these fields continued to rise steadily, from 1.91 times the national average wage in 2002 to 1.99 in 2007.

The ratio of high-tech wages to the national average wage is higher in Israel than elsewhere (Figure 6.12 and 6.13). The disparity stands out in service industries in particular and in R&D above all.

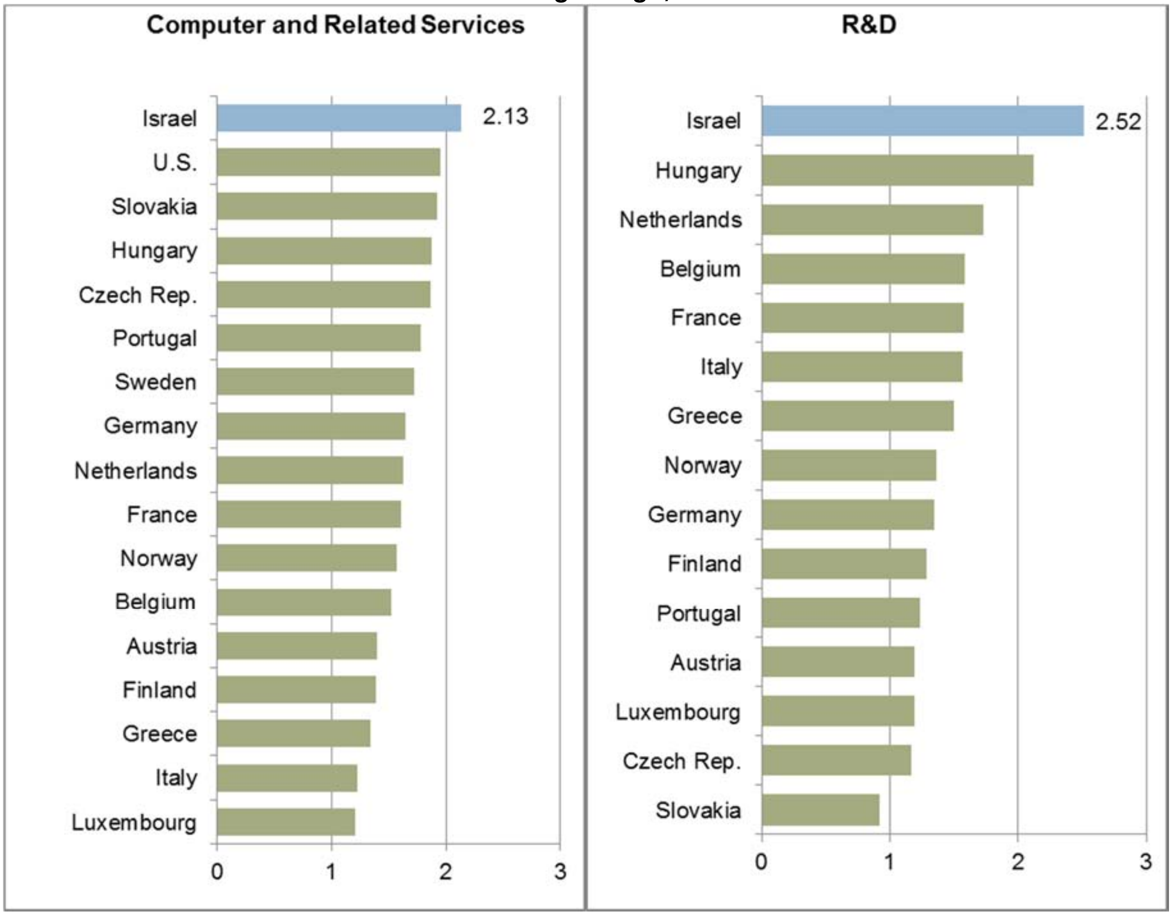
Notably, despite all the worldwide crises and changes, the ratio of wages in high-tech industries to the national average wage has remained constant in most developed countries. Thus, Israel has maintained its international standing in this sense, at least since 2000.

Figure 6.12: Average Wage per Employee Post in High-Tech Manufacturing Relative to National Average Wage, 2006



Sources: Central Bureau of Statistics and OECD.Stat.

Figure 6.13: Average Wage per Employee Post in R&D Industry and Computer and Related Services Relative to National Average Wage, 2007



Note: the data for Germany, Norway, Slovakia, Portugal, and France relate to 2006.
Sources: Central Bureau of Statistics and OECD.Stat.

6.3.2 Share of High-Tech in Total Employee Posts

It is conventional wisdom that Israel's high-tech industries are constantly developing and expanding. Figure 6.14, showing changes in number of employee posts in high-tech (in thousands and in percent of total employee posts nationwide) appears to demonstrate the truth of this claim and also provides several important points of emphasis.

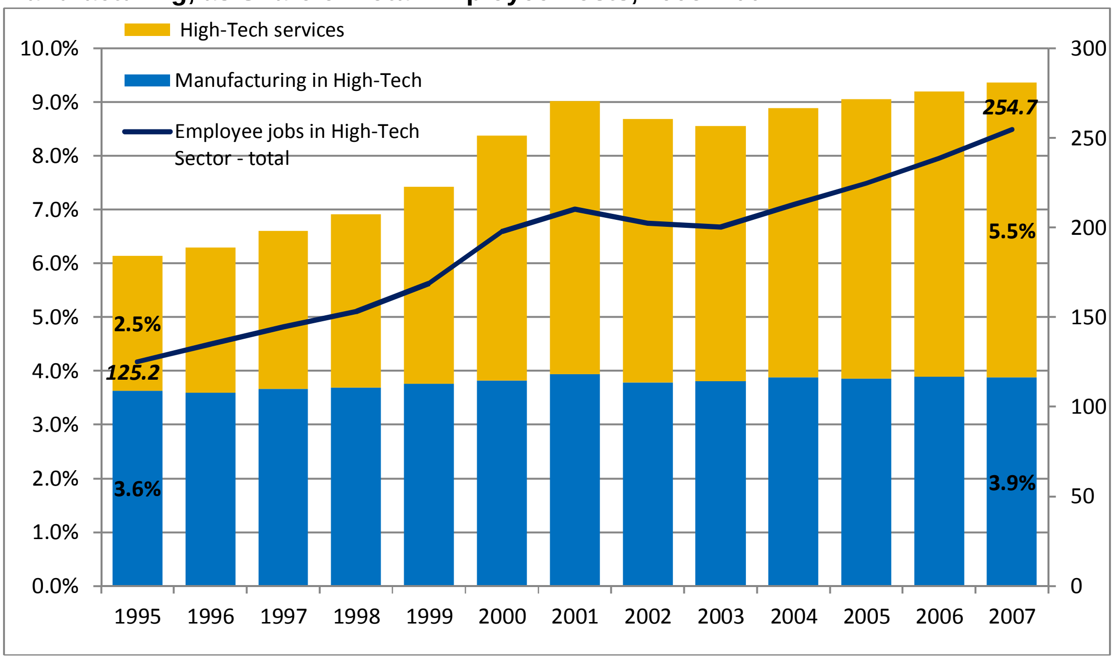
As one may see, the number of employee posts in high-tech increased by a factor of 2.15 within fifteen years (from 125,200 in 1995 to 268,300 in 2009). During most of that period, the number of posts increased and the pace of the upturn was nearly constant. Slight decreases occurred only between 2001 and 2003 (from 210,300 to 200,300) and between 2008 and 2009 (from 269,700 to 268,300) due to the recent crisis.

The share of high-tech in total employee posts also increased considerably, from 6.1 percent in 1995 to 9.6 percent in 2009. However, the proportion of employees who worked in high-tech manufacturing industries hardly changed during that time, inching upward from 3.6 percent in 1995 to 3.9 percent in 2009. The massive increase traces almost entirely to growth of the service industries, which generated 51,100 employee posts in 1995—2.5 percent of all employee posts—and 5.7 percent in 2009 (159,300).

Due to the difference in the rates of change, the ratio of high-tech employees in service industries to those in manufacturing industries has turned around. In 1995, 59 percent of all employee posts in high-tech were in manufacturing and only 41 percent were in the services. In 2009, the rates were reversed. This change reflects the process that transformed Israel into a country that specializes in technological services.

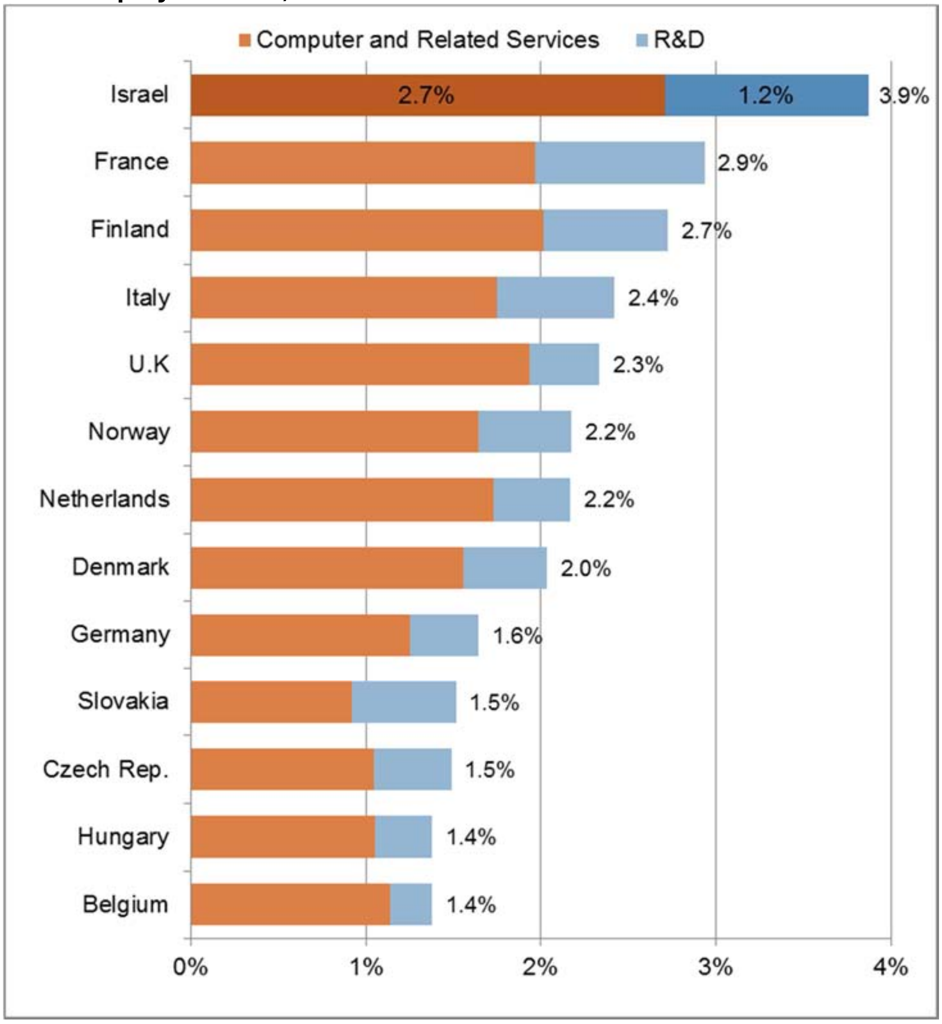
By international comparison, too, Israel has a high percent of employees in technological services among total employees by OECD standards. This is true both in computer and related services and in the R&D industry (Figure 6.15).

Figure 6.13: Employee Posts in Israeli High-Tech (Thousands), Services and Manufacturing, as Share of Total Employee Posts, 1995–2007



Source: Central Bureau of Statistics.

Figure 6.14: Employee Posts in R&D and Computer and Related Services as Share of Total Employee Posts, 2006



Note: the data for Denmark relate to 2005.
Sources: Central Bureau of Statistics and OECD.Stat.

6.4 Conclusion

- In 2000–2004, Israel's knowledge-intensive industries slumped due to the global dotcom crisis in 2000 and the economic crisis in 2003. Growth resumed in 2005 but at a slower pace than before the crises.
- The growth rate of Israel's medium-high technology industries accelerated in the years following the crisis in the early 2000s; today, these industries are developing more quickly than high-tech. However, high-tech still makes the larger contribution to Israeli manufacturing production.
- Most growth in Israel's knowledge-intensive industries is taking place in the technological services—R&D and computer and related services.
- The share of high-tech manufacturing and, above all, high-tech services is much greater in Israel than in other countries.

7. Science and Technology Output

- **The number of Israeli patents applied for and registered with the Israel Patent Authority (IPA), the USPTO, and the EPO has been trending up in the past decade.**
- **Some 67.5 percent of Israel-assigned patents recorded with USPTO in 1991–2009 belonged to firms. The others belonged to individuals, universities, and government bodies. A plurality of patent applications from Israeli firms and inventors, and patents granted to them, are in ICT: about one-third of patents of Israeli firms that registered patents in the U.S. and 21 percent of Israeli patent applications with the IPA.**
- **The most sought-after industry for the registration of foreign patents with the IPA is pharmaceuticals. In 1990–2008, 41 percent of patent applications from foreign firms in Israel were associated with this industry, as against 11 percent of Israeli applications.**
- **Israel ranked fifth in per-capita publications in scientific journals between 2004 and 2008 (a decline of two ranks relative to our previous report in this series, relating to 2001–2005) and in tenth place on the scale of quality (average citations per publication) in 1981–2008.**
- **In 2004–2008, 1.13 percent of publications worldwide were Israeli. (In the previous report, relating to 2001–2005, Israel's share was 1.25 percent).**
- **The quality of Israeli publications in the field of space science and physics is especially high, with average citations 50 percent above the world average. In immunology, psychology/psychiatry, and the social sciences, average citations of Israeli publications were below the world average in 2004–2008**

Several indicators are conventionally used to measure the outputs of scientific and technological research. The most common of them are:

- number of patents;
- number of scientific publications and extent to which they are cited, as an indicator of research quality.

Scientific publications are an indicator of knowledge that is created mainly in academia; patents attest to technological achievements that have economic potential. This chapter expands on and presents data related to these indicators.

We circumscribe our remarks by noting that (1) it sometimes takes years for research outcomes to mature after the research work is done; (2) not every specific invention that has commercial potential is registered as a patent for commercial and other reasons; and (3) some fruitful research efforts do not mature into a publication and are disseminated in other ways that are difficult to measure.

This chapter presents data about Israeli and foreign patents (R&D outputs) that were submitted for registration with the Israel Patent Authority (IPA) and Israeli patents presented for the same purpose to the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO). The data include international comparisons and reference to the inventors' or assignees' place of residence, priority date,[35] technological classification, and industry and sectoral classification. Farther on, we present data on scientific publications (another form of R&D output) by Israeli researchers in academic journals or at scientific conferences. In this respect, we provide international comparisons including reference to researcher's address, research institute, sectoral affiliation, and different fields of research.

The sources of data in this chapter are the Thomson Delphion database, the Israel patent database (shared with us courtesy of the Israel Registrar of Patents), and statistical data from the patent offices, WIPO, and OECD. The pool of publications that we used is the ISI database for Israel and the world collection of citations (both from Thomson). The Israel patent and publications data were put through a complex process of data cleansing, merger of addresses, crediting of each publication and patent to a relevant sector, etc.[36]

7.1 Patents

A patent is a legal right to owner intellectual property; it is issued to inventors by authorized entities in each country. A patent is usually valid for twenty years from the day on which the application is registered, although patents do have to be renewed periodically under the rules of the country of registration. The various countries' patent laws grant inventors a monopoly on their inventions in order to encourage private enterprise to develop inventions and make the economic and intellectual investment that this entails. A patent application includes details about the applicants

[35] The first date on which the patent application is registered anywhere in the world for the purpose of obtaining protection of the investment.

[36] The description of the work and the findings will be published soon by Samuel Neaman Institute in two bibliometric reports that analyze Israel's R&D outputs as manifested in publications and patents.

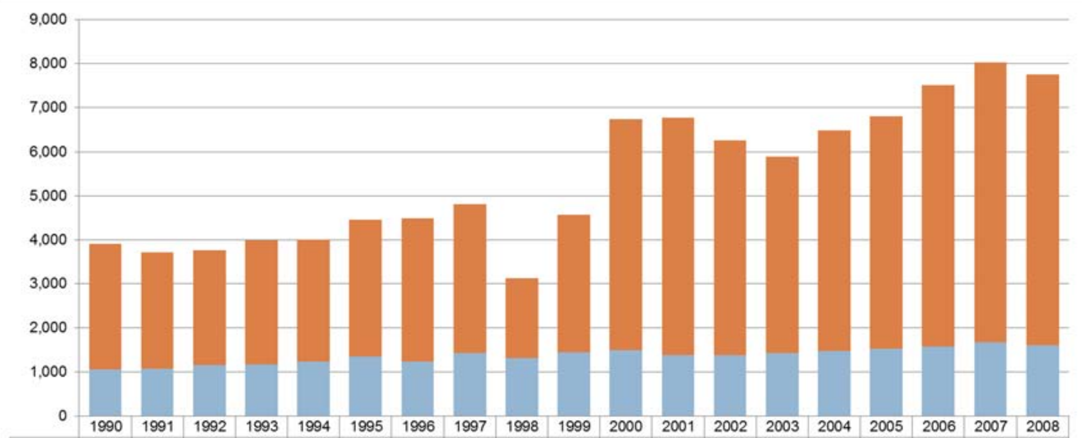
(assignees and inventors), their right to the invention (including partners, employer's rights, etc.), and details about the invention (name, description and sketches, how applied, and claims that define the invention). The application also includes relevant knowledge previously published. For a patent to be granted, the invention has to pass several tests: it must be innovative, it may not be trivial (not self-evident to a person skilled in the relevant technological fields), and it must be "applied," i.e., have commercial potential. Since the registration of patents is territorial, a patent is protected only in countries where it has been registered. In most countries, such protection covers the development, production, and importation of any product based on an idea identical to that of the patented product.

Patents may also serve as an indicator for the measurement of R&D output and productivity and the development of a country's technology and manufacturing industries. Analysis of patent data is one way of understanding inventions and judging whether a dynamic of innovation exists. Since patents provide information about new inventions, they also abet the dissemination of knowledge. Indeed, the patent index is the most common of the few existing measurable indicators of technological output. Notably, however, since patent indicators are calculated in different ways in different countries, one has to be careful when using them for international comparisons of science-and-technology outputs.

7.2 Applications Submitted to the Israel Patent Authority

The Israel Patent Authority (IPA) provides intellectual property in manufacturing with legal protection by registering patents of applicants from Israel and abroad. Figure 7.1 shows the number of patent applications submitted to the IPA by origin (Israel/abroad) in 1990–2008.

Figure 7.1: Patent Applications in Israel, by Origin, 1990–2008

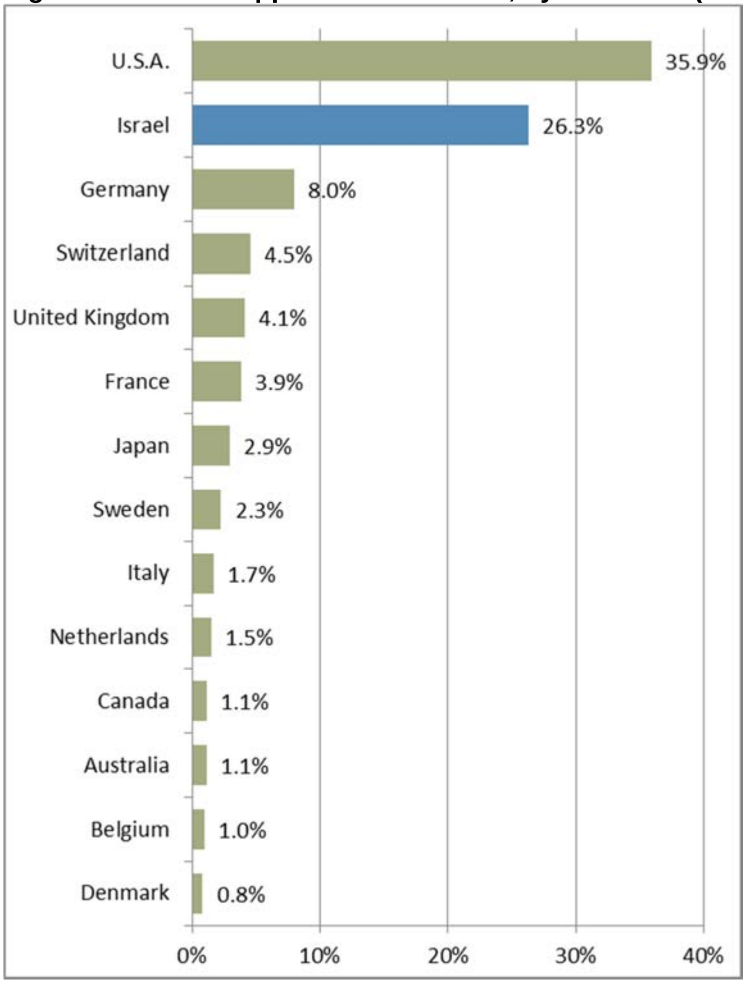


	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Foreign	2,857	2,650	2,605	2,814	2,767	3,116	3,256	3,381	1,804	3,134	5,250	5,381	4,883	4,463	5,008	5,272	5,948	6,347	6,145
Israeli	1,055	1,067	1,156	1,174	1,241	1,341	1,229	1,430	1,317	1,437	1,490	1,381	1,382	1,432	1,479	1,529	1,567	1,673	1,600

Source: IPA

As Figure 7.1 shows, 2007 was the record year in patent applications, both domestic and foreign. The PCT[37] went into effect in Israel in June 1996; this explains the steep decrease in patent applications from abroad in 1996 and 1997. Instead of turning directly to the IPA, some foreign investors preferred to submit PCT applications and to record Israel as one of the target countries. These applications join Israel's national tally 18–30 months after the international application is presented; indeed, the graph shows that the proportion of foreign applications went up considerably in succeeding years. Seventy-eight percent of patent applications presented in the past decade (2000–2008) were of foreign origin (48,697); the share of Israeli applications was only 22 percent (13,533). By comparison, 70 percent of total patent applications with the IPA in 1990–1999 were of foreign origin.

Figure 7.2: Patent Applications with IPA, by Countries (1990–2008 total)



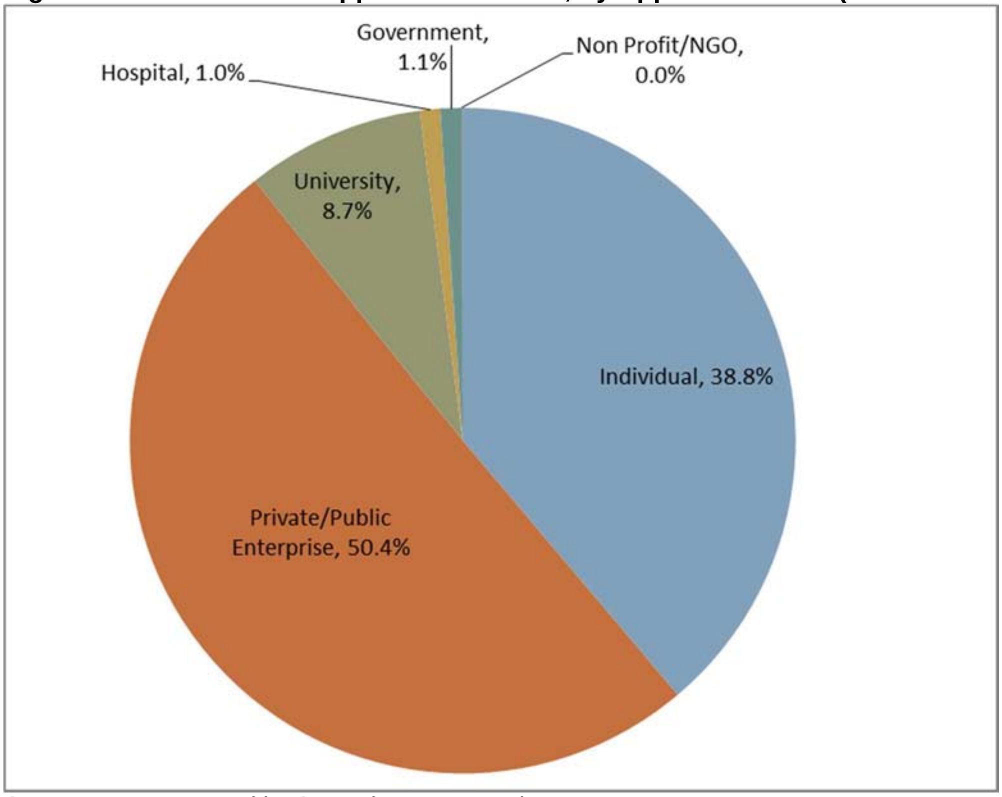
Source: IPA

[37] The Patent Cooperation Treaty (PCT) is an international treaty on patent cooperation. Its purpose is to create a standard mechanism for the registration of patents in several countries on the basis of one international patent application, chiefly to overcome the problem of dissimilarities in different countries' procedural conditions. As of June 2010, 142 countries had joined the PCT.

Most patent applications in Israel come from American assignees (inventors or firms). Israeli applications occupy second place, followed by those from Germany and other countries.

By analyzing the names of the inventors' and assignees' organizations and institutions as shown on patent application forms submitted to the IPA, we may sort the Israeli and foreign applications into applicant sectors: private/public firms, universities, hospitals, government institutions, NGOs, and private individuals.

Figure 7.3: Israeli Patent Applications to IPA, by Applicant Sector (1990–2008 total)

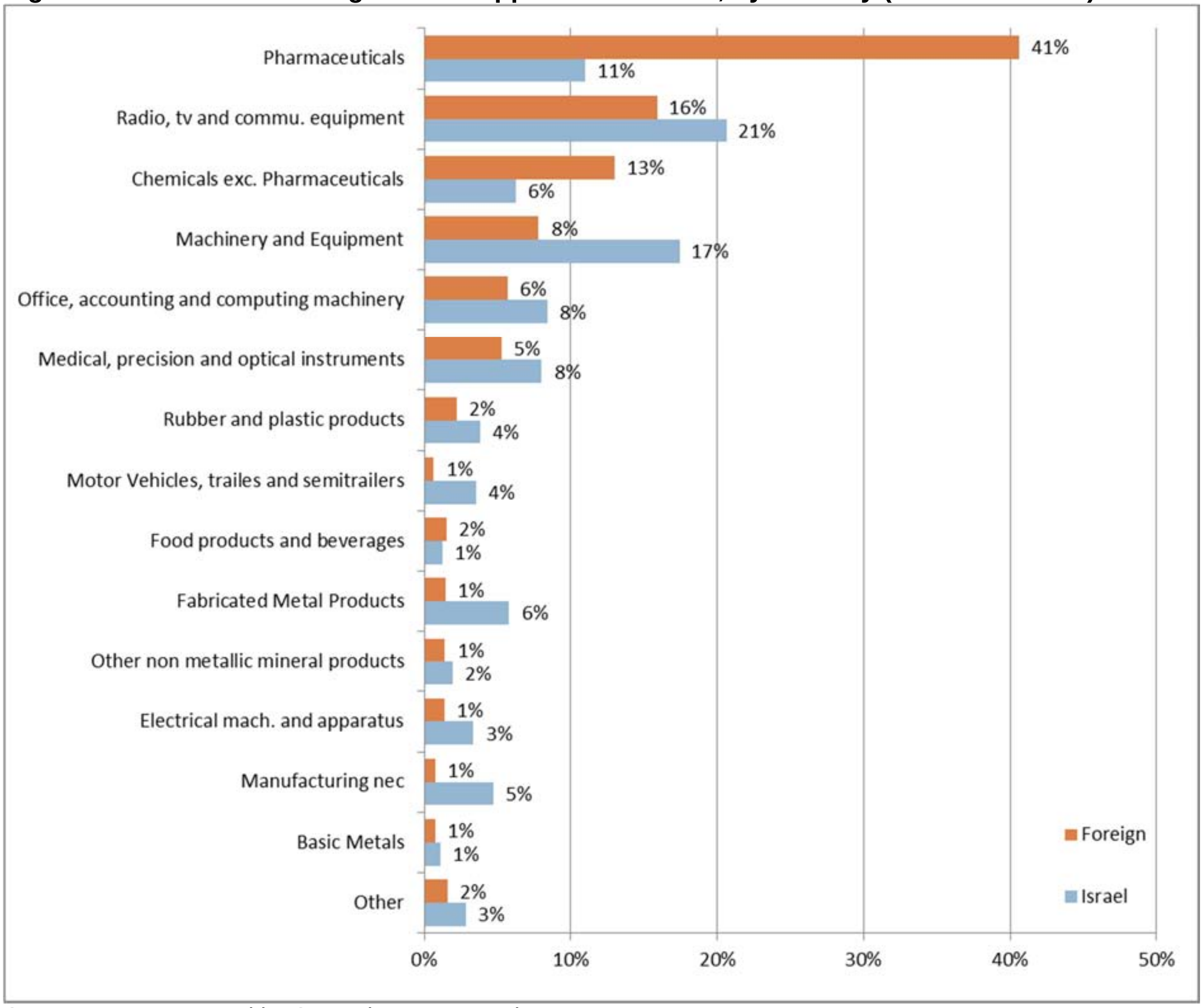


Source: IPA, processed by Samuel Neaman Institute

During this time (1990–2008), about half of the Israeli patent applications were from private or public firms (in manufacturing or services), 9 percent originated in R&D at Israeli universities, and 39 percent came from private individuals. The last-mentioned applications are those that do not specify an institution, organization, or firm. (It should be noted that some Israeli applicants who work for entities in various sectors are allowed to apply for patents as individuals.)

Although patents may serve as indicators of innovation inputs in manufacturing, neither the patent nor its related official documents refer to the industrial sector to which a given patent belongs. To link patent data with industrial sectors, it is necessary to distribute patents across each country's accepted list of industries (as determined by the country's designated collector of statistical data). To segment the patent applications by industries, we used Schmoch's methodology, which converts the IPC (International Patent Classification) into ISIC terms (International Standard Industrial Classification of All Economic Activities). Every patent application is attributed to one industry only.

Figure 7.4: Israeli and Foreign Patent Applications to IPA, by Industry (1990–2008 total)



Source: IPA, processed by Samuel Neaman Institute

Some 41 percent of patent protections sought by foreign firms in Israel are associated with the pharmaceutical industry, as against 11 percent of Israeli applications. Firms such as Merck, Pfizer, Bayer, and Abbott registered thousands of patents in Israel between 1990 and 2008. Importantly, the attribution of a firm to the pharmaceutical industry does not necessarily mean that the firm is a pharmaceutical company; instead, it denotes the holding of a patent that is attributed to this field (due to the conversion from its main IPC code). ICT is the leading industry in Israeli patent applications—21 percent of all Israeli patent applications, as against 16 percent of foreign applications.

7.3 Applications with International Patent Offices

The following tables present total patent applications with USPTO and EPO, parsed by Israel and other countries. Importantly, USPTO bases its classification of applications on the country that appears in the inventor's address (and insofar as several investors are listed, on that shown in the first inventor's address). EPO credits each patent once to each country among those of the applicant investors.

Table 7.1: Patent Applications to USPTO, 1998–2008

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
U.S.	135,483	149,825	164,795	177,511	184,245	188,941	189,536	207,867	221,784	241,347	231,588
Germany	13,885	16,978	17,715	19,900	20,418	18,890	19,824	20,664	22,369	23,608	25,202
Korea	5,452	5,033	5,705	6,719	7,937	10,411	13,646	17,217	21,685	22,976	23,584
Canada	5,689	6,149	6,809	7,221	7,375	7,750	8,202	8,638	9,652	10,421	10,307
UK	4,856	5,202	4,791	5,147	6,110	6,948	7,523	8,362	8,391	7,700	7,792
Israel	1,442	2,009	2,509	2,710	2,645	2,539	2,693	3,157	3,657	4,410	4,550
Sweden	2,359	2,570	2,825	2,827	2,410	2,314	2,270	2,243	2,680	3,164	3,265
Finland	970	1,376	1,530	1,840	1,811	1,935	2,096	2,032	2,383	2,444	2,621
Belgium	1,059	1,204	1,245	1,286	1,293	1,395	1,309	1,460	1,546	1,766	1,609
Singapore	336	460	632	786	807	771	879	919	1,143	1,188	1,266

Source: USPTO.

Table 7.2: Patent Applications to EPO, 1997–2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
EU-27	42,337	46,534	50,848	53,616	53,235	53,035	54,349	56,916	58,245	59,509
U.S.	27,364	29,922	32,299	33,263	32,400	33,589	34,178	35,460	36,498	34,446
Germany	18,379	20,651	22,121	23,462	23,182	23,053	23,424	24,434	25,263	25,287
UK	5,148	5,800	6,515	6,847	6,455	6,373	6,314	6,345	6,274	6,440
Korea	687	972	1,097	1,308	1,658	2,376	3,365	4,481	5,104	5,137
Sweden	2,213	2,267	2,421	2,499	2,334	2,216	2,229	2,380	2,613	2,851
Canada	1,445	1,669	1,948	2,011	2,080	2,136	2,207	2,538	2,670	2,693
Belgium	1,386	1,452	1,660	1,634	1,515	1,609	1,713	1,887	1,841	1,862
Finland	1,078	1,250	1,498	1,524	1,506	1,372	1,362	1,457	1,409	1,445
Israel	711	857	892	1,106	1,017	973	1,088	1,262	1,476	1,340
Singapore	99	133	186	203	251	251	293	340	338	350

Source: OECD.

Since the comparison includes small countries, large countries, and an aggregate of European countries (EU-27), one needs to take country-size differences into account when analyzing the results. Therefore, below we normalize the number of patent applications to EPO and USPTO in two ways: to population size and to total R&D expenditure.

Table 7.3 shows the number of applications to USPTO per million of population in selected countries between 1998 and 2008. Table 7.4 does the same for applications to EPO in 1997–2006.

Table 7.3: Patent Applications to USPTO per Million of Population, 1998–2008

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Korea	753	695	788	928	1,096	1,437	1,884	2,377	2,994	3,172	3,256
U.S.	444	492	541	582	604	620	622	682	728	792	760
Israel	199	277	346	374	365	351	372	436	505	609	628
Finland	183	260	289	347	342	365	395	383	450	461	495
Sweden	257	280	308	308	262	252	247	244	292	345	356
Canada	173	187	207	219	224	235	249	262	293	317	313
Germany	169	207	216	242	248	230	241	251	272	287	307
Singapore	67	92	127	158	162	155	176	184	229	238	254
Belgium	99	113	117	121	121	131	123	137	145	166	151
UK	79	85	78	84	100	114	123	137	137	126	127

Sources: USPTO, OECD

Table 7.4: Patent Applications to EPO per Million of Population, 1997–2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Korea	95	134	151	181	229	328	465	619	705	709
Sweden	241	247	264	272	254	241	243	259	285	311
Germany	224	251	269	285	282	280	285	297	307	308
Finland	203	236	283	288	284	259	257	275	266	273
Israel	98	118	123	153	140	134	150	174	204	185
Belgium	130	136	156	153	142	151	161	177	173	175
EU-27	85	93	102	107	107	106	109	114	117	119
U.S.	90	98	106	109	106	110	112	116	120	113
UK	84	95	107	112	106	104	103	104	103	105
Canada	44	51	59	61	63	65	67	77	81	82
Singapore	20	27	37	41	50	50	59	68	68	70

Source: OECD.

In the indicator of patent applications per million of population, Israel ranks higher at USPTO than at EPO among the countries shown. One reason for this is that many more Israeli applications are presented in the U.S. than in Europe (around 3,000 per year as against about 1,000 on average, respectively, during the period investigated). South Korea is far ahead of the field in applications to USPTO, followed by the U.S. (the “home team”) and then Israel, with an average of some 400 patent applications per million of population. Between 1997 and 2006, Israel presented EPO each year with 148 patent applications per million of population on average. South Korea was also the leader in applications to EPO, besting the countries shown by a considerable margin at 327 applications per million of population on average and posting an impressive annual rate of increase. Following Korea were Germany, Finland, and Sweden, at averages of 260–280 patents per million of population. Singapore and Canada had the lowest values in this indicator among the countries shown.

The next indicator presented is the number of patent applications normalized to R&D investment. This indicator, expressing the ratio of inputs to output, may give evidence of the efficiency of a country’s R&D system. Table 7.5 and Figure 7.5 show the number of patent applications to EPO by the countries listed above per USD 1 million (in 2000 prices, PPP) of investment R&D in between 1997 and 2006. Table

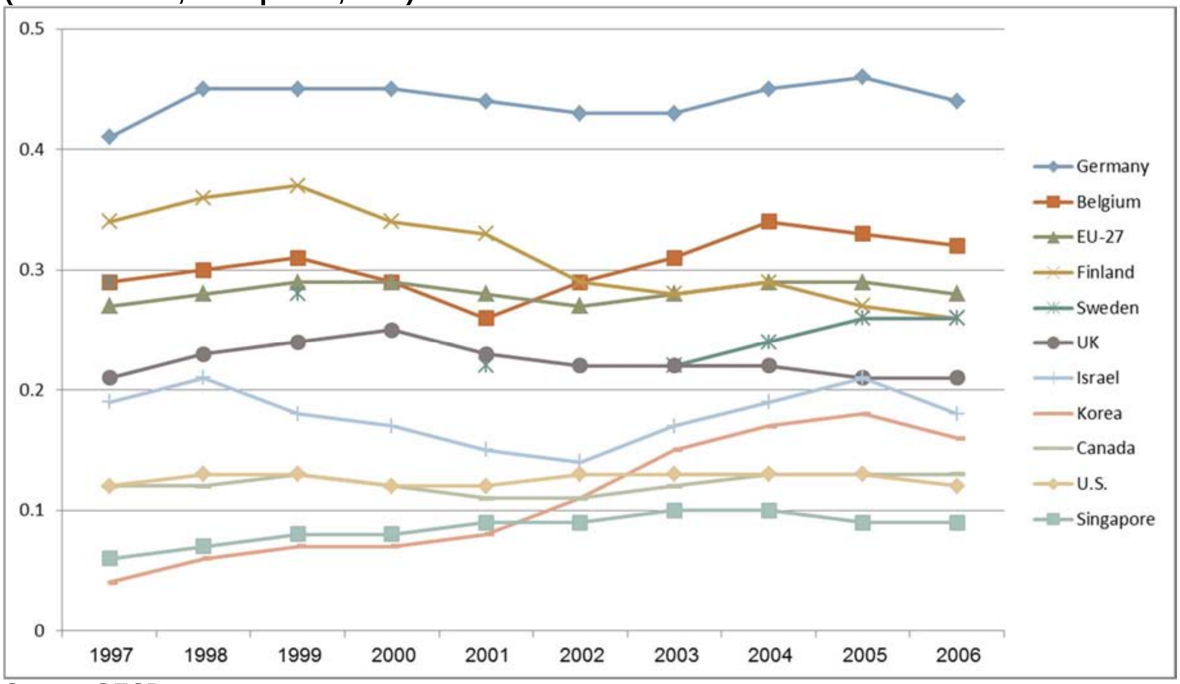
7.6 and Figure 7.6 do the same for applications to USPTO between 1997 and 2006 1998 and 2008. In this indicator (patent applications per R&D investment), each country's curve is more volatile than in the previous indicator (patent applications per million of population) because population size increased more steadily than R&D investment did.

Table 7.5: Patent Applications to EPO Relative to National Investment, 1997–2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Germany	0.41	0.45	0.45	0.45	0.44	0.43	0.43	0.43	0.46	0.44
Belgium	0.29	0.3	0.31	0.29	0.26	0.29	0.31	0.31	0.33	0.32
EU-27	0.27	0.28	0.29	0.29	0.28	0.27	0.28	0.28	0.29	0.28
Finland	0.34	0.36	0.37	0.34	0.33	0.29	0.28	0.28	0.27	0.26
Sweden	0.29		0.28		0.22		0.22	0.22	0.26	0.26
UK	0.21	0.23	0.24	0.25	0.23	0.22	0.22	0.22	0.21	0.21
Israel	0.19	0.21	0.18	0.17	0.15	0.14	0.17	0.17	0.21	0.18
Korea	0.04	0.06	0.07	0.07	0.08	0.11	0.15	0.15	0.18	0.16
Canada	0.12	0.12	0.13	0.12	0.11	0.11	0.12	0.12	0.13	0.13
U.S.	0.12	0.13	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.12
Singapore	0.06	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.09	0.09

Source: OECD.

Figure 7.5: Patent Applications to EPO Relative to National R&D Investment, 1997–2006 (USD millions, 2000 prices, PPP)



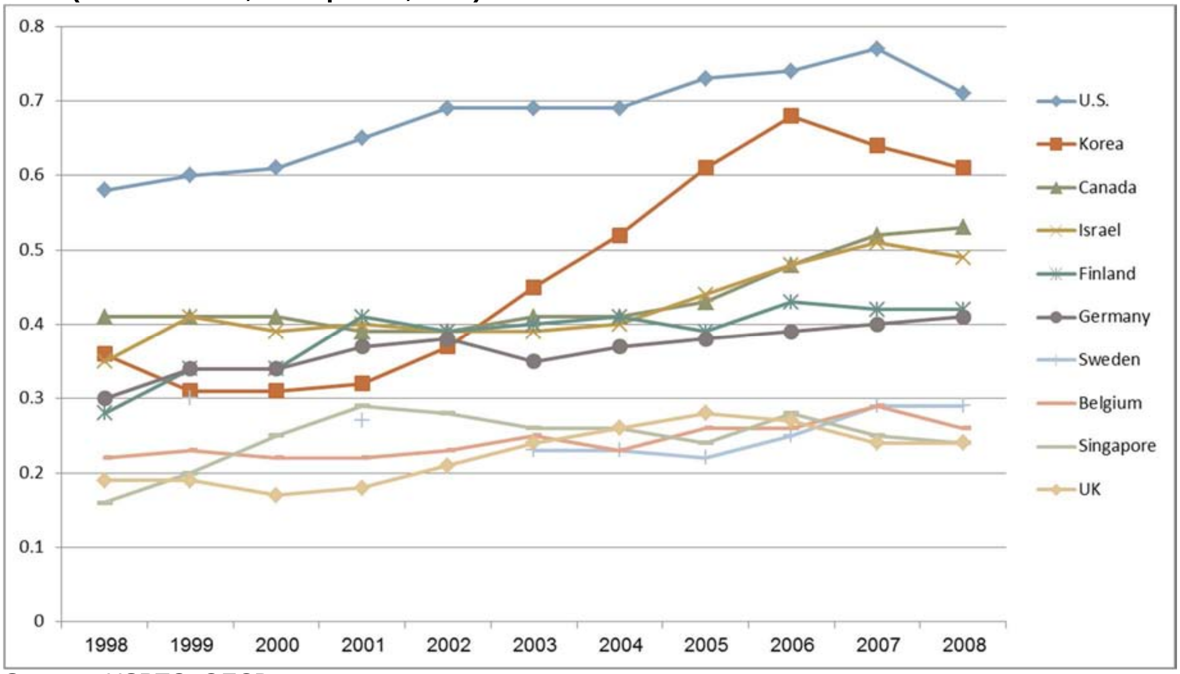
Source: OECD.

Table 7.6: Patent Applications to USPTO Relative to National R&D Investment, 1998–2008 (USD millions, 2000 prices, PPP)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
U.S.	0.58	0.6	0.61	0.65	0.69	0.69	0.69	0.73	0.74	0.77	0.71
Korea	0.36	0.31	0.31	0.32	0.37	0.45	0.52	0.61	0.68	0.64	0.61
Canada	0.41	0.41	0.41	0.39	0.39	0.41	0.41	0.43	0.48	0.52	0.53
Israel	0.35	0.41	0.39	0.4	0.39	0.39	0.4	0.44	0.48	0.51	0.49
Finland	0.28	0.34	0.34	0.41	0.39	0.4	0.41	0.39	0.43	0.42	0.42
Germany	0.3	0.34	0.34	0.37	0.38	0.35	0.37	0.38	0.39	0.4	0.41
Sweden		0.3		0.27		0.23	0.23	0.22	0.25	0.29	0.29
Belgium	0.22	0.23	0.22	0.22	0.23	0.25	0.23	0.26	0.26	0.29	0.26
Singapore	0.16	0.2	0.25	0.29	0.28	0.26	0.26	0.24	0.28	0.25	0.24
UK	0.19	0.19	0.17	0.18	0.21	0.24	0.26	0.28	0.27	0.24	0.24

Sources: USPTO, OECD

Figure 7.6: Patent Applications to USPTO Relative to National R&D Investment, 1998–2008 (USD millions, 2000 prices, PPP)



Sources: USPTO, OECD.

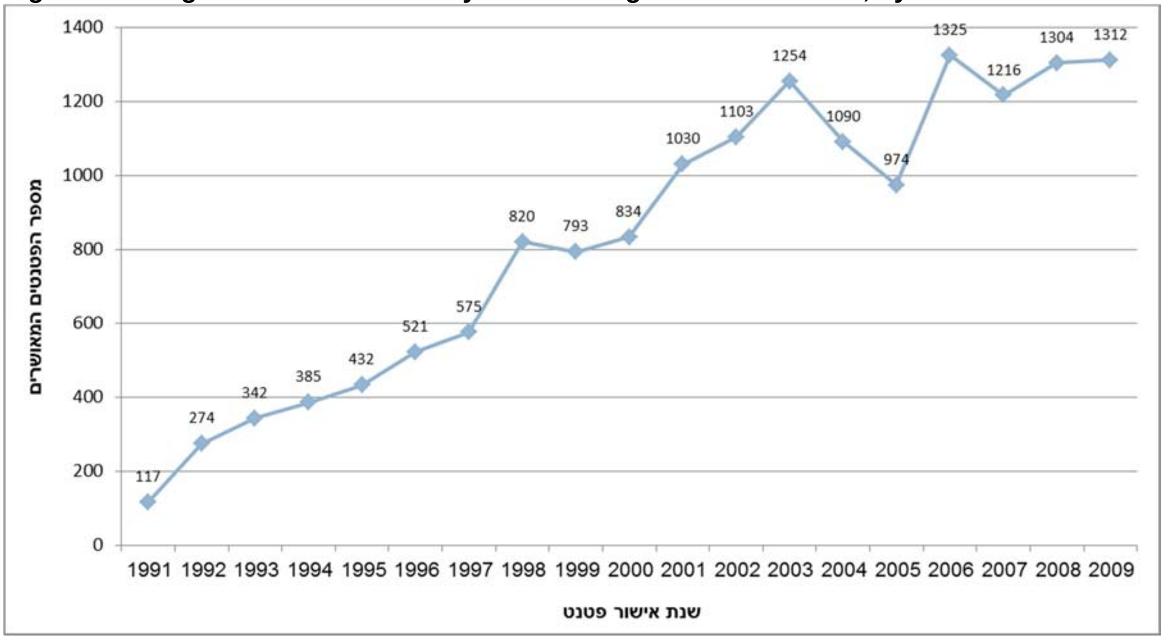
During these periods, Israeli inventors submitted 0.18 patent applications to EPO per USD 1 million of R&D investment on average, as against 0.42 applications to USPTO. Among the countries examined, the leader in applying to EPO is Germany at 0.44 patent applications per USD 1 million invested in R&D, on average. Israel is in seventh place only. In applying to USPTO, Israel is in fourth place among the countries examined, trailing the U.S., Korea, and Canada. In this indicator, too, Korea's impressive rate of increase is evident. Notably, this indicator is a highly indirect indicator of R&D productivity because it overlooks differences among countries in the costs of these activities. It is also affected by investor strategic and economic considerations that have nothing to do with R&D productivity.

7.3.1 Registration of Israeli Patents with USPTO

USPTO is still the first and main destination of Israelis who wish to register patents. The data below, derived from the Delphion database, include information about patents/patent applications that were registered/granted by USPTO to investors or assignees who have an Israeli address.

Figure 7.7 shows the number of Israel-assigned inventions for which patents were granted and recorded by USPTO in 1992–2008 (based on year of grant). The linear upward trend in the number of patents registered by Israeli assignees over the years is evident. Between 1992 and 2008, the number of patents registered by Israeli inventors increased 4.8 times over (or 10.3 percent on annual average).

Figure 7.7: Registration of Patents by Israeli Assignees with USPTO, by Year of Grant[38]



Source: USPTO. The data were retrieved from the Delphion database and processed by Samuel Neaman Institute on the basis of the industries of Israeli patents registered with USPTO.

Figure 7.8 shows the attribution of Israeli firms' patents to industries.[39] One-third of patents of Israeli firms (private or public) that registered patents in the U.S. are affiliated with the ICT industry (information and communication technologies or, as termed in the ISIC classification, manufacture of radio, television, and communication equipment). Some 15 percent are related to office accounting and computing machinery, 13 percent to machinery and equipment, 12 percent to industrial equipment for control and supervision and medical and scientific equipment, 8

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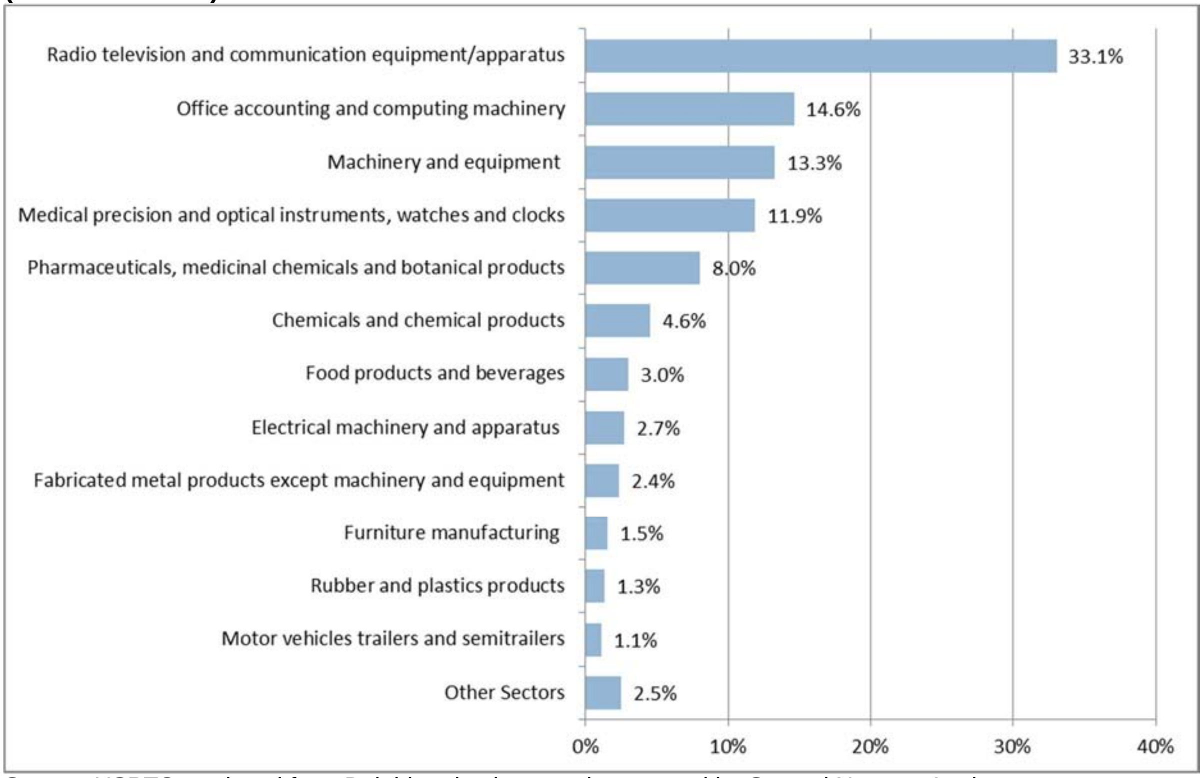
[38] The counts (simple counts) are based on year of grant and country of origin of the assignee who appears first on the assignees' address line (Israel).

[39] The data in the figure may be representative not of the industrial sector to which the firm belongs but to the industrial sector to which the firm's patent belongs.

percent to pharmaceuticals, 5 percent to food products and beverages, 3 percent to electronic components, and 8 percent to others (basic metals excluding machinery and equipment, furniture manufacturing, rubber and plastics products, motor vehicles, and other sectors).

Figure 7.8: Patents Granted to Firms, by ISIC Industrial Classification[40] (1990–2009 total)



Source: USPTO, retrieved from Delphion database and processed by Samuel Neaman Institute.

7.3.2 Sectoral Distribution of Israeli Holders of Patents Granted by USPTO

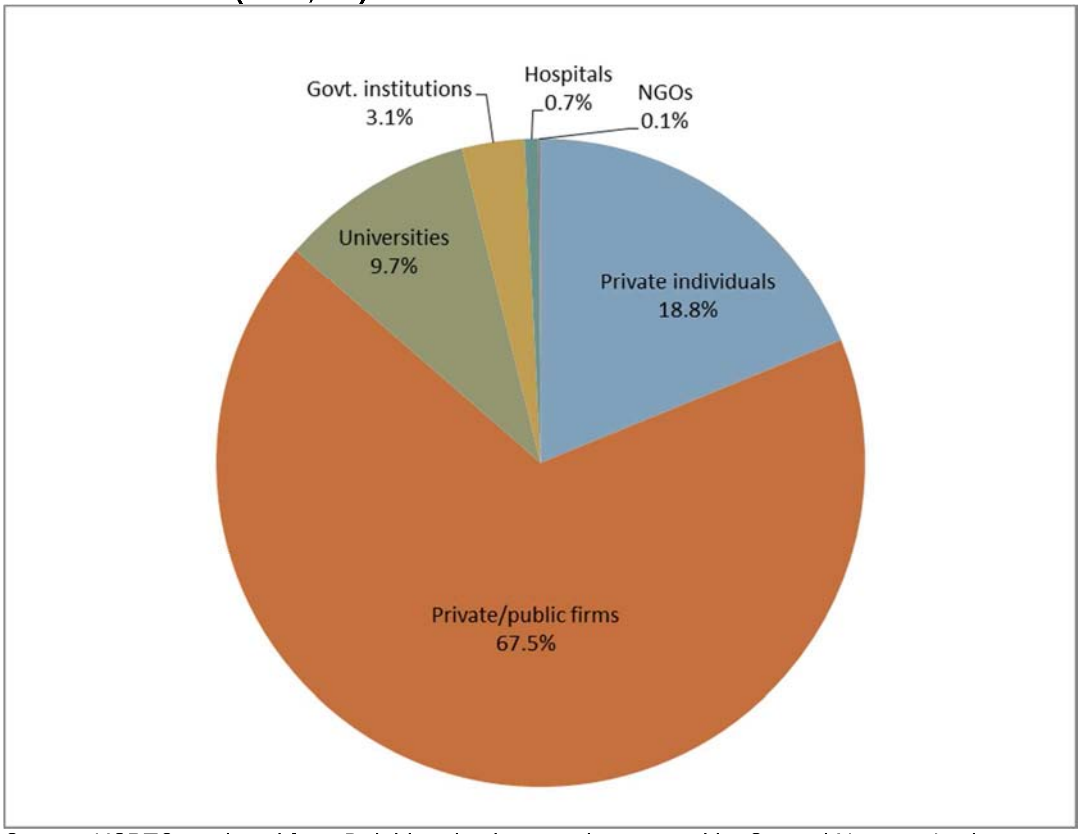
Figure 7.9 presents the sectoral distribution of patents granted to Israeli assignees (N=11,631) by USPTO between 1991 and 2009.

Analysis of these patents by applicant sector shows that 67.5 percent of Israel-assigned patents belong to firms (private or public), 19 percent to private individuals, 10 percent to universities, and 3 percent to government bodies. The share of patents held by hospitals and NGOs is negligible at less than 1 percent. The proportion of patents granted to firms has been rising steeply, consistently, and steadily over the years (from 42 percent in 1991 to 76 percent in 2009) and that of patents held by

[40] The patent data are based on the date of grant. IPC classifications were converted into ISIC classifications in accordance with the linkage tables in Schlock et al., 2003. The data relate to the name of the first patent assignee whose sectoral classification is that of a private/public Israeli firm. The analysis excludes government-owned companies. The rate obtained for each industry is relative to total applications/patents of firms that cite Israel in their first address.

private individuals has been falling steeply and steadily (from 46 percent in 1991 to 13 percent in 2009). The share of patents assigned to government also fell considerably during these years (from 8 percent to 2 percent in the respective years) and that held by universities was relatively stable (8–10 percent) during this time.

Figure 7.9: Sectoral Attribution of Patents Granted to Israel Assignees by USPTO, 1991–2009 Total[41] (N=11,631)

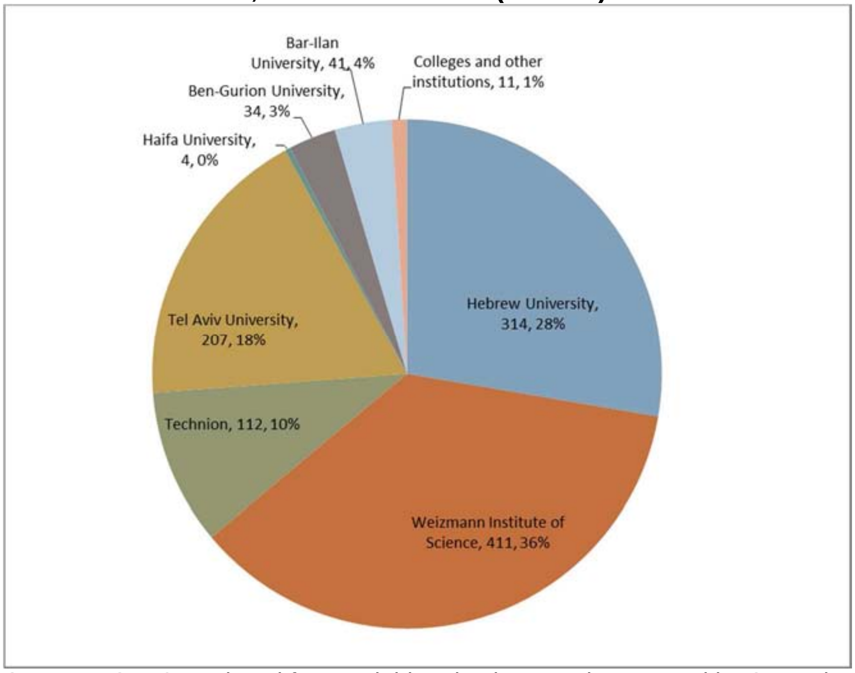


Source: USPTO, retrieved from Delphion database and processed by Samuel Neaman Institute.

Figure 7.10 shows the distribution of registered patents assigned to Israeli universities and research institutes. The graph demonstrates the dominance of the Weizmann Institute of Science in patent registration—more than one-third of all university patents belong to this institution. Slightly over one-fourth of registered patents are assigned to the Hebrew University of Jerusalem, about one-fifth to Tel Aviv University, and only about one-tenth to Technion Israel Institute of Technology. The other universities and research institutions hold less than 8 percent of the patents.

[41] The graph is based on dates of grant and (Israeli) first assignee address. The sectoral rate is relative to total Israel-assigned patents (first assignee address). N=11,631.

Figure 7.10: Distribution of Patents Granted by USPTO to Israeli Universities and Research Institutes, 1991–2009 Total[42] (N=1134)



Source: USPTO, retrieved from Delphion database and processed by Samuel Neaman Institute.

7.4 Classification of Patent Applications by Technologies

By performing an international comparison of the number of patent applications in the fields of biotechnology, ICT, and nanotechnology with EPO in 2000, 2003, and 2006, we may examine the various countries' R&D outputs in these evolving fields in the past decade. The count of applications in these tables is fractional, i.e., every patent granted to inventors affiliated with more than one country is credited to said countries commensurate with the proportion of inventors in this patent who come from each country. The sorting of patents into fields is done in accordance with the IPC classification. The years represent priority dates.

Table 7.7: Biotechnology Patent Applications Submitted to EPO, 2000, 2003, 2006

	2000	2003	2006
EU-27	2,980	2,580	2,482
U.S.	4,209	3,154	2,416
Germany	1,036	890	770
UK	545	379	320
Canada	225	205	172
Korea	84	101	138
Belgium	131	112	123
Sweden	131	101	99
Israel	111	125	91
Finland	35	40	33
Singapore	20	26	31

Source: OECD.

[42] The graph is based on dates of granting. The rate obtained is patents among total patents granted to Israeli universities and research institutes (first assignee address). N=1134.

Table 7.8: ICT Patent Applications Submitted to EPO, 2000, 2003, 2006

	2000	2003	2006
EU-27	15,970	14,885	14,521
U.S.	13,769	13,098	11,264
Germany	6,121	5,532	5,186
Korea	663	2,106	3,097
UK	2,353	1,932	1,806
Canada	666	756	1,111
Sweden	889	650	924
Finland	780	692	683
Israel	534	421	463
Belgium	297	317	314
Singapore	97	151	133

Source: OECD.

Table 7.9: Nanotechnology Patent Applications Submitted to EPO, 2000, 2003, 2006

	2000	2003	2006
EU-27	276	392	394
U.S.	317	429	345
Germany	117	150	155
Korea	17	49	46
UK	33	55	44
Sweden	20	12	15
Canada	13	15	14
Belgium	7	18	14
Israel	9	11	10
Singapore	2	1	8
Finland	1	3	8

Source: OECD.

The following table, published by WIPO[43] and showing the number of patent applications to all patent offices in 2003–2007, illustrates the areas of Israeli R&D activity in broader strokes. The applications were sorted into main areas of technology by means of a conversion table from IPC classifications. Since a patent may be attributed to more than one classification, the number of applications reported in the table exceeds the actual number. Applications are attributed to individual countries on the basis of the residential address of the first inventor (the one whose name appears first on the list of inventors on the application form).

[43] WIPO Statistics Database, September 2010.

Table 7.10: Total Patent Applications to All Patent Offices, by Country of First Investor and Main Area of Technology, 2003–2007

	Belgium	Canada	Finland	Germany	Israel	Singapore	Sweden	UK	U.S.
I - Electrical engineering									
Electrical machinery, apparatus, energy	614	4,147	1,480	42086	816	642	1676	6294	68760
Audio-visual technology	423	2,093	1,346	15176	759	742	1262	3632	42735
Telecommunications	315	5,275	6,651	15389	1847	662	5770	5088	76564
Digital communication	180	6,688	8,996	13650	1402	501	7532	4631	72334
Basic communication processes	138	829	729	5749	251	444	880	1097	20605
Computer technology	725	8,027	4,928	28184	3799	1666	3264	9131	191835
IT methods for management	108	1,377	462	3435	435	193	407	1686	33610
Semiconductors	586	620	390	19493	393	1744	303	1592	55107
II - Instruments									
Optics	707	1,292	571	12566	887	554	817	2894	40779
Measurement	777	3,507	1,871	34065	1558	731	2476	7830	66252
Analysis of biological materials	471	1,080	265	4431	410	141	717	2388	18341
Control	224	1,618	551	12410	630	216	1127	3397	32626
Medical technology	920	4,096	1,048	25002	5217	438	5203	10007	138389
III - Chemistry									
Organic fine chemistry	2,939	2,381	486	28219	1970	139	4405	9184	66066
Biotechnology	1,900	3,517	780	12402	1615	467	1509	6103	61478
Pharmaceuticals	3,815	5,481	791	22203	3664	297	6024	11222	102133
Macromolecular chemistry, polymers	1,417	793	1,017	14476	178	98	214	1488	28838
Food chemistry	631	1,020	435	3835	419	46	247	1966	18655
Basic materials chemistry	1,053	1,451	561	21106	609	64	506	5310	41444
Materials, metallurgy	815	1,388	1,002	11707	195	92	1124	1851	17908
Surface technology, coating	732	1,185	754	11501	292	148	978	1918	32061
Micro-structural and nano-technology	23	84	71	913	18	72	82	108	2006
Chemical engineering	867	1,983	1,604	18013	491	205	1680	4471	36172
Environmental technology	383	1,378	688	9523	287	102	840	2275	16165
IV - Mechanical engineering									
Handling	895	2,271	2,271	21137	556	166	1874	5851	40615
Machine tools	266	2,048	1,130	23880	869	214	2949	2486	31445
Engines, pumps, turbines	443	2,535	554	32546	328	113	1718	4412	33440
Textile and paper machines	1,270	637	2,894	18503	327	91	1054	1939	24344
Other special machines	1,300	4,135	1,403	21128	954	159	1781	4488	40582
Thermal processes and apparatus	393	1,418	761	10747	206	90	982	1635	13884
Mechanical elements	500	2,122	760	38207	306	64	3271	5000	33375
Transport	741	4,109	909	55296	534	166	4875	5788	46991
V - Other fields									
Furniture, games	609	3,327	607	11290	564	151	1357	6590	46078
Other consumer goods	813	1,846	420	12786	595	140	880	4714	29660
Civil engineering	968	5,825	1,689	21429	655	218	3236	8804	43037

Source: WIPO.

According to the foregoing table, most Israeli applications belong to the following areas of technology: medical instruments, computers, pharmaceuticals, organic chemistry, telecommunications, biotechnology, measurement equipment, and digital communication.

7.5 Scientific Publications

Bibliometric tools (a.k.a. citation analyses) offer quantitative answers to questions about R&D productivity and quality of scientific publications in various fields. Among the conventional methods of inquiry in this respect, scientific publications serve as an indicator of productivity in scientific research and citations of such publications are offered as an indicator of the research quality. These bibliometric indicators make it possible to perform various comparisons (among individual researchers, institutions, or countries) and generate statistics that attest to the quality and quantity of publications in the various domains.

The bibliographic results, like those elicited by other statistical tools, should be taken with a grain of salt. The user should be wary of possible biases and generalizations and should combine several bibliometric indicators instead of relying on only one.

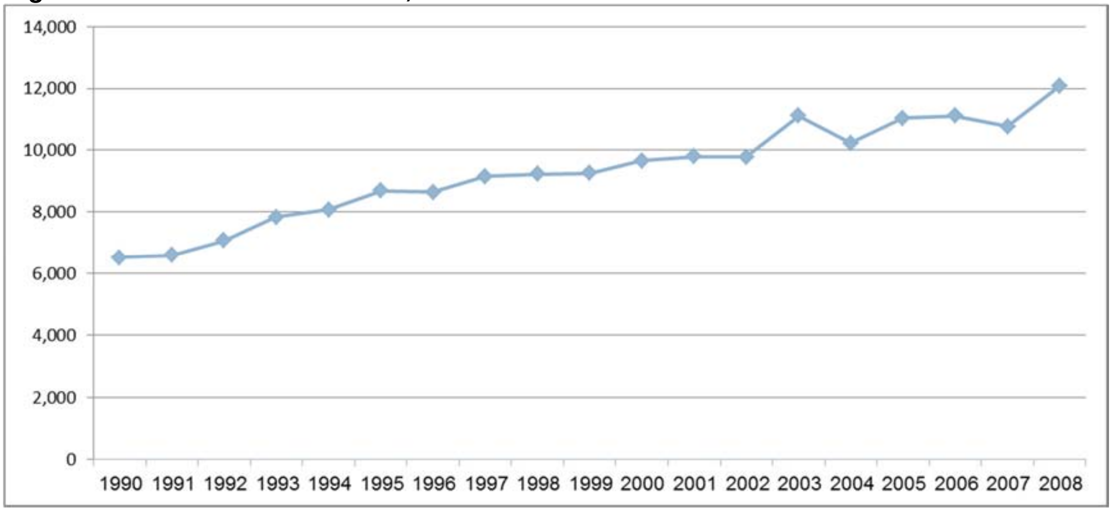
Most bibliometric studies that measure scientific output use the Thomson Reuters scientific databases (formerly the ISI Web of Knowledge). These databases, foremost those of the Science Citation Index (SCI), are multidisciplinary databases that cover scientific and technological literature from tens of thousands of sources (journals, condensed proceedings of scientific conferences, books, etc.) and contain copious bibliographic details about the items appearing in them (titles, contents, authors' names and addresses, year of publication, etc.). The bibliometric data in this chapter were processed from these databases (especially the database of Israel publications—the National Citation Report—and a statistical database of various countries' publications—the National Science Indicators—that are current up to the end of 2008). The data were put through control and cleansing processes and were tailored to specific statistical software that was developed for database retrieval and advanced analysis. The databases contain data on Israeli publications (those in which at least one author has an Israeli address) and on publications from other countries.

First we describe the situation in Israel; then we compare Israel with other countries in three respects: research productivity, priority of research fields, and indicators of publication quality.

7.5.1 Indicators of Research Productivity

176,654 Israeli publications appeared between 1990 and 2008, with a gradual uptrend in the number of publications per year. Figure 7.11 plots the increase in the number of Israeli publications each year.

Figure 7.11: Israeli Publications, 1990–2008



Source: Thomson Scientific, National Science Indicators.

Between 1990 and 2008, the number of Israeli publications increased by 85 percent overall and by 3.6 percent on annual average.

Since each country's number of publications depends among other things on the size of its population, the conventional way to compare different countries is by normalizing the number of publications to population size. Figure 7.2 presents the average number of publications per year per 100,000 of population for the twenty world leaders in number of publications.

Figure 7.12: Leading Countries in Publications per 100,000 of Population, 2004–2008

Source: Thomson Scientific, National Science Indicators

Israel ranks fifth in this indicator. Notably, in Neaman Institute's previous publication (*Indicators for Science, Technology, and Innovation in Israel: A Comparative Data Infrastructure,* 2006), which ranked countries by this indicator in 2001–2005, Israel was third in publications per population, after Switzerland and Sweden.

To examine and compare the scale of research in Israel and other countries, the tables that follow show the extent of publications in various fields. The classification follows the ISI; the publications included in each field appeared in journals and other sources and sorted into appropriate fields on the basis of their content. The fields are unevenly sized and reflect different extents of coverage. In this chapter, we chose to present data for several countries in addition to Israel: Finland and Ireland as countries with similar characteristics for comparison purposes; Switzerland, ranked at the top levels on most scales of publication quality; and the U.S. and the average of the twenty-seven member states of the European Union as important countries in scientific research.

Table 7.11 compares the shares of each country's publications in each field among all the country's publications and includes the global average, which represents the rate of publishing in the various domains in the total number of publications included in the database in those years. This priory indicator reflects the weight of R&D outputs in the various domains in each country shown.

Table 7.11: Percent of S&T Publications in Total Publications in Country, International Comparison, 2004–2008

	Israel	Finland	Ireland	Switzer land	EU-27	U.S.	World
Clinical medicine	23.54	23.87	21.93	23.81	22.34	23.87	20.72
Physics	12.12	8.54	9.13	12.03	9.80	7.27	9.60
Chemistry	7.68	7.77	7.54	10.08	11.01	7.36	12.06
Engineering sciences	6.74	6.95	7.46	6.19	7.36	6.65	8.13
Biology and biochemistry	5.85	5.64	5.03	5.59	5.64	6.32	5.60
Social sciences (general)	4.73	3.58	4.77	2.13	3.31	6.53	4.09
Computer sciences	4.54	3.76	4.65	2.73	3.25	2.71	3.09
Mathematics	4.53	1.88	2.74	1.68	2.92	2.28	2.57
Life and plant sciences	4.16	6.39	5.80	5.01	5.44	5.06	5.55
Brain sciences	3.87	3.58	2.72	3.79	3.27	4.03	3.01
Psychology/psychiatry	3.86	2.63	2.28	2.07	2.35	4.07	2.46
Molecular biology and genetics	3.59	3.14	2.82	3.82	2.97	4.13	2.84
Materials theory	2.24	3.11	3.68	3.00	3.91	2.43	4.76
Environmental sciences	1.97	5.32	2.37	3.22	2.75	2.90	2.71
Earth sciences	1.80	3.12	2.42	4.26	3.06	3.02	2.80
Economics and business	1.62	1.62	1.90	1.33	1.63	2.25	1.51
Immunology	1.51	1.40	1.38	1.93	1.35	1.75	1.24
Microbiology	1.45	1.72	2.54	1.80	1.81	1.84	1.68
Space sciences	1.45	1.89	2.04	1.93	1.75	1.86	1.23
Pharmacology and toxicology	1.06	1.70	1.67	1.68	1.70	1.77	1.87
Agricultural sciences	0.99	2.16	4.92	1.55	2.02	1.42	2.05
Multidisciplinary sciences	0.69	0.25	0.22	0.35	0.36	0.48	0.46

Source: Thomson Scientific, National Science Indicators

In Israel, about one-fourth (23.5 percent) of publications in recent years were in clinical medicine and 12 percent were in physics. The research fields that had the lowest rates of publications during that time were agriculture, pharmacology, and space science (1 percent). In other countries, too, clinical medicine yielded the largest percentage of publications. The share of mathematics in Israeli publications surpassed the world average markedly (4.5 percent as against 2.5 percent).

Another indicator that illuminates different countries' priorities in areas of research is the country's number of publications in a given field divided by the total number of publications in that field worldwide. This indicator represents the country's contribution to global R&D output (in terms of number of publications) in these fields.

Table 7.12 presents the fractions of the various countries in total world publications in each field.

Table 7.12: Countries' S&T Publications as Percent of All Publications Worldwide in Field of Research, 2004–2008

	Israel	Finland	Ireland	Switzer-land	EU-27	U.S.
Mathematics	2.00	0.66	0.50	1.21	42.39	27.59
Psychology/ psychiatry	1.78	0.96	0.43	1.56	35.63	51.40
Multidisciplinary sciences	1.72	0.49	0.22	1.43	29.00	32.70
Computer sciences	1.67	1.10	0.71	1.64	39.34	27.32
Brain sciences	1.46	1.07	0.42	2.34	40.59	41.71
Molecular biology and genetics	1.43	0.99	0.46	2.49	39.04	45.21
Physics	1.43	0.80	0.45	2.32	38.06	23.55
Immunology	1.39	1.02	0.52	2.89	40.79	44.10
Space sciences	1.34	1.39	0.78	2.91	53.08	47.19
Social sciences (general)	1.32	0.79	0.55	0.97	30.23	49.73
Clinical medicine	1.29	1.04	0.50	2.13	40.23	35.84
Economics and business	1.22	0.97	0.59	1.64	40.42	46.45
Biology and biochemistry	1.19	0.91	0.42	1.85	37.59	35.13
Microbiology	0.98	0.92	0.71	1.99	40.27	34.18
Engineering sciences	0.94	0.77	0.43	1.41	33.80	25.47
Life and plant sciences	0.85	1.03	0.49	1.67	36.52	28.36
Environmental sciences	0.83	1.77	0.41	2.20	37.92	33.30
Earth sciences	0.73	1.00	0.40	2.82	40.73	33.52
Chemistry	0.72	0.58	0.29	1.55	34.04	18.98
Pharmacology and toxicology	0.64	0.82	0.42	1.67	33.98	29.42
Agricultural sciences	0.55	0.95	1.12	1.40	36.81	21.61
Materials theory	0.54	0.59	0.36	1.17	30.69	15.90
All fields	1.13	0.90	0.47	1.85	37.31	31.11

Source: Thomson Scientific, National Science Indicators

As the table shows, Israeli publications were 1.13 percent of all global publications in all fields between 2004 and 2008 was. Notably, our previous publication, relating to this indicator in 2001–2005, gave Israel a 1.25 percent share. This reflected Israel's very strong performance in this respect from the early 1990s, when a steady growth trend ensued, to 2005, when the trend stopped. If we observe the 2008 data only, we find that Israel's share of world publications was only 1.06 percent. This, however, is still relatively high in view of Israel's minuscule share of the global population (0.1 percent).

As one may see, Israel's contribution to world publications among the fields of research is largest in mathematics, at 2.0 percent (2.19 percent in 2001–2005). This manner of measurement also highlights the relative importance of the U.S. and Europe in space and brain sciences and of Finland in the environmental sciences.

Thus far, we have presented each country's priorities in the various fields of research. This indicator, however, does not allow international comparison of the productivity or level of the research performed because it is affected by the countries' differences in size.

To examine research productivity in each separate field relative to other countries, it is the conventional practice to neutralize the effect of size by checking the average number of publications per capita in each field. Table 7.14 does this for the years 2004–2008.

Table 7.13: Publications per Capita (100,000 of population), 2004–2008

	Israel	Finland	Ireland	Switzerland	U.S.
Clinical medicine	179.21	197.02	115.16	282.81	119.00
Physics	92.28	70.50	47.94	142.85	36.24
Chemistry	58.49	64.13	39.59	119.72	36.69
Engineering sciences	51.32	57.40	39.20	73.56	33.16
Biology and biochemistry	44.50	46.56	26.43	66.43	31.51
Social sciences (general)	36.04	29.52	25.05	25.32	32.56
Computer sciences	34.59	31.05	24.41	32.43	13.51
Mathematics	34.52	15.51	14.40	19.97	11.37
Life and plant sciences	31.69	52.72	30.47	59.49	25.24
Brain sciences	29.49	29.59	14.27	45.03	20.09
Psychology/psychiatry	29.35	21.68	11.98	24.59	20.27
Molecular biology and genetics	27.35	25.90	14.82	45.41	20.59
Materials theory	17.08	25.66	19.31	35.65	12.12
Environmental sciences	15.03	43.90	12.45	38.28	14.46
Earth sciences	13.69	25.77	12.70	50.63	15.05
Economics and business	12.30	13.35	9.96	15.81	11.21
Immunology	11.51	11.59	7.24	22.94	8.74
Microbiology	11.04	14.19	13.34	21.42	9.17
Space sciences	11.00	15.59	10.69	22.88	9.28
Pharmacology and toxicology	8.06	14.04	8.78	19.98	8.81
Agricultural sciences	7.50	17.83	25.86	18.40	7.10
Multidisciplinary sciences	5.27	2.04	1.15	4.20	2.40
All fields	761.30	825.54	525.21	1187.80	498.54

Source: Thomson Scientific, National Science Indicators.

In this indicator, Israel leads the pack by a wide margin in mathematics, computer sciences, psychology/psychiatry and social sciences.

7.5.2 Indicators of Research Quality

The bibliometric databases also contain bibliographical details on publications cited in each article. This makes it possible to count and tally when, where, and how often a given publication was cited in other articles. The number of times a given article is cited in other scientific articles may attest to the recognition that this article has earned in the scientific world and, in turn, its influence and importance. It is conventional to rank an article by the number of citations that it received relative to the average number of citations per article in the same field of knowledge at a similar period of time.

Table 7.14 presents an international comparison of the average number of citations by research field in science and technology between 2004 and 2008.

Table 7.14: Average Number of Citations of S&T Publications, International Comparison, 2004–2008

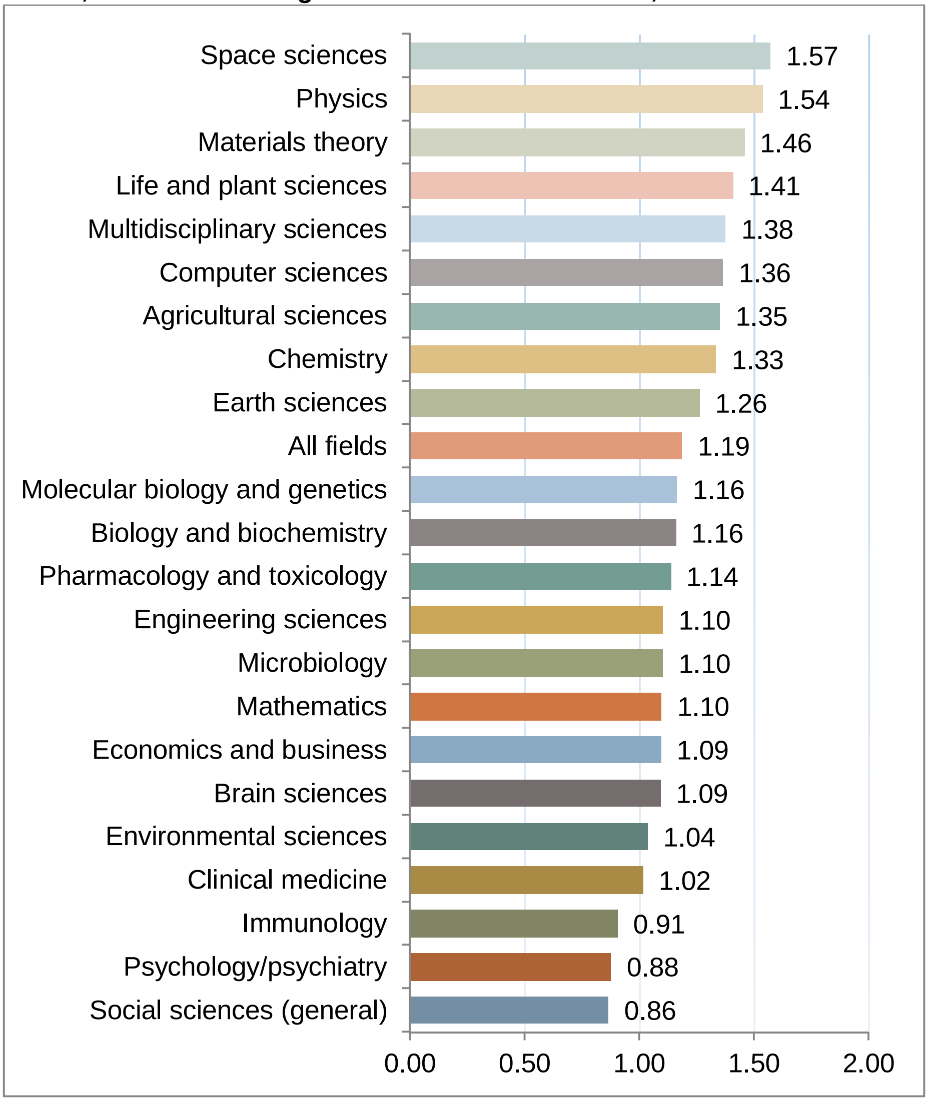
	Israel	Finland	Ireland	Switzerland	EU-27	U.S.	World
Molecular biology and genetics	13.18	11.22	11.04	16.20	11.59	14.80	11.33
Space science	11.22	6.58	8.47	12.51	8.09	9.84	7.14
Immunology	8.97	8.89	14.76	13.08	9.47	12.46	9.91
Brain science	8.77	8.03	8.90	9.89	8.08	10.47	8.03
Biology and biochemistry	8.55	7.67	7.64	11.14	7.56	10.35	7.38
Microbiology	7.74	6.55	7.83	9.84	7.45	9.91	7.03
Chemistry	6.76	5.01	6.38	7.80	5.65	8.18	5.07
Physics	6.39	6.55	6.00	7.83	4.95	6.51	4.16
Pharmacology and toxicology	6.16	5.98	5.80	7.46	6.10	7.23	5.42
Clinical medicine	5.85	8.21	6.28	8.52	6.03	8.01	5.76
Multidisciplinary sciences	5.57	4.20	5.16	8.84	4.69	7.24	4.05
Earth sciences	4.97	5.21	4.64	6.73	4.39	5.65	3.94
Environmental sciences	4.59	5.94	4.31	7.35	4.87	5.75	4.43
Life and plant sciences	4.46	3.99	3.37	4.93	3.74	4.09	3.17
Materials theory	4.40	2.83	4.80	5.34	3.36	5.15	3.02
Agricultural sciences	3.86	4.5	3.71	3.9	3.38	3.78	2.86
Psychology/ psychiatry	3.72	4.50	4.24	4.22	4.13	5.04	4.25
Economics and business	2.33	1.62	1.52	2.28	1.83	2.87	2.13
Engineering sciences	2.18	2.37	2.25	2.98	2.10	2.52	1.98
Computer sciences	2.06	1.54	1.51	2.07	1.48	2.42	1.51
Social sciences (general)	1.71	1.94	1.86	2.45	1.90	2.36	1.98
Mathematics	1.49	1.54	1.24	1.92	1.49	1.82	1.36
All fields	5.57	5.84	5.28	7.64	5.12	6.84	4.70

Source: Thomson Scientific, National Science Indicators.

Among publications that appeared in 2004-2008, in no field did Israeli publications surpass the average number of citations among the other countries examined.

We believe it correct to note here that this indicator should not be compared across different research fields because the conventions in citing publications vary from one field to the next. Therefore, the cross-country comparison for this indicator should be performed within the same field. To examine each country's situation in each field relative to the world at large in terms of the quality of its publications, one may examine the ratio of the indicator of citations of the country's publications in a certain field to the value of the worldwide citation index. A ratio equal to 1 means that the country's publications in the relevant research field were cited at the world average level during the period in question. A ratio greater than 1 means that the citation index in the given research field in that country surpasses the global average, and vice versa if the ratio is smaller than 1. The next graph shows the average citations of Israeli publications in the various research fields relative to the worldwide averages.

Figure 7.13: Ratio of Average Number of Citations of Israel Publications in Various S&T Fields, vs. World Average in Same Research Fields, 2004–2008



Source: Thomson Scientific, National Science Indicators.

Israel's ratio was greater than 1 in most research fields. In space sciences and physics, its average citations of Israel surpassed 1.5 (meaning that Israeli publications in these fields were cited 50 percent more than the average citations per article in these fields worldwide). In immunology, psychology/psychiatry, and social sciences, Israel's average citations were under the world average.

We sum up this chapter by listing the twenty-five leading countries on the quality scale in all research fields. The table shows the average citations per publication among all publications in our database, which covers a twenty-seven-year period (1981–2008). On this scale, Israel ranks tenth in the world.

Table 7.15: Ranking of Countries on Quality Scale (Average Citations per Publication), Publications and Citations in 1981–2008

Rank	Country	Avg. citations per publication	Citations	Publications
1	U.S.	21.97	150,777,498	6,862,395
2	Switzerland	21.43	7,052,983	329,150
3	Sweden	19.71	7,062,512	358,233
4	Denmark	19.54	3,569,996	182,669
5	Netherlands	19.03	8,665,689	455,267
6	UK	18.25	30,831,754	1,689,393
7	Canada	17.34	15,764,525	909,187
8	Finland	16.67	2,705,755	162,358
9	Belgium	15.85	3,755,945	236,997
10	Israel	15.76	3,638,183	230,868
11	Norway	15.31	1,860,900	121,539
12	Australia	15.13	7,806,489	515,850
13	France	14.81	16,799,702	1,134,511
14	Germany	14.81	23,339,250	1,575,725
15	Austria	13.95	2,243,672	160,877
16	Italy	13.59	9,761,677	718,258
17	New Zealand	13.54	1,402,143	103,588
18	Japan	12.80	20,396,088	1,593,608
19	Spain	11.10	5,251,207	473,237
20	Hungary	9.77	997,815	102,080
21	S. Africa	9.61	979,834	101,921
22	Greece	8.69	971,549	111,843
23	Mexico	8.10	806,913	99,574
24	Poland	7.41	1,792,466	242,040
25	Taiwan	7.32	1,520,642	207,678

Source: Thomson Scientific, National Science Indicators.

8. Globalization

- **High-tech exports added up to Million USD 17,150, 42 percent of all manufacturing exports (2008).**
- **Exports of computer and information services were USD 2,738 million and exports of R&D services were USD 4,983 million—19 percent and 34 percent of all services exports, respectively (2008).**
- **International R&D centers accounted for 48 percent of research expenditure in the R&D industry (NIS 4,914 million) and 45 percent of research expenditure in computer services (NIS 3,390 million) (2007).**
- **Nonresidents invested USD 1,442 million in acquisitions of Israeli startups (2008)—48 times more than in 2002.**
- **Nonresidents submitted 6,145 patent applications to the Israel Patent Authority—79 percent of all patent applications (2008).**
- **Israeli scientists in the fields of science and engineering published 4,618 works that had at least one foreign co-author—44.5 percent of all publications in these fields (2008).**
- **Some 3,700 foreign students—48 percent from North America, 8 percent from France, and 7 percent from Russia—participated in first- and second-degree programs in Israel (2008/09).**

Globalization trends in technological development, scientific research, and commerce in knowledge-intensive products and capital have been gathering speed in recent decades. With a major contribution by the electronic media, a global space is being created and the effects of geographic distance are declining. The connection between progress and globalization is not a one-way street: knowledge-intensive industries are availing themselves of the world's finest knowledge, studies, and researchers in every field. In fact, creation of knowledge and R&D activities have themselves become material components of global trade, each country exploiting its technological and scientific advantages. A survey among the world's thousand leading firms in R&D investment and innovation, for example, was found that 55 percent of their R&D investments are made in R&D players outside their home country. More and more firms are scattering their R&D activities across many countries. The main reasons for this are (a) saving on direct R&D costs, chiefly due to large disparities between developed and emerging markets in the wages of researchers, engineers, and scientists, (b) the wish to employ the world's best people and research establishments in solving S&T problems in different fields, and (c) the need for proximity and understanding of a local market's needs in order to develop it as a destination for the firm's output.

The globalization process and enlistment in the global market have advantages and disadvantages. The advantages are that openness to global markets encourages more efficient resource allocation, expands the possibilities of production, and makes investment portfolios less risky due to diversification. However, the exposure occasioned by this openness makes wage income more volatile, creates susceptibility to the spread of global financial crises ("contagion"), and exacerbates extremes in business cycles. Openness to the capital markets also changes the ways in which macroeconomic policy is implemented.[44]

These remarks are all the more pertinent for a small country such as Israel, where the economy is largely based on a vigorous and creative high-tech sector, technological R&D prowess, and scientific research institutes that are among the world's most advanced. Israeli firms need access to international markets at all phases of value creation—research, raising of capital for the acquisition of advanced S&T equipment and raw materials, and sales. Given the small dimensions of its domestic market, Israel must rely on global markets for its outputs, especially in high-tech fields. The high-tech sector depends on the depth of the international economic and trade relations for its economic stability.

Until about three decades ago, most international trade took place in commodities and products. Today, the service industries, including computer and R&D services, are claiming a growing share of this activity. Israel today is considered the world's fourth-ranking country in attracting R&D investments from foreign sources in the ICT field (trailing the U.S., the UK, and India). ICT accounts for 30 percent of Israel's total exports of goods and services and ICT services constitute 43 percent of ICT exports (2009).

Many factors explain Israel's attractiveness as an incubator of technological R&D. Some are related to the fact that Israel preceded many other countries in developing a high-tech sector, establishing a supportive infrastructure for the training of top-notch S&T personnel, and developing an advanced venture-capital sector that can support technological entrepreneurs in ICT above all. These advantages, however, have weakened over time due to changes in the extent of government support for science, the development of areas of research in which Israel has no substantial

[44] "Globalization—The Israeli Economy in the Shadow of Global Economic Processes," the Tenth Economic Conference 2002, conference manager and editor: Reuven Gronau, Israel Democracy Institute.

advantage, and the adoption of aggressive R&D support policies by many other countries.

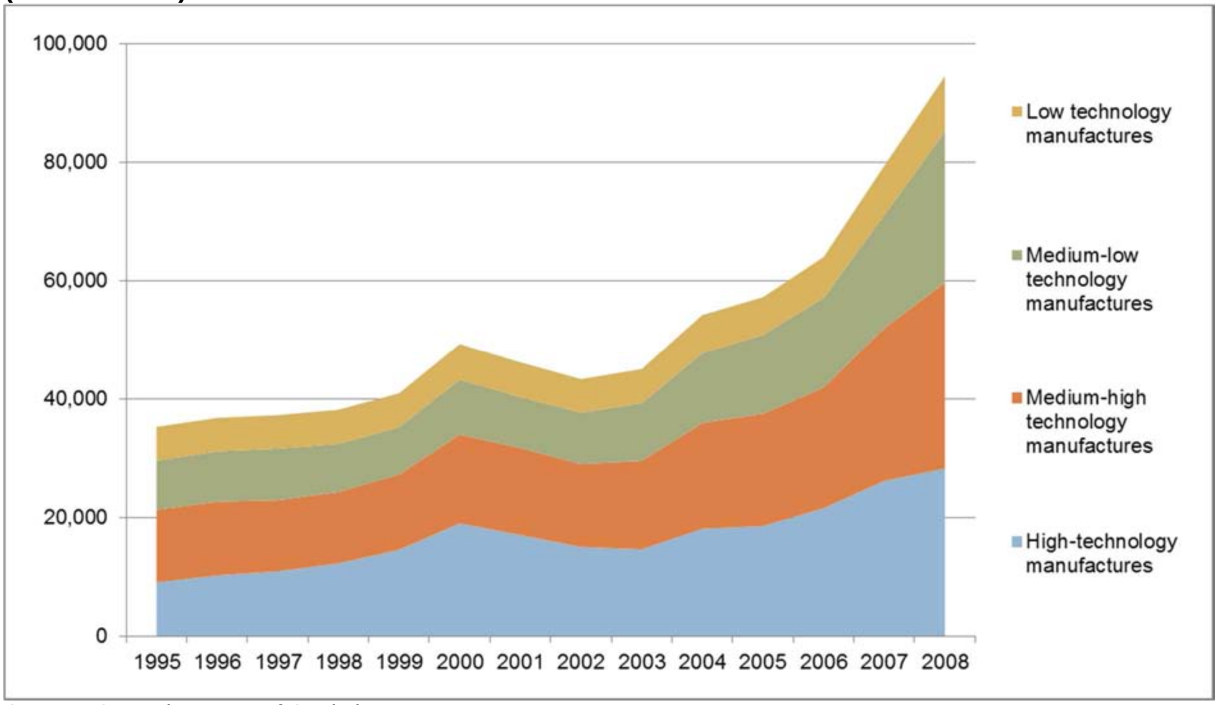
The globalization of S&T development and the growing importance of international trade in technology underscore the need for thorough ongoing testing of Israel's place in the international arena. This chapter examines several aspects of globalization—international trade, foreign investment in Israel (and Israel residents' investments abroad), and international cooperation in science and high-tech development.

8.1 International Trade by Technology Intensity

International trade is the basic indicator of globalization, especially at the macroeconomic level. Figure 8.1 shows Israel's volumes of international trade (imports+exports) in 1995–2008.

8.1.1 Growth of International Trade by Technology Intensity

Figure 8.1: Growth of Israel International Trade by Technology Intensity, 1995–2008 (USD millions)



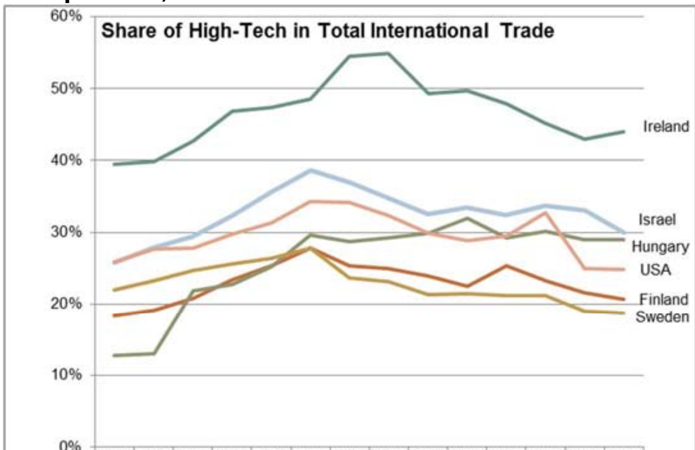
Source: Central Bureau of Statistics

The graph above shows that Israel's trade has expanded massively, from USD 35 billion in 1995 to USD 94 billion in 2008. The main leap forward took place in the past five years; the volume of trade more than doubled during that time (from USD 45.1 billion in 2003 to USD 94.6 billion in 2008).

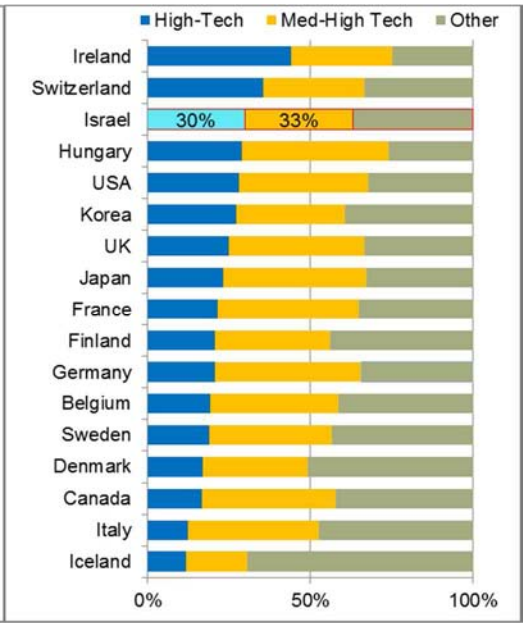
The increase in trade in high-tech products also stands out. In volume terms, it grew 3.1 times over relative to 1995 while total trade expanded by a factor of 2.7.

The share of high-tech products in Israel's total international trade climbed from 26 percent in 1995 to a record 39 percent in 2000, retreated slightly after the "dotcom crisis," and settled at 30 percent in 2008 (Figure 8.2)—the third-largest share among OECD countries (trailing Ireland at 44.2 percent and Switzerland at 35.4 percent).

Figure 8.2: Israel International Trade by Technology Intensity, International Comparison, 2008



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Finland	18%	19%	21%	23%	25%	28%	25%	25%	24%	22%	25%	23%	22%	21%
Hungary	13%	13%	22%	23%	25%	30%	29%	29%	30%	32%	29%	30%	29%	29%
Sweden	22%	23%	25%	26%	26%	28%	24%	23%	21%	22%	21%	21%	19%	19%
Ireland	40%	40%	43%	47%	47%	49%	54%	55%	49%	50%	48%	45%	43%	44%
Israel	26%	28%	29%	32%	36%	39%	37%	35%	33%	33%	32%	34%	33%	30%
USA	26%	28%	28%	30%	31%	34%	34%	32%	30%	29%	30%	33%	25%	25%



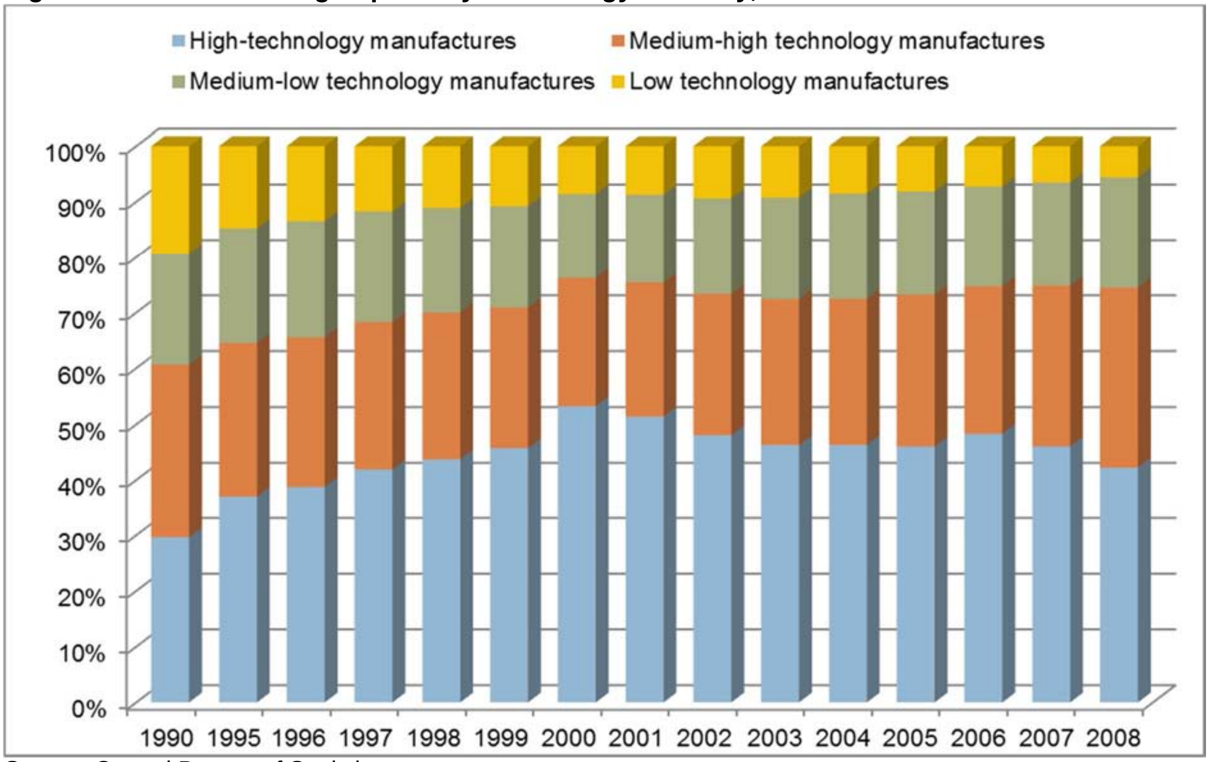
Sources: Central Bureau of Statistics and OECD.Stat.

8.1.2 Manufacturing Exports by Technology Intensity

The trend in Israel's manufacturing exports is similar but even more conspicuous. Since 1990, the share of high-tech and middle-high-technology industries in manufacturing exports increased from 61 percent to a peak of 76 percent in 2000 and then leveled off at 74 percent in 2008.

A watershed was crossed in 2000. Until then, the share of high-tech increased at the expense of all other sectors (from 30 percent in 1990 to 53 percent in 2000). Since then, the share of high-tech in exports has been contracting and that of high-middle technology industries has been rising—from 23 percent in 2000 to 32 percent in 2008 (Figure 8.3).

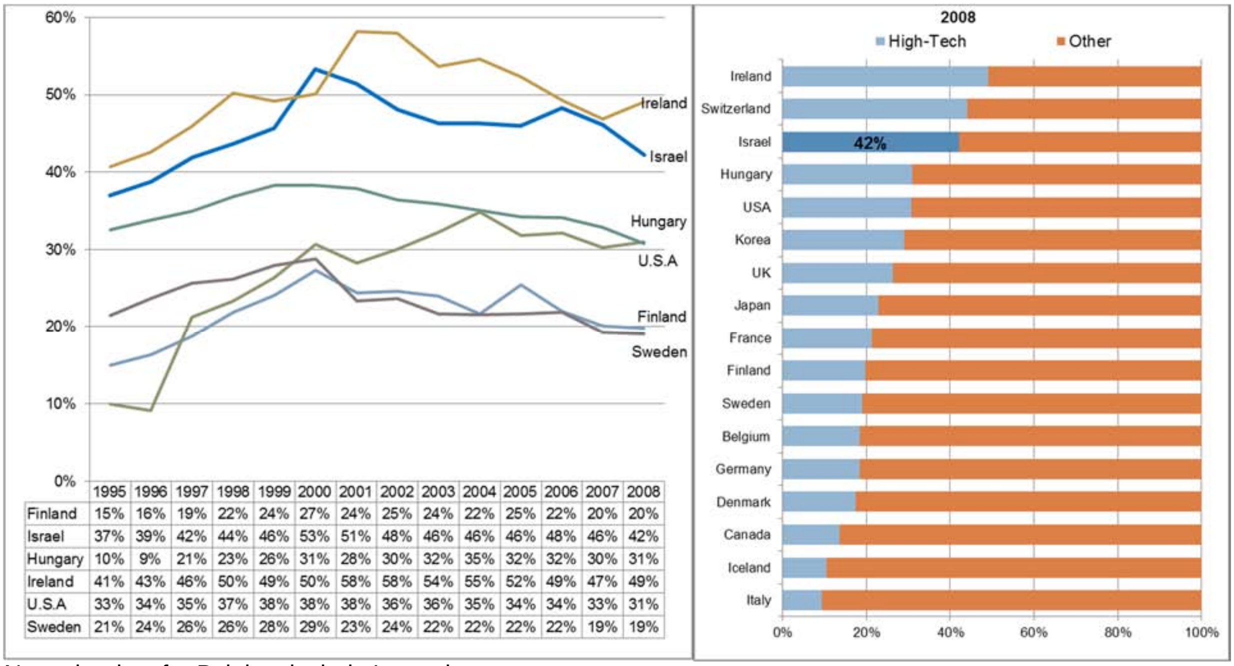
Figure 8.3: Manufacturing Exports by Technology Intensity, 1990–2008



Source: Central Bureau of Statistics.

Figure 8.4 shows that despite the relative contraction of high-tech in Israel exports, Israel is one of the world leaders in this indicator. This is because the trends of the Internet crisis affected other countries similarly.

Figure 8.4: Manufacturing Exports by Technology Intensity, International Comparison, 2008



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Finland	15%	16%	19%	22%	24%	27%	24%	25%	24%	22%	25%	22%	20%	20%
Israel	37%	39%	42%	44%	46%	53%	51%	48%	46%	46%	46%	48%	46%	42%
Hungary	10%	9%	21%	23%	26%	31%	28%	30%	32%	35%	32%	32%	30%	31%
Ireland	41%	43%	46%	50%	49%	50%	58%	58%	54%	55%	52%	49%	47%	49%
U.S.A	33%	34%	35%	37%	38%	38%	38%	36%	36%	35%	34%	34%	33%	31%
Sweden	21%	24%	26%	26%	28%	29%	23%	24%	22%	22%	22%	22%	19%	19%

Note: the data for Belgium include Luxembourg.
Sources: Central Bureau of Statistics and OECD.Stat.

8.1.3 Contribution to Trade Balance, by Technology Intensity

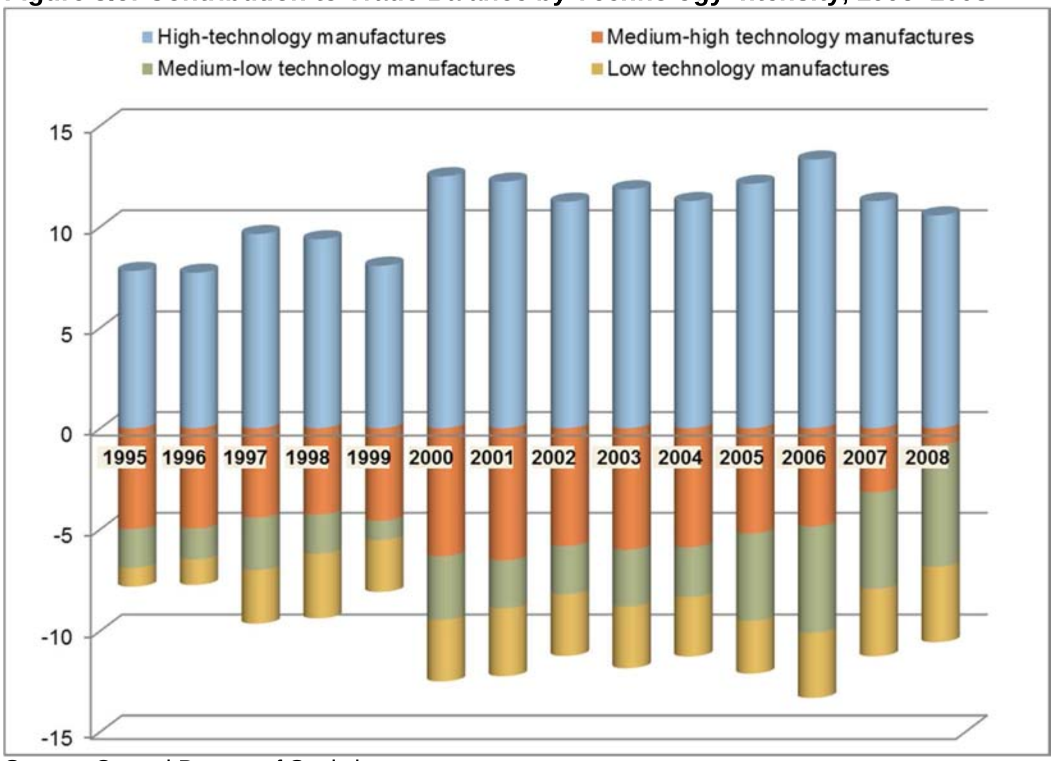
To gauge the contribution of technology intensity to the trade balance, this subsection measures the combination of imports and exports in various manufacturing industries that are sorted by technology intensity. This combination of industry-level import and export data allows us to examine the relative effect of each industry on the total trade balance. For each industry (or each partial aggregate of industries), the difference is calculated between the industry's actual trade balance and its share in the total trade balance in terms of volume of trade, using the following formula:

$$\frac{(X_i - M_i) - \left[\frac{(X - M)(X_i + M_i)}{(X + M)}\right]}{X + M}$$

where:
M = total imports
X = total exports
M_i = imports by technology intensity
X_i = exports by technology intensity

If this indicator has a positive value, the industry in question makes a larger contribution to the trade balance than its share in total volume of trade. The values of the indicator for all industries add up to zero by definition. The result is a common denominator that allows us to compare different countries' data at different times.

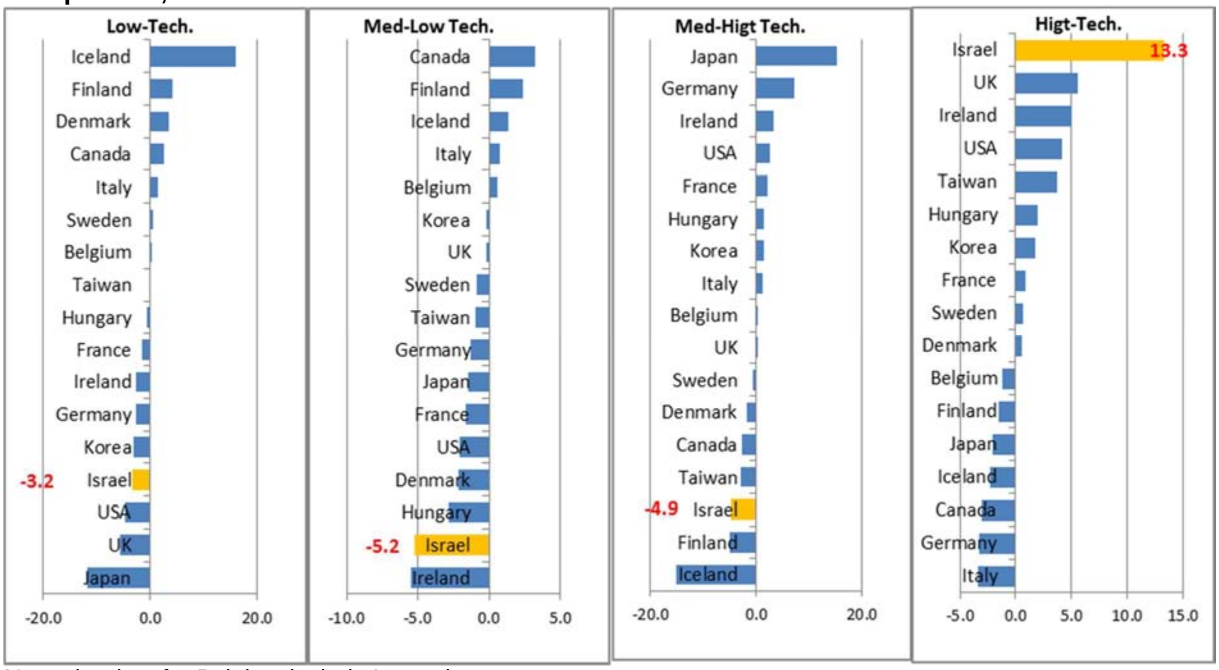
Figure 8.5: Contribution to Trade Balance by Technology Intensity, 1995–2008



Source: Central Bureau of Statistics

As Figure 8.5 shows, only high-tech industries had more exports than imports; all other industries made a negative contribution to the trade balance. This happened in other countries as well but was particularly extreme in Israel's case. The positive contribution of high-tech to Israel's trade balance is the world's largest. Conversely, Israel ranks at the bottom of the list in all other industries, meaning that firms in most manufacturing industries are unable to compete in the global market and are, in effect, "piggybacking" on high-tech.

Figure 8.6: Contribution to Trade Balance by Technology Intensity, International Comparison, 2006



Note: the data for Belgium include Luxembourg.
Sources: Central Bureau of Statistics and OECD.Stat.

Table 8.1 and Figure 8.7 show the trade balance by high-tech manufacturing divisions in 1995–2008. Generally speaking, imports exceed exports only once during this time (in 1996). Most divisions posted export surpluses in most years.

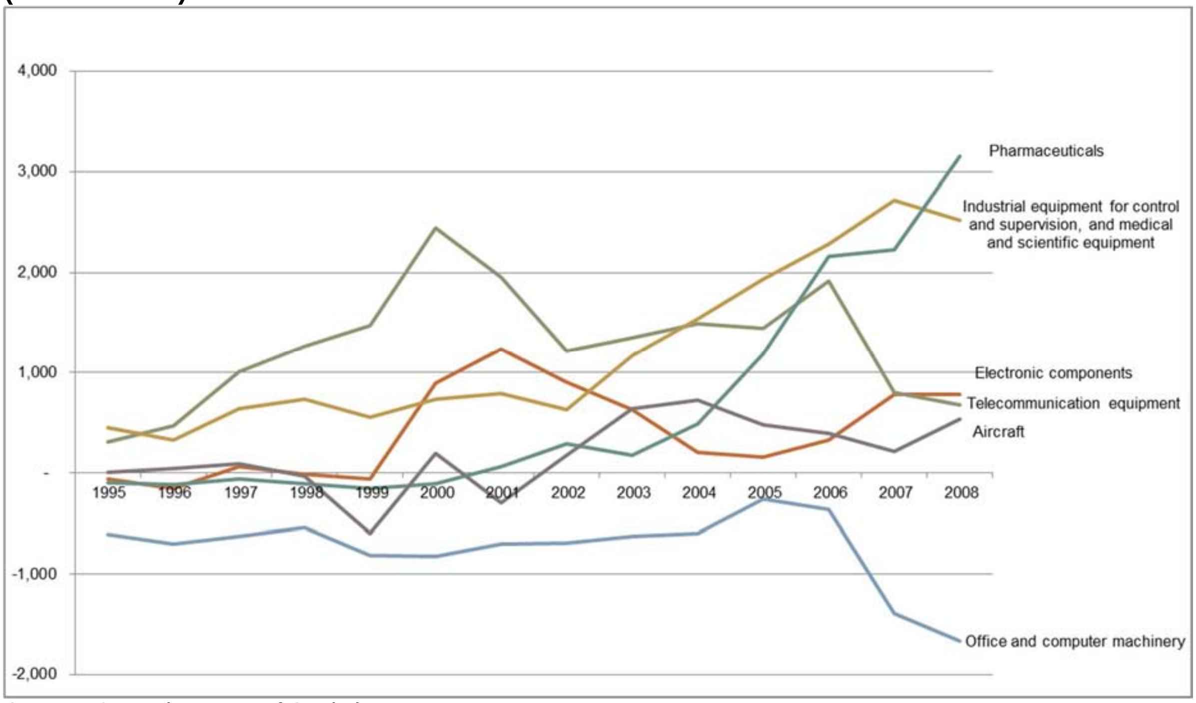
Table 8.1: Trade Balance in Goods, High-Tech Divisions, 1995–2008 (USD millions)

	30	32	33	34	245	355	
	Office and computer machinery	Electronic components	Telecommunication equipment	Industrial equipment for control and supervision, medical and scientific equipment	Pharmaceuticals	Aircraft	Total trade balance
1995	–610	–63	308	450	–95	11	***1***
1996	–698	–153	468	326	–117	42	***–132***
1997	–624	65	1,005	636	–60	96	***1,118***
1998	–544	–15	1,265	738	–103	–29	***1,312***
1999	–815	–55	1,476	557	–152	–600	***411***
2000	–825	896	2,444	738	–106	196	***3,343***
2001	–698	1,238	1,953	792	67	–296	***3,056***
2002	–688	900	1,219	627	288	180	***2,526***
2003	–628	631	1,346	1,168	177	640	***3,334***
2004	–594	206	1,488	1,536	488	723	***3,847***
2005	–255	158	1,441	1,933	1,188	484	***4,949***
2006	–365	329	1,920	2,286	2,157	390	***6,717***
2007	–1,394	786	800	2,716	2,228	218	***5,354***
2008	–1,664	786	681	2,516	3,153	535	***6,007***

Source: Central Bureau of Statistics.

The only division that posted import surpluses regularly was office and computer machinery. Another noteworthy finding is the steep increase in pharmaceuticals exports. Until 2000, this division's imports exceeded its exports. Since 2001, however, its export surplus has been rising steadily and today it generates more than half of the total export surplus of high-tech industry at large.

Figure 8.7: Trade Balance in Goods, High-Tech Industries, by Divisions, 1995–2008, (USD millions)



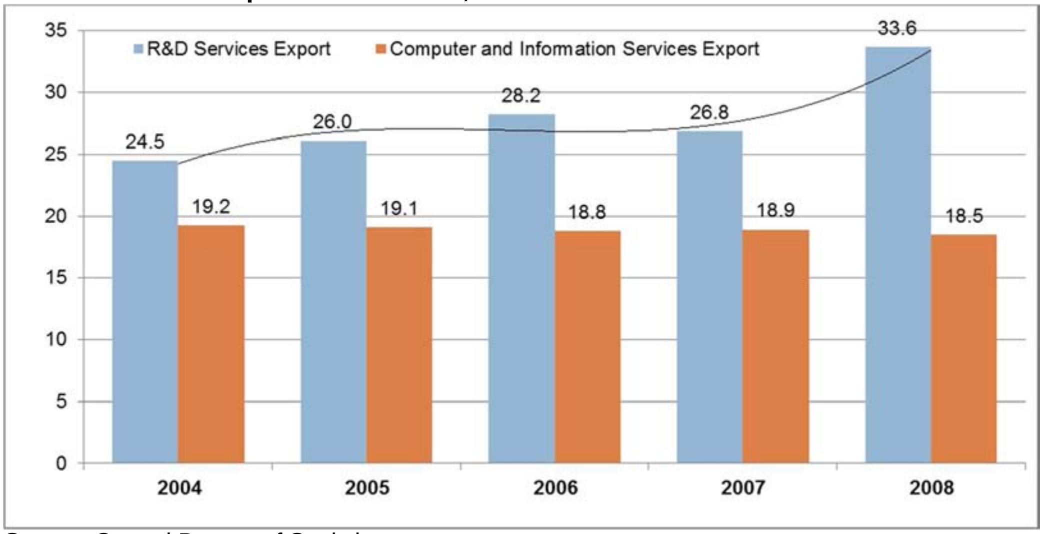
Source: Central Bureau of Statistics.

8.1.4 Exports of Services

To analyze trade in services, it is necessary to use different tools from those for the analysis of trade in goods. The division by economic branches in the classification scheme—an indispensable tool in the analysis of trends in international trading goods—is less effective in the case of trade in services because different industries may use the same type of service (financial services, computer services, etc.). Accordingly, the OECD classifies trade in services by types of service. The Israel Central Bureau of Statistics has adopted this approach.

Figure 8.8 shows the trends in exports of two kinds of services—R&D Services (Division 73 in the CBS typology) and Computer and Information Services (Division 72). In 2008, these service divisions, which are clearly identified with high-tech, generated more than half of Israel's exports of services.

Figure 8.8: Exports of Computer and Information Services and R&D Services as Percent of Total Exports of Services, 2004–2008

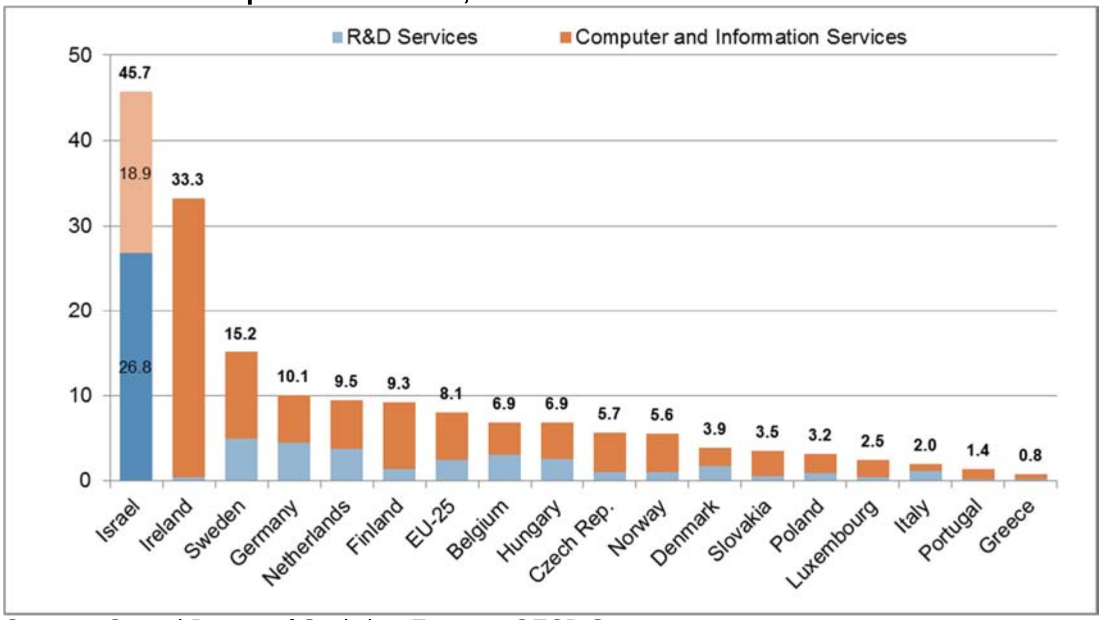


Source: Central Bureau of Statistics.

As stated, these two types of services are the largest in Israel's services exports. However, they have been trending differently over the years. The share of computer and information services has been contracting, albeit very slowly—from 19.2 percent of services exports in 2004 to 18.5 percent in 2008. Conversely, the share of R&D services in total services exports has been rising, from 24.5 percent to 33.6 percent in the respective years. The increase traces to the recovery of the startup market. (See Chapter 6, Section 3.4.)

An international comparison of the components of exports supports the claim that Israel has established a specialization in technological services and, above all, R&D. In 2007, the share of computer and information services and R&D services in Israel's exports was the largest among the countries shown. Within the total, exports of computer services were 18.9 percent of total exports (in second place, after Ireland at 32.9 percent) and R&D services exports were 26.8 percent—a very large share by the standards of other Western countries. In 2007, R&D accounted for less than 5 percent of Sweden's exports and even a smaller share of the exports of other Western countries (Figure 8.9). For example, in Ireland, which is also considered a high-tech country, the share of R&D in total exports of services was 0.4 percent.

Figure 8.9: Exports of Computer and Information Services and R&D Services as Percent of Total Exports of Services, 2007



Sources: Central Bureau of Statistics, Eurostat, OECD.Stat.

8.2 Multinational Firms

This section presents various indicators of international economic relations: the activity of Israeli subsidiaries abroad (OUT firms), that of Israeli firms controlled by nonresidents (IN firms), foreign investment in Israeli firms and resident investments in foreign firms, financing and acquisition of Israeli startups by nonresidents, and investments by Israeli venture-capital funds in foreign firms. In most of the analyses that follow, we present the share of high-tech industries and survey its unique characteristics.

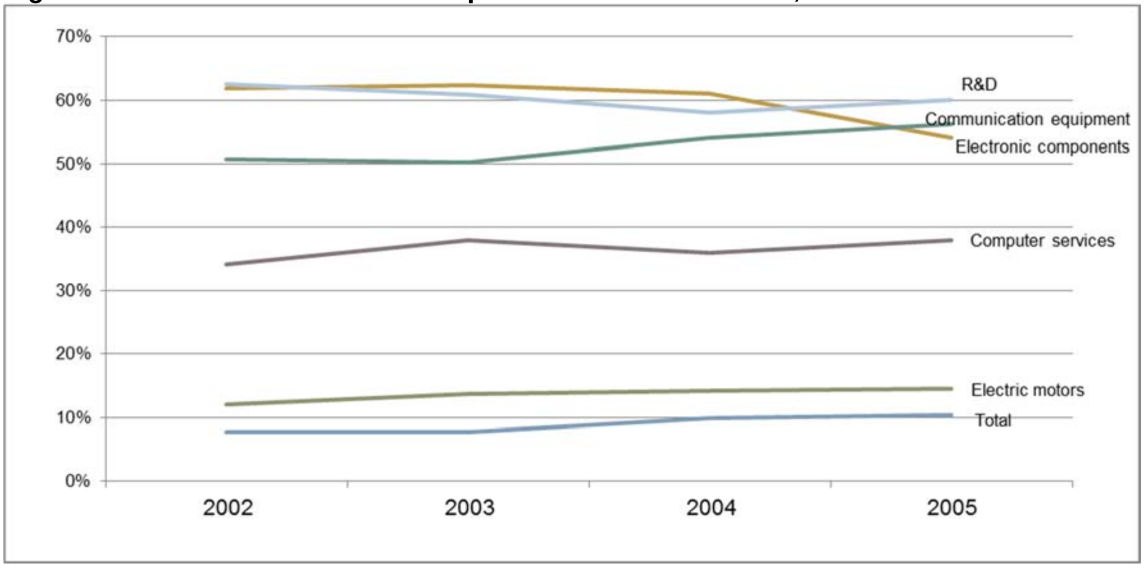
8.2.1 IN Firms

An IN firm is a firm that operates in Israel and is held by a nonresident (corporation or individual) at a rate exceeding 50 percent of its share equity.

As Figure 8.10 shows, the share of IN firms in the output of knowledge-intensive industries usually rests in the 40–60 percent range, far exceeding the share of these firms in the output of the economy at large (around 10 percent). Only in manufacture of electrical motors does the presence of foreign firms approximate the national average.

Several changes occurred between 2002 in 2005. The electronic-components industry lost altitude, the share of IN firms in its output slipping from 62 percent to 54 percent in the respective years. Concurrently, the share of IN firms in the manufacture of telecom equipment (mainly in the ICT industries) rose from 50 percent to 56 percent. Foreign firms were especially well represented in the R&D industry; in 2005, 60 percent of industry output was generated by IN firms, mainly international R&D centers. (See Chapter 7, Section 3.2.)

Figure 8.10: Share of IN Firms in Output of Selected Industries, 2002–2005



Source: Central Bureau of Statistics.

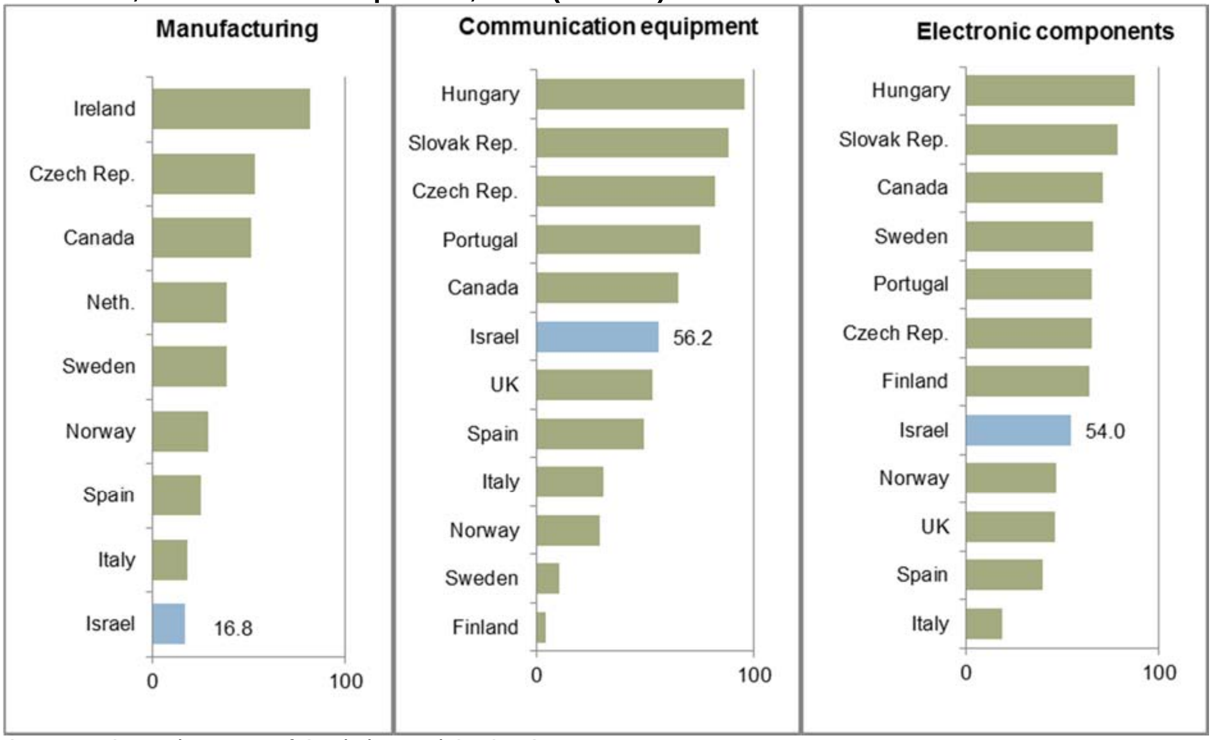
Figure 8.11 presents an international comparison of the share of IN firms in various industries' output. The data in the graph and in the preceding one indicate that IN firms' activity in Israel focuses on the service industries and, evidently, in the knowledge-intensive part of the sector. The share of these firms in business-sector output came to 10 percent in 2005; their share in manufacturing output was 16.8 percent. Consequently, manufacturing accounts for about one-third of the output of IN firms in Israel.[45] Similarly, Figure 8.11 shows that the participation rate of IN firms in the output of various high-tech manufacturing industries resembles that in other

[45] The calculation is as follows: let X_{IND} denote the manufacturing output of IN firms, X_{NI} the rest of their output, and Y and Y_{IND} business products and manufacturing output. Thus, if Y_{IND}/Y=.20, we obtain:

$$\frac{0.10}{0.168} = \frac{X_{IND} + X_{NI}}{Y} \Big/ \frac{X_{IND}}{Y_{IND}} = \frac{X_{IND} + X_{NI}}{X_{IND}} \times 0.2$$

developed countries. Notably, IN firms account for a large share of high-tech manufacturing in Eastern European countries such as Hungary and Slovakia.

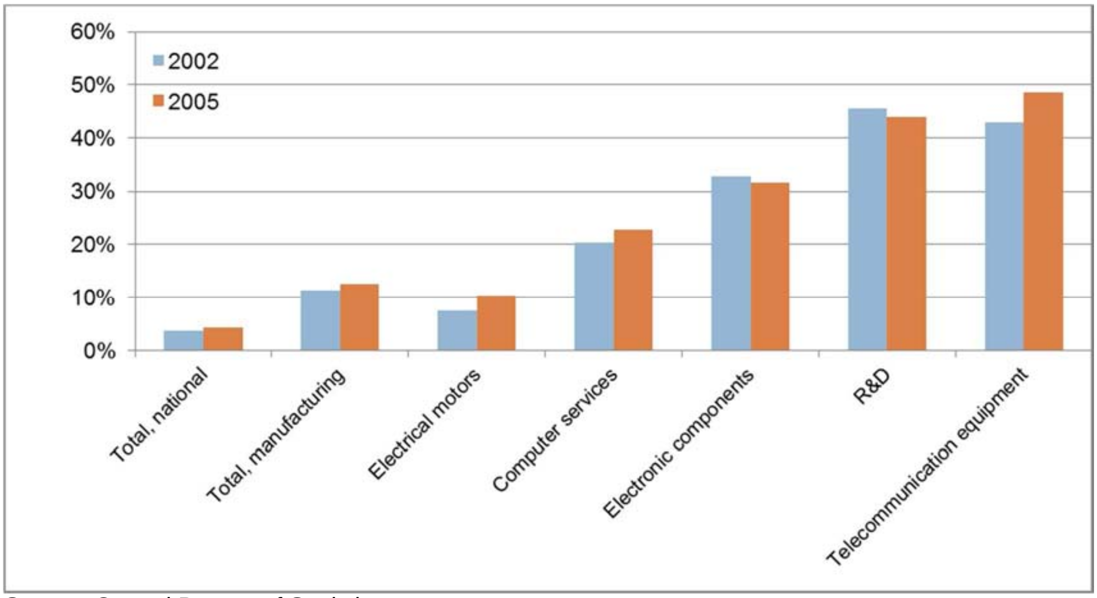
Figure 8.11: Share of IN Firms in Manufacturing Output and Output of Selected Industries, International Comparison, 2005 (Percent)



Sources: Central Bureau of Statistics and OECD.Stat.

Like their share in output, the share of IN firms in employment in knowledge-intensive industries surpasses the average in the economy and in manufacturing (Figure 8.12). However, since these firms account for a smaller fraction of employment than of output, their output per employee exceeds the business-sector average. This phenomenon stands out in the knowledge-intensive services: computer services (Division 72) and R&D (Division 73). In 2002, for example, 44 percent of employees in the R&D industry worked for IN firms and generated 60 percent of industry output. In 2005, the respective rates were 46 percent and 62 percent, respectively. This matters is described at length in Subsection 8.3.2.

Figure 8.12: Share of IN Firms in Employment, National and in Selected Industries, 2002 and 2005



Source: Central Bureau of Statistics.

Another indicator of IN firms' activity is "internal exports," i.e., exports by an IN firm to related firms abroad (parent companies, subsidiaries, etc.). Such exports account for about two-thirds of these firms' total exports and have been growing steadily in volume while their share in these firms' total exports has held steady (Table 8.2). This demonstrates the importance of IN firms in Israel's international trade relations, which are integrating the domestic economy into the global system.

Table 8.2: Internal Exports as Share of Total Exports of IN Firms' Israeli Affiliates, 2002–2005 (USD millions)

	Internal exports	Total exports	%
2002	5,083	7,518	67.61%
2003	5,248	7,748	67.74%
2004	5,809	8,520	68.18%
2005	6,334	9,292	68.17%

Source: Central Bureau of Statistics.

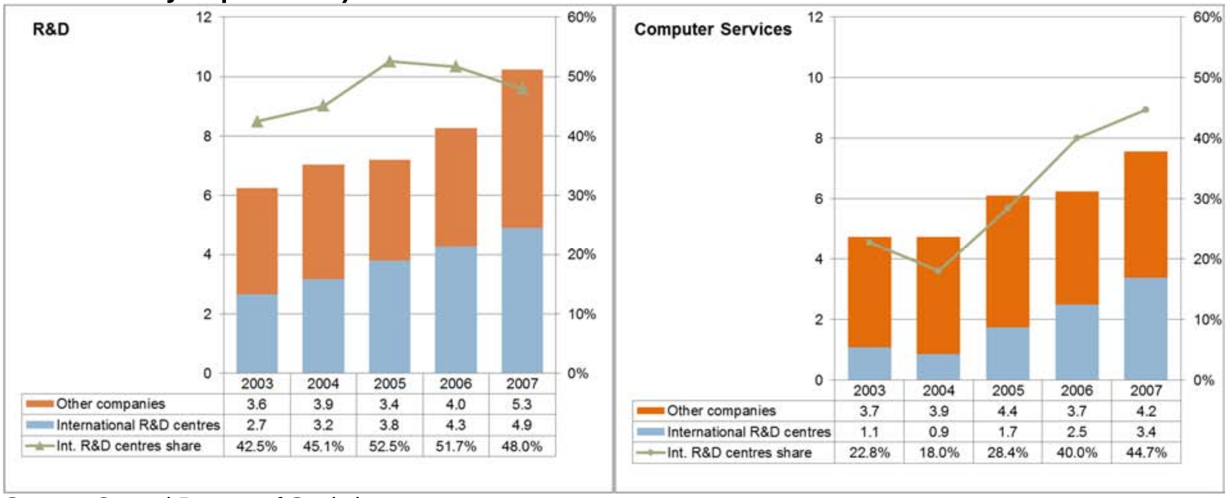
8.2.2 Multinational Firms' R&D Centers

Globalization allows firms that operate in the global market to scatter development and production processes across different countries in accordance with profit considerations. Many such firms have chosen in recent years to place their research and development centers in Israel.

Figure 8.13 illustrates the importance of the multinationals' centers for Israeli R&D in knowledge-intensive industries. Some 45 percent of total R&D expenditure in the R&D and computer-services industries in 2007 was performed at the R&D centers of multinational firms—NIS 4.9 billion and NIS 3.4 million in the respective industries.

Thus, these centers were responsible for around one-third of all business R&D performed in Israel!

Figure 8.13: International Centers' R&D Expenditure, 2003–2007 (NIS billions, Share of Total Industry Expenditure)

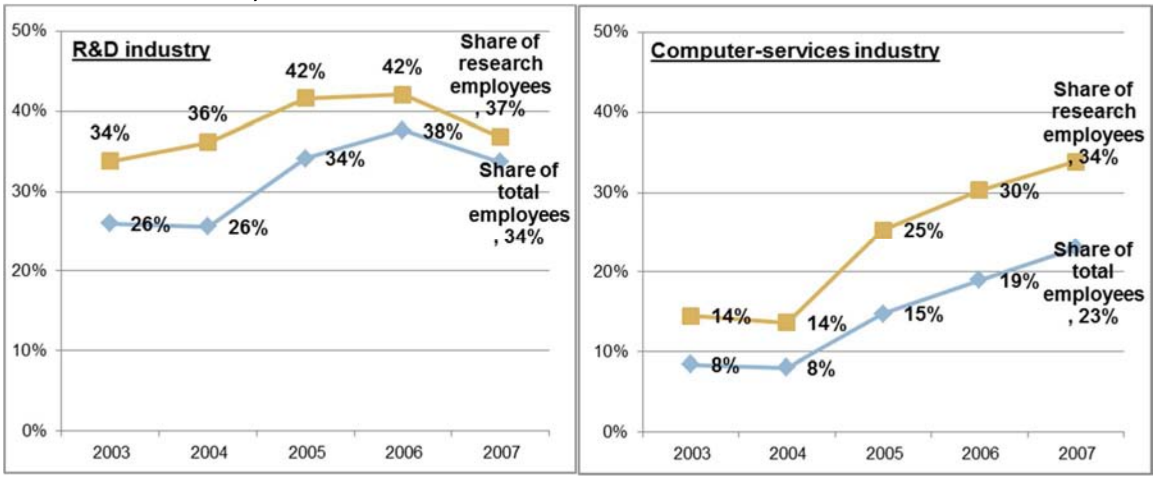


Source: Central Bureau of Statistics.

Such a large share of R&D expenditure in the hands of these centers affects Israel's overall R&D picture and, in a sense, distorts it. The reason is that since the centers are affiliates of large multinational firms, they are different from Israeli firms that operate in the same industry in terms of their structure, their marketing orientation, and, above all, their parent firms' commitment to remaining in Israel as active entities and employers.

The share of research staff among all employees of multinationals' R&D centers in Israel exceeds the national average. Figure 8.14 shows the proportion of the centers in total employment in computer services and R&D (Divisions 72 and 73, respectively) among research employees in these industries. When a large proportion of research employees at foreign firms' R&D centers in Israel is found, it means that for every R&D employee at a multinational center, the proportion of other employees who work there (staff, services, technical support, etc.) is below the national average.

Figure 8.14: Share of Foreign Firms' R&D Centers in Employment, Computer-Services and R&D Industries, 2003–2007



Source: Central Bureau of Statistics.

Multinational firms' R&D centers seldom engage in marketing activity; instead, they transfer the results of their R&D to their parent firms. Statistically, this movement is considered an export transaction at the value equal to the R&D expenditure. In other words, when a center does little marketing activity, its ratio of turnover to expenditure is close to 1 and its share of foreign income in total income verges on 100 percent.

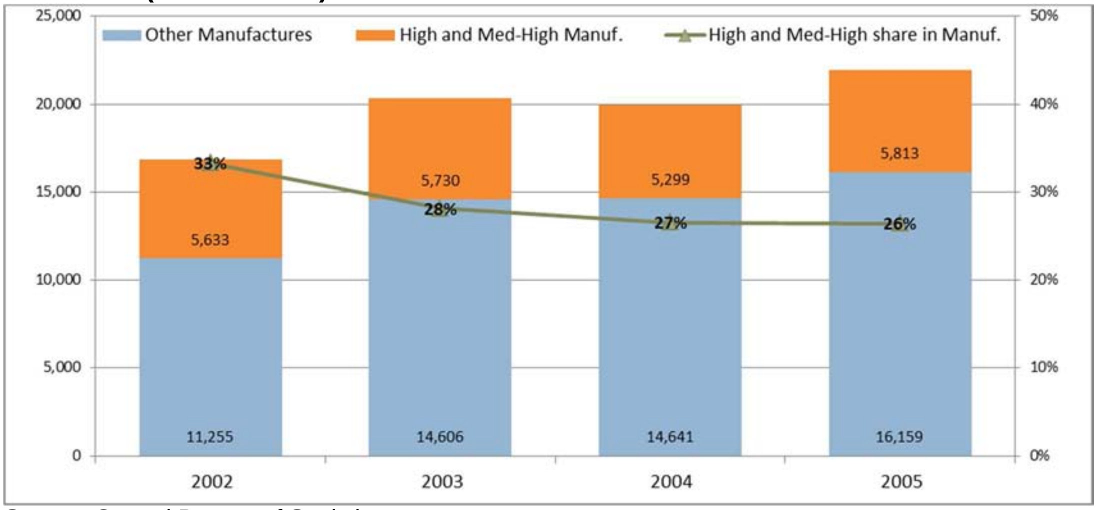
In 2003–2007, 99.3 percent of the income of multinational R&D centers in the computer-services industry came from abroad (as against 83.2 percent on average in this industry). In the R&D industry, the share of multinational centers' income from abroad has been declining perceptibly: from 99.9 percent in 2003–2005 to only 81.1 percent in 2006–2007, below the industry average (84.7 percent). During the same years, the share of R&D expenditure and also of employment at the multinational centers in the R&D industry declined. In 2007, employment at the centers in simple count also decreased, even as R&D expenditure and employment rose steadily in the computer-services industry.

8.2.3 Foreign Subsidiaries

This subsection discusses the activity of OUT firms, i.e., foreign firms in which at least 50 percent of share equity is held by an Israeli parent firm.

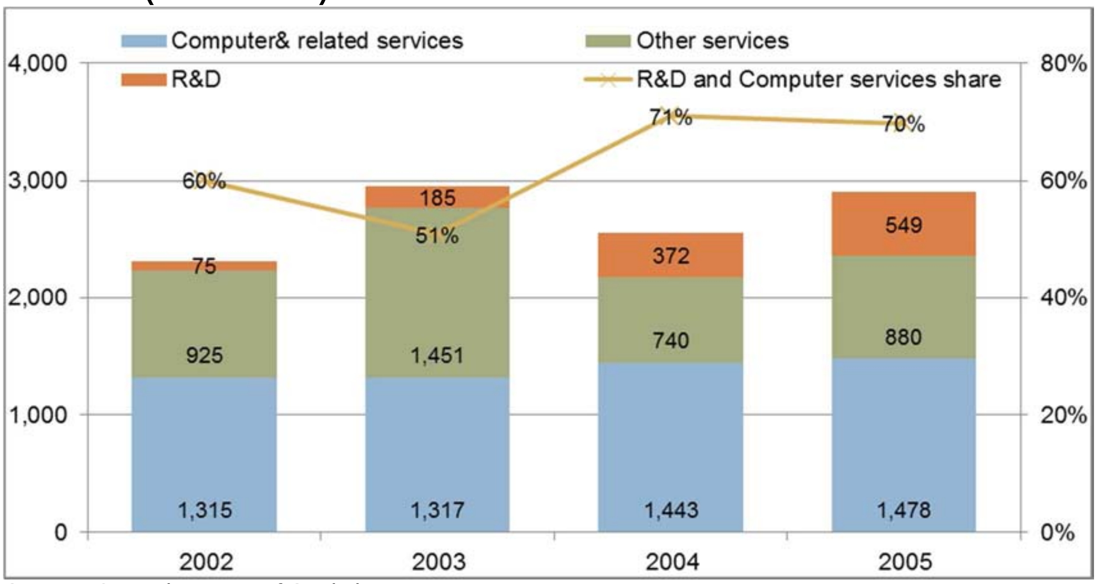
Figure 8.15 and 8.16 show that foreign subsidiaries sell much more goods (manufactures) than services. In another important phenomenon, their share of high-tech and middle-high technology industries in sales is not high and has been falling steadily. In contrast, the proportion of services sold by these subsidiaries, mainly in R&D and computer services, has been trending up.

Figure 8.15: OUT Firms' Sales of Manufactures, by Industry of Israeli Parent Firms, 2002–2005 (USD millions)



Source: Central Bureau of Statistics.

Figure 8.16: OUT Firms' Sales of Services, by Industries of Israeli Parent Firms, 2002–2005 (USD millions)



Source: Central Bureau of Statistics.

8.2.4 Foreign Direct Investment

Foreign direct investment (FDI) is investment made for the purpose of acquiring a significant controlling stake in a firm that operates outside the investor's country. Only when a single investor acquires more than 10 percent of the targeted firm's share equity is the investment considered a direct one. Such investments include acquisition of shares, principals' loans, and reinvestment of earnings. FDI is an indicator of investors' confidence in the stability of the target country's economy and firms.

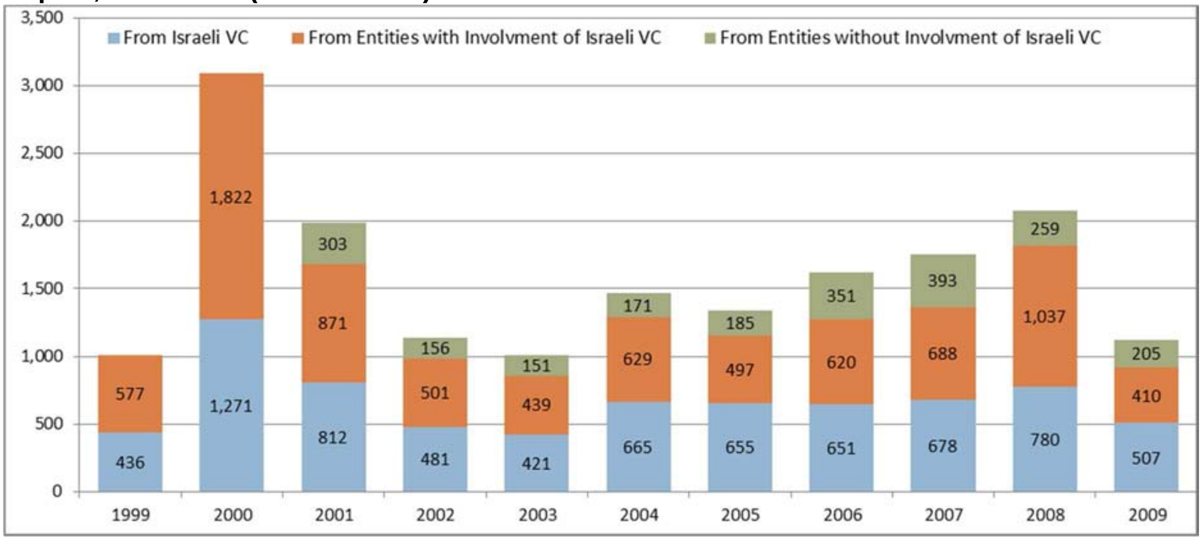
FDI in Israel has been growing steadily, from 1.41 percent of GDP in 1995 to 4.84 percent in 2008. Both the growth rate of the investment flow and its absolute value resemble those of other developed countries, showing the Israel is perceived by the world as an economy at least as stable and attractive as most OECD member-states (if not more so).

A cross-industry comparison may show which domestic industries are most attractive to foreign investors. We intend to include such an analysis in our next reports, once the Central Bureau of Statistics finishes gathering the requisite data.

8.2.5 Startups

As noted, Israel's R&D industry (Division 73) includes a large proportion of startups that rely heavily on venture capital. Consequently, foreign investors' activity in the Israeli VC market may be regarded as an indicator of the level of globalization of Israeli R&D.

Figure 8.17: Venture-Capital Investments in Israeli High-Tech Firms, by Source of Capital, 1999–2009 (USD millions)



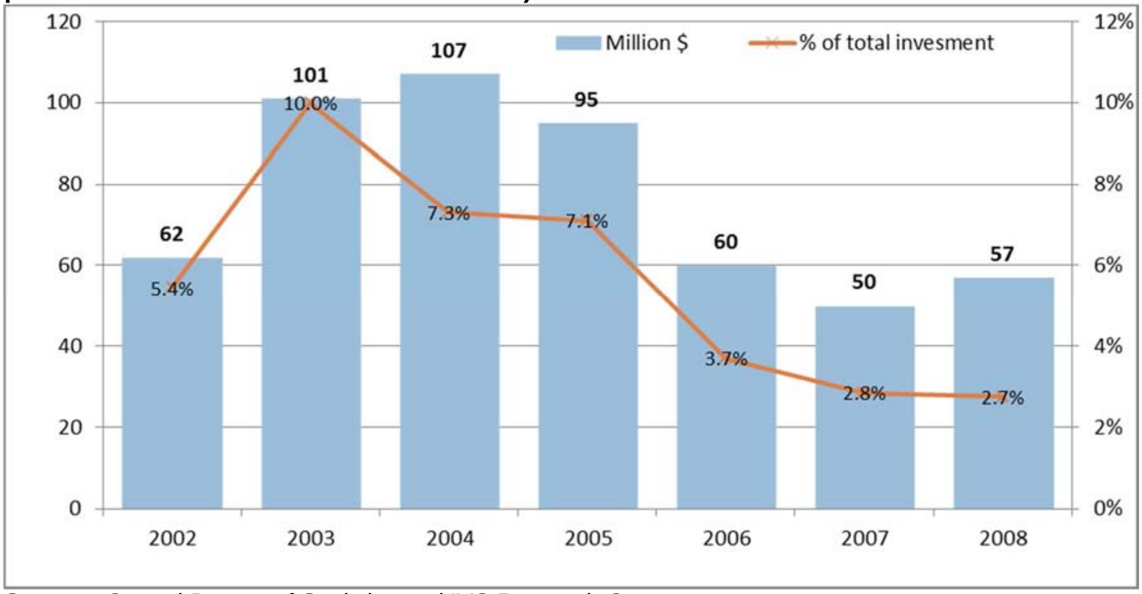
Source: Central Bureau of Statistics.

Figure 8.18 shows the extent of VC investment in Israeli high-tech firms and its apportionment between Israeli and foreign investors. The share of Israeli VC funds fell gradually from 43 percent in 1998 to 38 percent in 2008. Some 62 percent of total VC investment was of foreign or semi-foreign origin—50 percent from entities in which Israeli funds are involved and 12 percent from funds that have no Israeli involvement. The first year of significant investment by foreign VC funds in the Israeli market was 2001. Their involvement peaked in 2006 and 2007, at 22 percent of total investment in Israeli high-tech firms, and receded to 12 percent in 2008.

The recent crisis took a severe toll on funding for Israeli startups. In 2009, investments in these ventures fell by 46 percent relative to the previous year. The main change took place in the activity of mixed funds, which slashed their investments in Israel by 60 percent in 2009 relative to 2008. Israeli funds and foreign funds reduced their activity by 35 percent and 21 percent, respectively. Consequently, mixed funds accounted for only 37 percent of total VC investments in 2009, the lowest rate since measurement began, and Israeli funds and foreign funds generated 45 percent and 18 percent of the investment, respectively.

Conversely, Israeli VC funds do not invest extensively abroad. From 2004 on, as investment in Israeli high-tech firms increased, investments in foreign firms contracted from 10 percent of total investment (USD 101 million) in 2003 to 2.7 (USD 57 million) in 2008 (Figure 8.18).

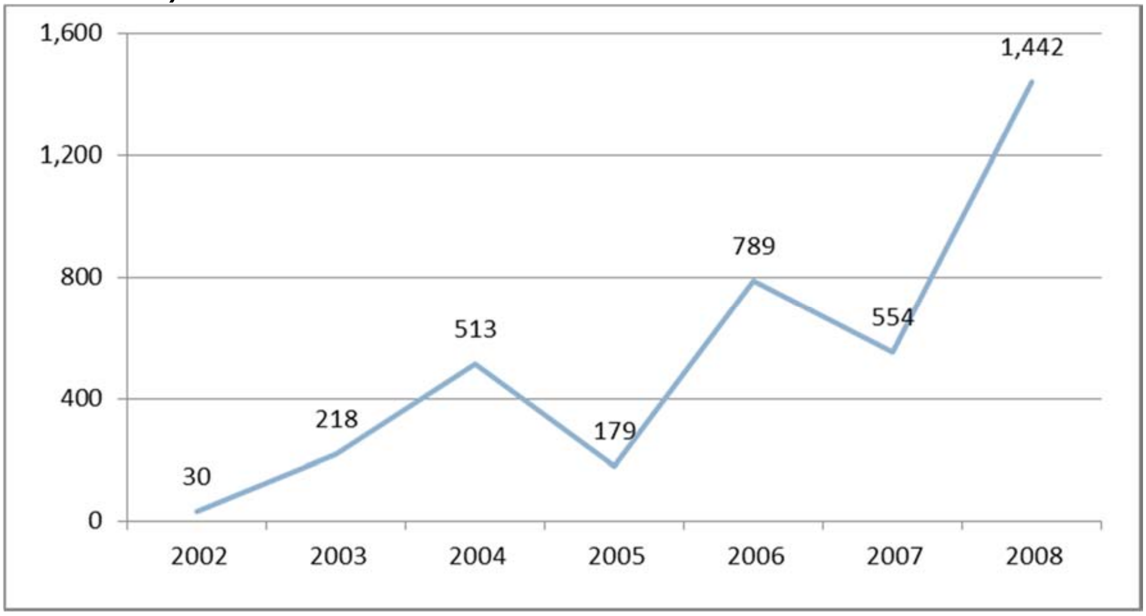
Figure 8.18: Israel Venture-Capital Fund Investments in Foreign Firms, 2002––2008 (in pct. of total investment and USD millions)



Sources: Central Bureau of Statistics and IVC Research Center.

Another way to measure globalization is via the extent of nonresident acquisitions of Israeli startups. The total value of these acquisitions increased 48 times over (!) between 2002 and 2008, from USD 30 million to USD 1,442 million (Figure 8.19). This indicator should be taken with a grain of salt, of course, because one large transaction can sometimes change an entire picture. Still, the general upward trend in nonresident acquisitions of Israeli startups is undoubted.

Figure 8.19: Nonresident Acquisitions of Israeli Startups, 2002–2008 (Sale value in USD millions)



Source: Central Bureau of Statistics.

It is also conventional practice to examine the extent of nonresident acquisitions of startups by judging sale value relative to investments made in the firms before they are sold. If the ratio is high, it shows that the buyers are willing to pay much more for the company that had been invested in it. This may happen when a product is acquired in its initial development stages or when it seems very attractive. A high ratio suggests that the investor expects future revenue that will exceed the investments already made in the firm and attests to the high quality of Israeli R&D in nonresident investors' eyes.

Table 8.3: Pre-Sale Investment in Startups, Sale Value of Startups, and Ratio

Year	Pre-sale investment (USD thousands)	Sale value (USD thousands)	Ratio
2002	7,700	30,000	3.9
2003	25,000	218,000	8.7
2004	234,000	513,000	2.2
2005	118,451	179,300	1.5
2006	301,400	789,000	2.6
2007	290,600	554,000	1.9
2008	238,300	1,442,300	6.1
Total	**1,215,451**	**3,725,600**	**3.1**

Source: Central Bureau of Statistics.

8.3 Globalization in Science

International scientific relations are crucial for the enhancement of the human capital on which Israel's knowledge-based industries are based. This section presents two current indicators of quality of these relations (patents, publications) and one indicator of future trends (international student mobility).

8.3.1 Patents

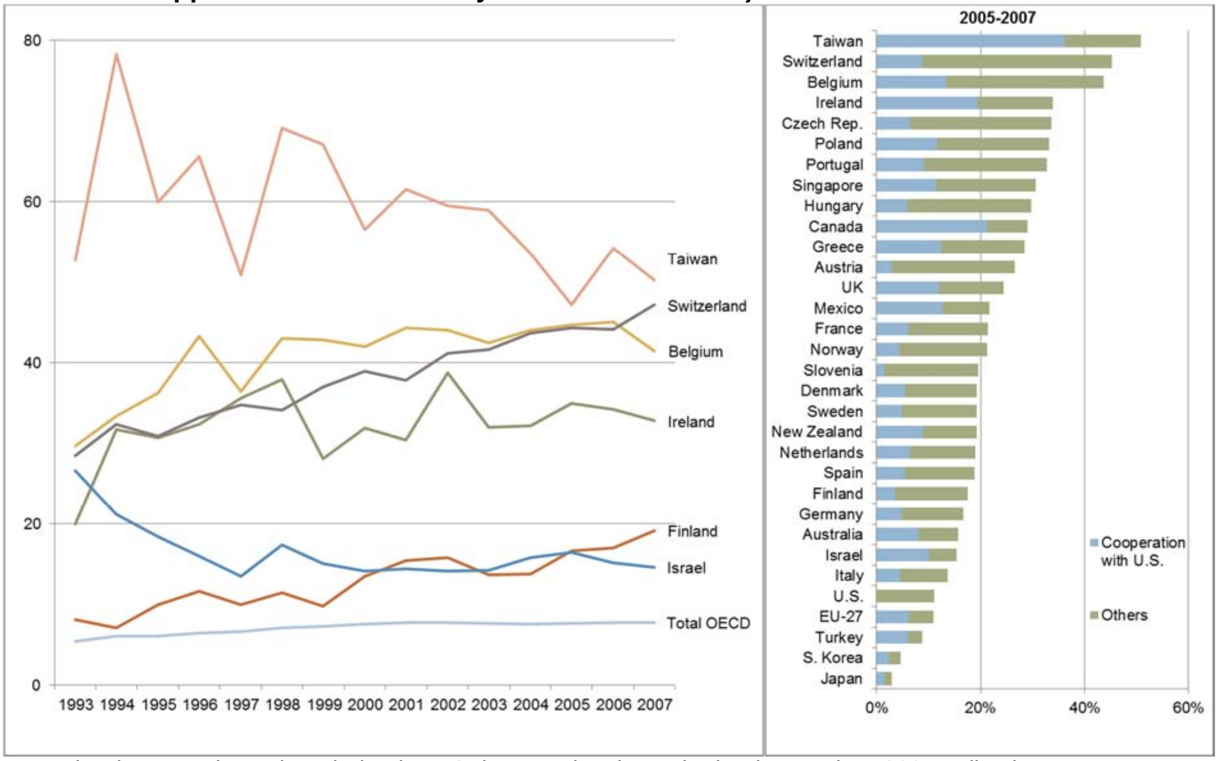
International cooperation in registering patents is an important indicator of a country's status in the global technological arena. It reflects both the quality of the country's R&D by world standards and the country's importance in as a participant in the global markets for knowledge-intensive products.

Today, international cooperation in patents takes place under the PCT (Patent Cooperation Treaty), which deals with international patent applications. The PCT was executed in Washington in 1970 in order to establish a standard mechanism for patent registration in multiple countries on the basis of one international application. By June 2010, 142 countries had ratified the PCT; Israel did so in June 1996.[46]

The OECD has proposed several indicators to test the strength of relations among inventors in different countries. One of them is the proportion of patents held by inventors from several countries. Figure 8.20 contrasts Israel with selected countries in cooperation between domestic and foreign inventors in 1993–2007. The graph on the right lists countries that submitted more than 300 applications in 2005–2007.

[46] See http://www.justice.gov.il/MOJHeb/RashamHaptentim/PCT/Odot.htm.

Figure 8.20: Cooperation between Domestic and Foreign Inventors (Percent of total PCT Patent Applications Submitted by Domestic Inventors)



Note: the data are shown by priority date. Only countries that submitted more than 300 applications are listed.
Source: OECD Patent Databases, June 2010.

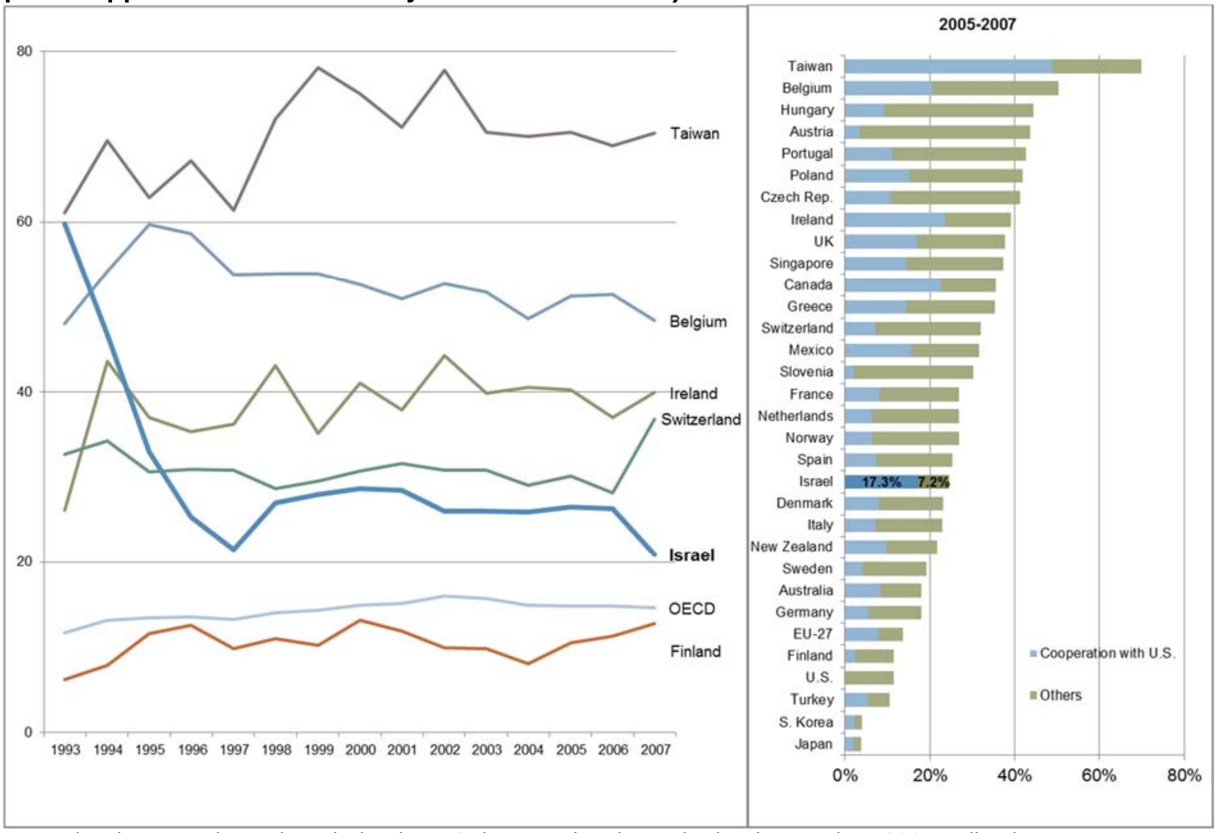
The graph on the left, showing the long-term trends, indicates that international cooperation by Israeli inventors is declining, contrary to the global trend. The downturn halted in 1997 after the PCT was ratified but resumed in 1999, albeit at a slower pace.

Another significant trend illuminated by the graph is the high rate of collaboration with American inventors. Between 2005 and 2007, almost two-thirds of Israeli inventors' foreign co-applicants were American. Only Canada (72.7 percent) and Taiwan (71.3 percent) surpassed Israel in this respect.

Studying the trends in the index of cooperation between Israeli and foreign inventors over time, one can discern a decrease in cooperation between Israeli and American inventors—from 78.9 percent in 1993 to 65.5 percent in 2007—and a vigorous increase in cooperation with inventors from the EU-27 countries, from 17.5 percent to 27.4 percent in the respective years.

Another significant indicator of patent cooperation is the rate of foreign assignment of local inventions, a parameter that may be seen as a reflection of the drain of intellectual property. Figure 8.21 shows the share of domestic patents that are foreign-assigned.

Figure 8.21: Foreign Assignment of Domestic Patent Applications (Percent of total PCT patent applications submitted by domestic inventors)



Note: the data are shown by priority date. Only countries that submitted more than 300 applications are listed.
Source: OECD Patent Databases, June 2010

As the graph shows, Israel is among the leaders in this indicator. Israel's rate of foreign assignment of domestic inventions in 2005–2007 was 24.5 percent as against 69.9 percent in Taiwan, 50.3 percent in Belgium, and 44.4 percent in Hungary. The indicator for Israel declined steeply in the 1990s and has been stable in recent years.

Another statistic illuminated by Figure 8.21 is that 70.6 percent of the foreign assignees of Israeli inventions are American—the highest rate in the world,[47] followed by Taiwan (69.9 percent) and Canada (53.1 percent)—as against 14.7 percent of foreign assignees from the EU. In 1993, the corresponding rates were 75 percent of foreign assignees from the U.S. and 23.4 percent from the EU-27. The narrowing of the spread between these rates is evidence of the growing interest of other countries' inventors in Israeli patents.

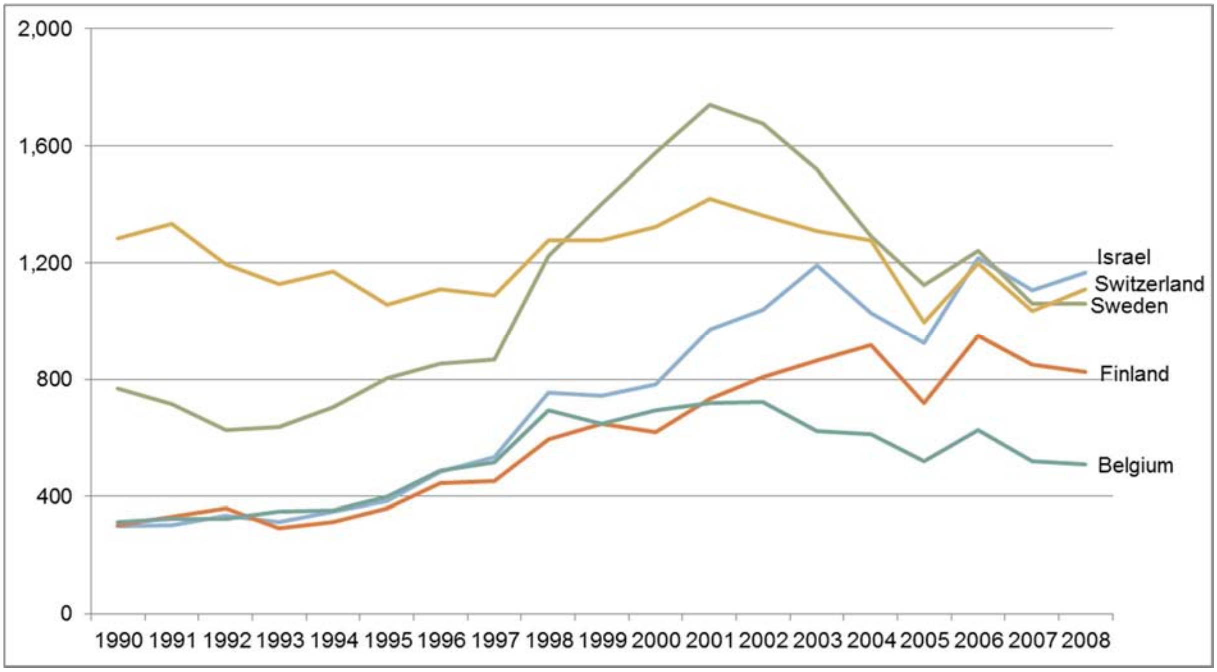
The number of patent registrations may also be used as a gauge of international business relations. Since a patent is protected only in countries where it is registered,

[47] Among countries whose citizens presented more than 300 patent applications in 2005–2007, of which more than 100 were assigned to nonresidents.

willingness to register a patent in a given country may be indicative of the market's interest in that country.

For example, in 2008 (and in previous years), more patents belonging to inventors from Israel were registered with USPTO (the United States Patent and Trademark Office) than of inventors from OECD countries of similar size (Figure 8.22). This suggests not only a rapid pace of innovation but also strong economic relations with the U.S. For a further breakdown of Israeli patents registered with USPTO, see Section 3 of Chapter 7.

Figure 8.22: Patents Registered with USPTO, by Country Shown in Inventor's Address, 1990–2010

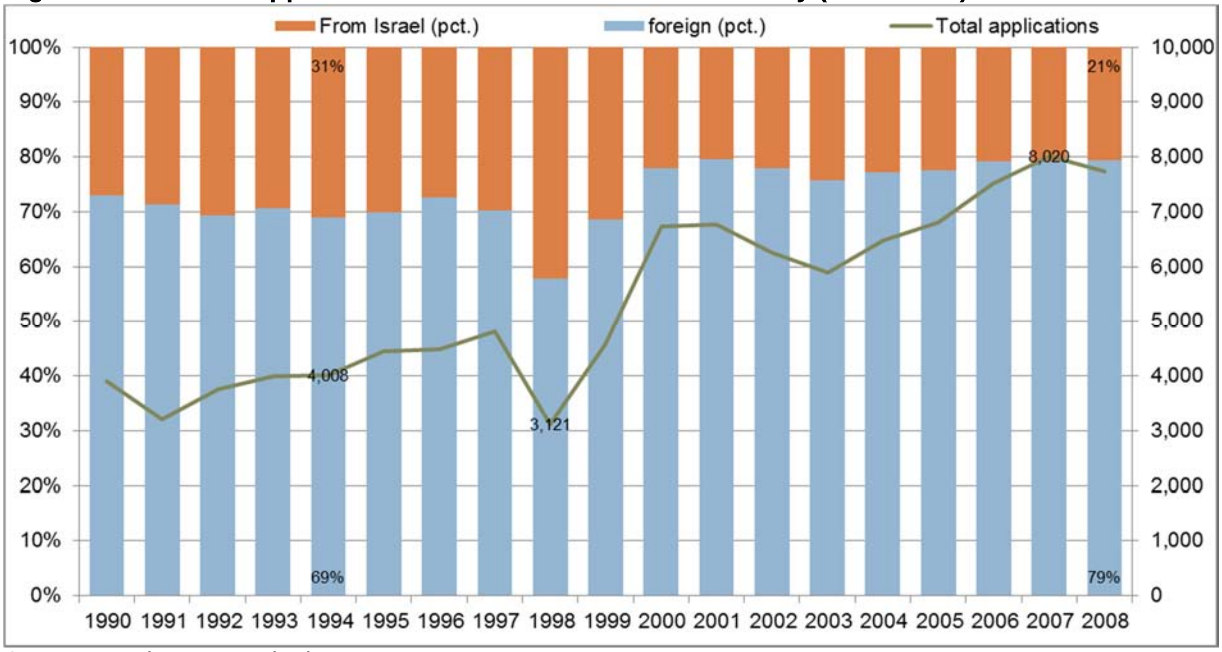


Source: USPTO.

Citizens of foreign countries also wish to register patents with the Israel Patent Authority (IPA). As noted in Chapter 7, the number of patent applications of foreign origin has been growing steadily since 1991. Figure 8.23 shows the impressive increase in the number of patent applications with IPA between 1991 and 2008, as well as the slower growth in the proportion of foreign applications during that time.

Although this upward trend in the rate of foreign applications is a global one, it is more vigorous in Israel than elsewhere. According to data from WIPO (the World Intellectual Property Organization), 34.5 percent of patent applications submitted to national patent offices in 1994 were submitted by nonresidents; by 2006, this rate increased to 43.6 percent. The WIPO report cites IPA as one of the world's leaders in the rate of foreign patents. (IPA also appears among the world's twenty largest patent offices in simple count of applications.)

Figure 8.23: Patent Applications with the Israel Patent Authority (1990–2008).



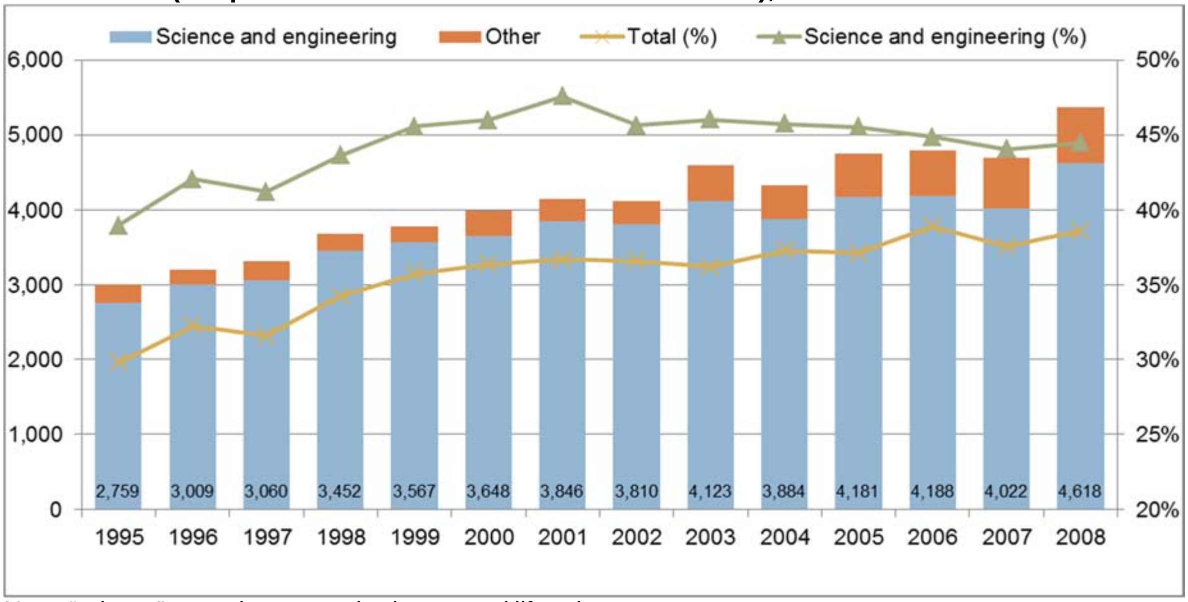
Source: Israel Patent Authority

As shown above (Chapter 7, Table 7.1), roughly half of the nonresidents who apply to IPA are American; this gives further evidence of the strength of relations between the countries. For more detailed data on patent applications in Israel, see Chapter 7, Section 7.2.

8.3.2 Publications

The conventional indicator of the extent and quality of international scientific relations is collaboration in scientific publications. Figure 8.24, charting this collaboration, shows a steady increase in the number of publications. In 1995, 3,006 publications by Israeli researchers had a foreign co-author; 92 percent of them were in the fields of science and engineering. The count increased to 4,142 in 2001 (thereof: 93 percent in science and engineering) and 5,374 in 2008 (86 percent in science and engineering). Although a large majority of the collaborative publications were in science and engineering, the growth rate of such articles was faster in other fields of knowledge. The share of collaborative publications in all publications by Israeli researchers has also been trending upward, from 29.8 percent in 1995 to 38.6 percent in 2008. In science and engineering, however, the rate has been stable in the long term, at around 45 percent in 1998–2008.

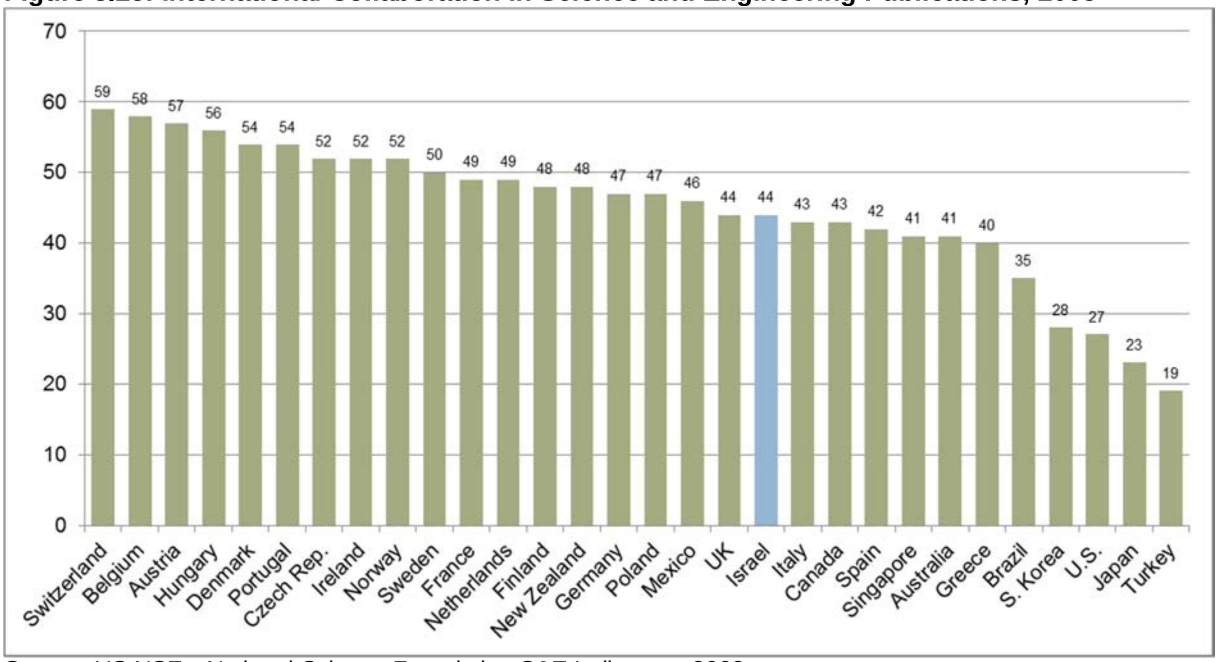
Figure 8.24: Publications by Israeli Researchers in Conjunction with Foreign Researchers (Simple Count and Share of Total Publications), 1995–2008



Note: "science" comprises natural sciences and life sciences.
Source: Database of Israeli publications (1981–2008), prepared especially by Thomson Reuters and processed by Samuel Neaman Center.

Figure 8.25 compares Israel with other countries in collaborative science and engineering publications. At the bottom of the list, alongside relatively backward countries such as Turkey and North Korea, are two large developed countries—the U.S. and Japan. Researchers in these countries have no need for international collaboration because their own countries have extensive infrastructures and large numbers of potential colleagues.

Figure 8.25: International Collaboration in Science and Engineering Publications, 2005



Source: US NSF—National Science Foundation S&E Indicators, 2008.

A decrease in co-authorship of scientific articles is not necessarily a negative development; it may indicate that country has taken the relevant research field to a higher level or developed enough expertise in a given discipline that its researchers have less incentive to seek co-authors abroad. Analysis of the data on the number of publications by fields supports this conclusion. It turns out that the major decrease in the share of co-authored publications occurred in the computer sciences—from 45 percent of all publications in 1995 to 30 percent in 2008. Israel is one of the world's leaders in the computer sciences and this field has been developing more quickly than other fields in Israel. Thus, in 2008, Israeli researchers published 911 articles in the computer sciences, 2.4 times more than in 1995.

Net of computer sciences, scientific collaboration hardly changed over time. The level was highest in 2001; 50 percent of all publications that year were the products of collaborative efforts of Israeli and foreign researchers. Since then, the share of co-authored publications has been 47–48 percent.

Table 8.4: International Collaboration, by Fields of Research (1995, 2001, 2008)

Disciine		**1995**	**2001**	**2008**
Biochemistry	Publications	633	681	922
	Collaborative (%)	***40%***	***50%***	***48%***
Genetics	Publications	776	844	936
	Collaborative (%)	***41%***	***53%***	***52%***
Engineering	Publications	863	905	1154
	Collaborative (%)	***29%***	***37%***	***39%***
Chemistry	Publications	744	946	1125
	Collaborative (%)	***40%***	***45%***	***40%***
Materials sciences	Publications	364	476	636
	Collaborative (%)	***33%***	***44%***	***39%***
Computer sciences	Publications	376	525	911
	Collaborative (%)	***45%***	***41%***	***30%***
Microbiology	Publications	150	165	222
	Collaborative (%)	***31%***	***38%***	***44%***
Mathematics	Publications	591	657	922
	Collaborative (%)	***50%***	***56%***	***51%***
Physics	Publications	1444	1591	1841
	Collaborative (%)	***47%***	***57%***	***54%***
Space physics	Publications	164	173	280
	Collaborative (%)	***55%***	***74%***	***63%***
Total, sciences and engineering	**Publications**	**6,105**	**6,963**	**8,949**
	Collaborative (%)	***41%***	***49%***	***46%***

Source: Database of Israeli publications (1981–2008), data prepared especially by Thomson Reuters and processed by Samuel Neaman Institute.

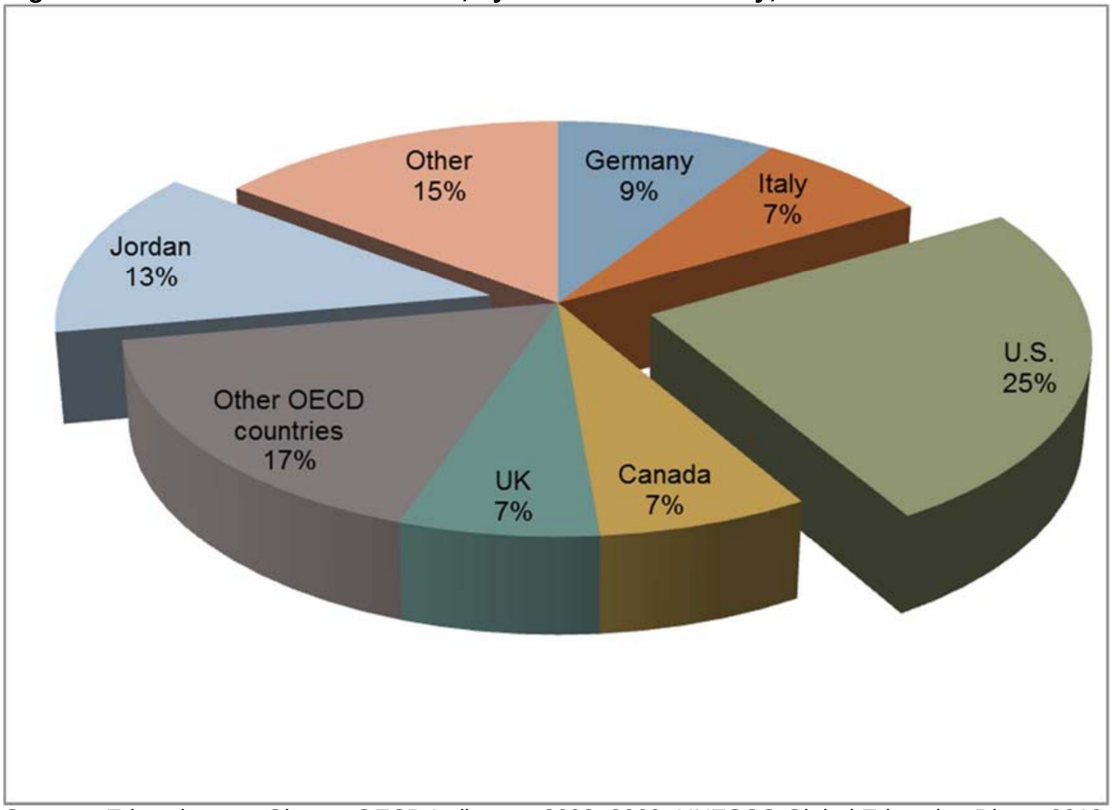
As expected, Israel's largest partner is the U.S. In 1998, the names of American researchers appeared in 55.1 percent of collaborative publications in science and engineering. In 2008, this indicator slipped a little, to 52.3 percent.[48]

8.3.3 Students

International student mobility is an indicator, on the one hand, of the intensity of a country's international relations and, on the other hand, of the attractiveness of its education system. Of course, international comparisons of student mobility are strongly affected by the availability or non-availability of study and employment opportunities that do not require fluency in the country's language—an indicator in which Israel has a structured inferiority. This subsection examines main trends among Israelis who study abroad and foreign students in Israel, with emphasis on science and engineering—the most important subjects for future technological advancement.

All data relating to Israelis abroad pertain to students who are pursuing first, second, and third degrees, unless stated otherwise.

Figure 8.26: Israeli Students Abroad, by Destination Country, 2006/07



Sources: Education at a Glance: OECD Indicators 2003–2009; UNESCO Global Education Digest 2010 (for Jordan only).

[48] *Science and Engineering Indicators,* 2010.

As Figure 8.26 shows, Israeli students prefer to study in developed countries; 72 percent chose institutions in OECD member-states. The leading destination country, as expected, is the United States, where one-fourth of "international" Israeli students do their studies.

In second place among the preferred destination countries is Jordan, with a 13 percent share of all Israeli students abroad. However, this figure should be treated very cautiously. It is based on the number of students from Israel that appeared in the *UNESCO Global Education Digest 2009* (N=1,863). Official data from the Jordanian Council for Higher Education, in contrast, as reported by Haj Yihye and Arar (2009),[49] counted 2,155 students. The disparity between these sources widened in 2010: 2,136 according to UNESCO and 5,400 according to the Jordanian CHE.

The population of those who take studies in Jordan is significantly different from that of students who go overseas. It is composed solely of Arabs who go there for medical or related studies, and their motives for choosing their destination are different from those of students at large.

Therefore, our long-term analysis is based exclusively on data relating to students who choose OECD countries.

Table 8.5: Israeli Students in OECD Countries as Percent of All Israeli Students, 2001–2007

	2001	2002	2003	2004	2005	2006	2007
Total Israeli students	270,979	299,716	301,326	301,227	310,937	310,014	327,108
Overseas Israeli students	7,541	8,505	8,781	9,822	9,247	10,226	10,005
Overseas Israeli students as % of all students	**2.8%**	**2.8%**	**2.9%**	**3.3%**	**3.0%**	**3.3%**	**3.1%**

Source: Education at a Glance: OECD Indicators 2003–2009.

Israeli international student mobility is increasing more slowly than the world average but more quickly than that of students from OECD countries. Between 2001 and 2007, the number of Israeli students in OECD countries increased by 33 percent, as against a 64 percent increase in the total number of students from all countries who elected to study abroad and only a 24 percent growth rate in students from OECD countries who chose to study in other OECD countries.

The four favorite OECD countries for Israeli students are trending in different directions. The number of Israeli students who enroll in British and American universities has been declining steadily in recent years; the Israeli community in the universities of Italy and Germany, in contrast, has been expanding from one year to

[49] Kussai Haj Yihye and Khaled Arar, "Outflow of Arab Students from Israel to Higher Studies in Jordan: Push Factors, Pull Factors, and Challenges," in Van Leer Jerusalem Institute, *The Arab Society in Israel Book,* 2009 (Hebrew).

the next. Thus, the number of Israel citizens who chose to study in Germany increased from 876 in 2000 to 1,324 in 2006, and those choosing Italy grew from 670 in 2001 to 1,121 in 2007. Conversely, the number of Israel residents attending higher-education institutes in the UK declined from 1,609 in 2002 to 889 in 2007 and those who did so in the U.S. slipped from 3,524 in 2003 to 3,341 in 2007.[50]

Data on the proportions of students who enroll in science and engineering programs abroad are so scanty that one cannot develop an overall picture from them. Table 8.6 shows the number of Israel citizens studying these disciplines as reported by the NSF. Due to differences in definitions, we cannot cross-tabulate the NSF data with those of the OECD, which relate to residents and not to citizens.

Table 8.6: Israel Citizens Studying Science and Engineering in the U.S.

	2006	2007	2008	2009
Total science and engineering students	850	760	700	660
New science and engineering students	170	120	170	130

Sources: US NSF 10-324 InfoBrief July 2010,
http://www.nsf.gov/statistics/infbrief/nsf10324/nsf10324.pdf

Israel does not keep systematic records on the flow of incoming foreign students. Therefore, we base this part of the discussion on data from Israeli academic institutions.

The following Israeli academic institutions had visiting-student and student-exchange programs in the 2008/09 academic year:

- *Universities*—Ben-Gurion, Bar-Ilan, Haifa, Tel Aviv, Hebrew, Technion, Weizmann Institute of Science.
- *Other*—Jerusalem College of Technology (Machon Lev); Bezalel Academy of Arts and Design, Jerusalem; Jerusalem Rubin Academy of Music and Dance; ORT Braude College of Engineering; Netanya Academic College; Ariel University Center in Samaria; The Interdisciplinary Center, Herzliya; Holon Academic Institute of Technology; Jerusalem College; Shenkar College of Engineering and Design.

The most recent study in Israel on this topic refers to data up to 1995/96. That year, visiting students attended programs run by five universities (Hebrew, Tel Aviv, Haifa, Bar-Ilan, Ben-Gurion) and Jerusalem College. Some 2,200 students attended these institutions either in degree programs or for credits toward a degree abroad;

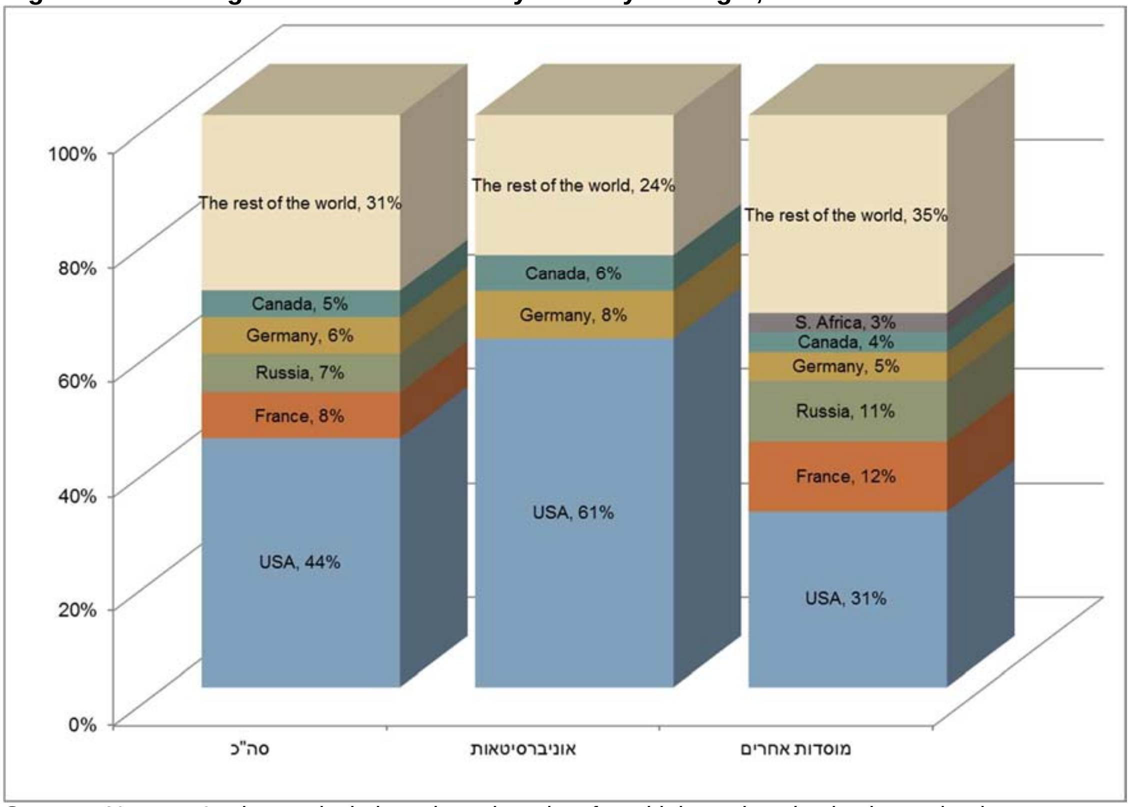
[50] *Education at a Glance: OECD Indicators 2003–2009.*

seventy-one additional students came to study medicine. Some 93 percent of the overseas students were from North America.[51]

In recent years, the number of institutions that are willing to admit foreign students has been growing commensurate with the number of foreign students. In 2008/09, according to data given to the Samuel Neaman Institute, some 3,700 foreign students attended degree programs (first degree, second degree, or credits); they came from North America (48 percent), France (8 percent), Russia (7 percent), and elsewhere.[52] Additionally, 470 students were studying for doctoral degrees in medicine; more than 99 percent of them were from North America, chiefly the U.S.

The population of foreign students in Israel may be divided into two groups—those at universities and those at other academic institutes (Figure 8.27). In 2008/09, there were 1,570 students in the first group, 42 percent of all foreign students. This group was homogeneous in terms of their origin in a small number of OECD countries. The other institutes, in contrast, were attended that year by 2,136 students from seventy countries.

Figure 8.27: Foreign Students in Israel by Country of Origin, 2008/09



Sources: Neaman Institute calculations, based on data from higher-education institutes that have overseas-student programs.

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[51] Cohen, Erik H., *The Israel University Experience. A Comprehensive Study of Visiting Students in Israel (1994–1997),* Jerusalem, April 1998, p.13.

[52] Not including approx. 50 first- and second-degree students for whom data were not provided.

Table 8.7 shows the percent of students of science and engineering among total students. It may be seen, for example, that foreign students from developed countries are not inclined to study science and engineering in Israel. Thus, whereas 38.9 percent of German students who went abroad for studies in 2008 did so in order to study science, only 2.3 percent of German students who studied in Israel in 2008/09 chose programs in the exact sciences. Much the same was found in regard to other countries that we examined. The significance of this finding is that Israel's higher-education system is definitely a poor competitor in the global market where science is concerned.

Table 8.7: Foreign Students in Israel, Science and Engineering Programs, 2008

	Share of all students*	Share of first- and second-degree students in Israel**	At universities**	At other institutes**
Total		**9.8**	**2.9**	**13.0**
Canada	32.2	6.3	1.0	9.3
Germany	38.9	1.7	2.3	0.0
U.S.	36.7	5.5	1.5	10.7
France	29.2	29.8	29.4	28.7

* For Canada, Germany, and U.S.—international (mobile) students; for France—foreign students.
** Foreign students.
1. International students are defined on the basis of their country of residence.
2. Foreign students are defined on the basis of their country of citizenship.

Source: Neaman Institute calculations, *Education at a Glance, 2010*.

Notably, however, academic institutes in Israel are making efforts to change this by opening various programs to attract foreign students. In 2009/10, for example, the Technion inaugurated an English-language program for overseas students interested in studying engineering, and Ariel University Center in Samaria is planning to launch a Russian-language program in science for students from the former USSR.

9. Technological Readiness—Households, Government, and Education

- **62 percent of households in Israel have Internet access (2008), under the OECD average.**
- **91 percent of households in Israel own a cellular telephone (2008).**
- **In the UN's comprehensive e-government readiness index, Israel ranked 17th among 192 participating countries with a relative score of 74 percent (2008).**
- **The UN index is based on four components. Israel ranked 19th in the "Web measure" index, 16th in the telecommunication infrastructure index, 36th in the human-capital index, and 38th in the e-participation index.**
- **In the Economist's e-readiness rankings in 2009, Israel was No. 27 (out of 70), with a relative score of 7.09 on a 1–10 scale.**

9.1 Households

The digital revolution has changed much of daily life for each of us in recent decades. Only in the past twenty years, however, have information technologies begun to penetrate workplaces and households. The information revolution that began in the past decade has strongly influenced our ways of life, from how we work to how we consume to how we pursue leisure. The rapid development and availability of ICT for the public at large has created disparities between population groups that have access to various ICT-based products and those that do not. This disparity, known as the digital gap or digital divide, is a sociopolitical issue that relates to the inequality of population groups that have regular and efficient access to digital technologies relative to those that do not. Information technology gives the population that uses digital technologies an advantage and leaves behind those who do not use them for whatever reason. Access to digital technologies confers advantages in schooling, society, culture, and employment. Another advantage is access to and performance of operations on line, e.g., government, healthcare, education, banking, and commercial services.

The digital gap may originate in defects in the education system, physical infrastructure that does not allow access to the information technology, economic inequality that prevents the purchase of a computer and an Internet connection, lack of awareness of the effect of the digital world and the need for broader use of information technologies, computer phobia, prejudices, religious motives, etc.

The digital gap claims a price not only in terms of social justice and resilience but also in economic terms. In the information era, national and global economies reward individuals who have skills in information technology. Countries that invest in equipping tomorrow's workers with these skills will improve their economic productivity and national product. The economic importance of the ICT industries for Israel may be demonstrated via the parameter of output per worker. In 2006, this metric was NIS 525,000 in low-tech manufacturing as against NIS 1 million in high-tech and middle-high-technology manufacturing.

In the past, a country's wealth was measured in the quantity of its natural resources and its capabilities in traditional manufacturing. Today, wealth also gravitates to countries that know how to "produce" and sell knowledge. Indeed, the most affluent societies today are those that engage in computers, software, and products that sort, analyze, and process information. Israel, a small country that does not abound in natural resources and sources of energy, is able to promote knowledge-based industry and, with the assistance of a correct policy, to carve out a respectable place in the global economy. As we have shown in previous chapters, Israel has excellent scientific capabilities, advanced academic institutions, and impressive technological achievements by all standards. Israel has also managed to develop a splendid ICT industry that competes successfully in the global market. In various indicators of the digital gap, however, Israel rests in a "comfortable place in the middle" by other countries' standards. To close the digital gaps, strengthen the economy, and acquire a long-term competitive edge in the global playing field, Israel's government needs to plan and formulate a policy on this matter.

In 2005, under the auspices of the National Information Society Committee and with government support, Israel performed its first-ever survey and in-depth study to map its digital gaps. The survey probed various aspects of the topic, such as computer ownership, computer use, and connection to and use of the Internet. The survey focused on the measurement of infrastructures and technological access, the population's training and abilities in ICT use (which are indicators of a digital gap), and the uses made of ICT in education and in the workplace. The report that came out in the aftermath of the survey ("The Digital Gap: The Situation in Israel and Selected Countries," 2007; the findings of the survey and the study may be accessed at http://www.maor.gov.il) shows that Israel ranks relatively high among countries in the percent of people who own a personal computer and use the Internet at home. Israel's weaknesses relate to use of the Internet generally, at the workplace, and by persons with disabilities. The Israeli population groups that suffer from conspicuous digital gaps resemble those in most countries: persons of low income, residents of peripheral areas, and members of special population groups: religious (the "ultra-Orthodox"), minorities, and seniors. The gap in home-computer access among children under age seventeen is especially wide in Israel and aberrant by international standards, demonstrating the difficulties that the education system has encountered in assimilating the technology.

This chapter presents indicators of the population's access to and use of ICT and the integration of technologies in governance ("e-government") on the basis of the UN indices.

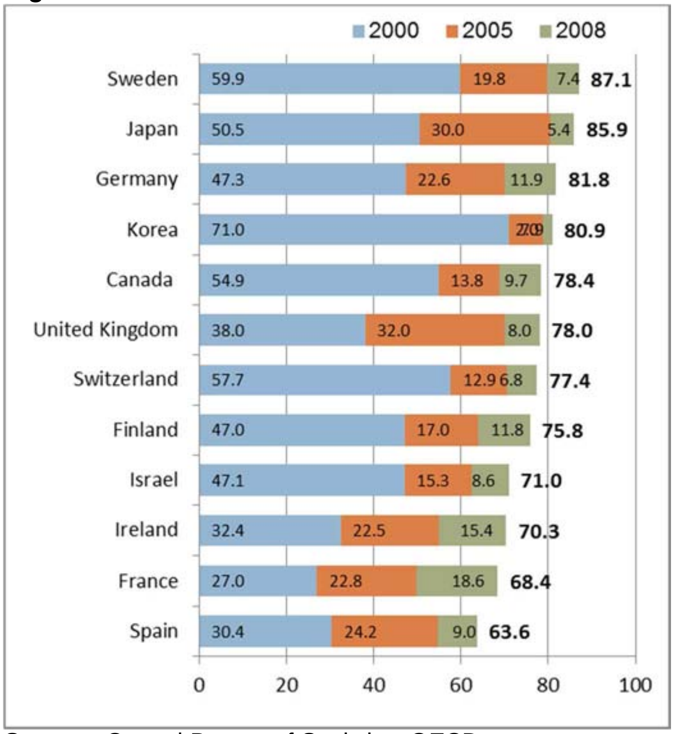
9.1.1 <u>Computer Access</u>

By examining the percent of households that have computer access, we can estimate the total potential of the Israeli population in applying and using ICT relative to other countries.

Studies about the digital gap show that Israel has large disparities in computer and Internet use between affluent and impoverished population groups, developed areas and peripheral ("development") towns, and the well-educated and the poorly educated. The gap between Israel and other countries is established by the primary and secondary stages of education. In 1993, the Ministry of Education did issue an applied master plan for the digitization of the education system; its goal was to provide one computer for every ten pupils. According to data from the Ministry for 2009, Israel has one computer per twelve pupils on average. In the U.S. and Europe, the ratio is verging on one per five (!). The disparity in Israel, a conservative country, is fueled by fear of technology on cultural or religious grounds, a low level of knowledge among teachers, a shortage of appropriate infrastructures, lack of parental motivation, the children's social environment, and other factors.

Figure 8.1 compares Israel with selected countries in the percent of households that had home-computer access in 2000, 2005, and 2008. Since 2000, this indicator has been trending up in many countries. In Israel in 2008, 71 percent of households had access to a home computer—up 50 percent from 2000, when only 47.1 percent of households owned a computer. Even in 2008, however, Israel's ranking in this index was lower than that of countries such as Sweden (87 percent), Japan (85 percent), and Germany (81 percent).

Figure 9.1: Percent of Households with Access to Home Computer, 2000, 2005, 2008

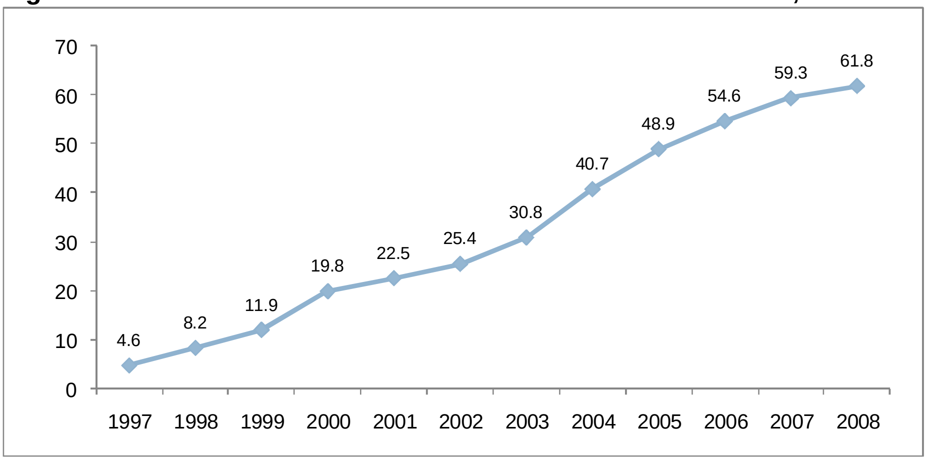


Sources: Central Bureau of Statistics, OECD.

9.1.2 Communication and Internet Access

Figure 9.2 shows changes between 1997 and 2008 in the share of households connected to the Internet. In 1997, few households had an on-line connection (4.6 percent); by the end of 2008 this indicator grew thirteen times over and came to 61.8 percent of all households. The increasing prevalence of on-line connection and its use during this time may be traced to economic and technological factors such as the expansion of the infrastructure that makes Internet access possible, an increase in the importance and utility that people attribute to Internet use, a decrease in Internet service providers' prices, wider use of telephone lines, and, of course, an increase in ownership of and access to computers.

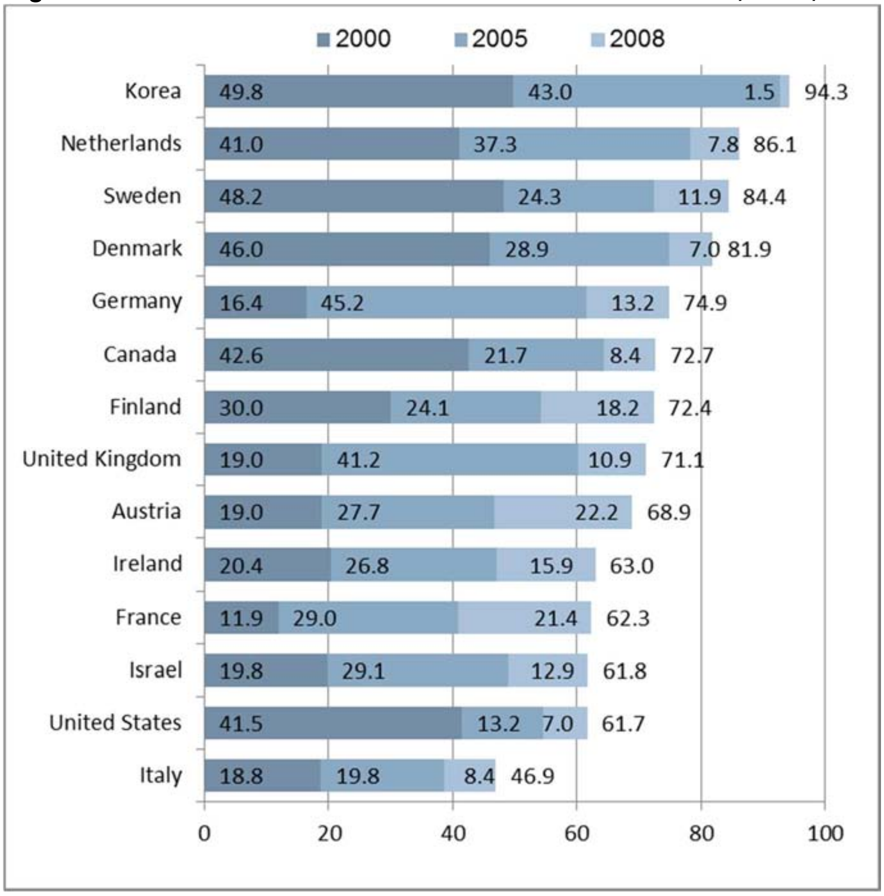
Figure 9.2: Percent of Israeli Households with Internet Access, 1997–2008



Source: Central Bureau of Statistics.

Figure 9.3, comparing Israel with other countries in terms of the share of households connected to the Internet, shows that although the percent of such households in Israel has been rising steeply in the past decade, Israel is at the bottom of the list of advanced countries. The leading countries in this indicator in 2008 were S. Korea (94 percent), the Netherlands (86 percent), and Sweden (84 percent). The increase in Internet use in a country or region cannot be explained by economic and technological factors only; one also has to take account of social and cultural factors such as the economic, commercial, and cognitive openness of the national culture and the existence of democratic governance, political tendencies, and government encouragement. All of these figure importantly in the process that encourages certain population groups to embrace technological progress.

Figure 9.3: Percent of Households with Access to Internet, 2000, 2005, 2008



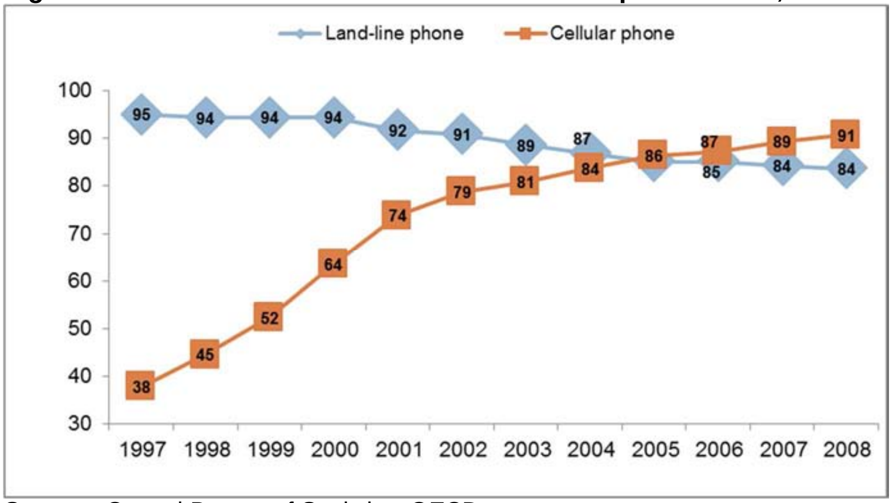
Sources: Central Bureau of Statistics, OECD.

Another technological change in the past decade is the introduction of cellular telephony as a medium widely used by the population at large. Figure 9.4 shows the share of households that own land-line and cellular phones. After a 140 percent rate of penetration of cellular telephony between 1997 and 2008, a higher percent of households owned cellular phones than land-line phones in the latter year. One reason for this is that new households took out mobile-phone subscriptions only;

another reason is that Bezeq, the country's main telephony service provider, is competing today against cellular providers that allow land-line phones to be used using VOiP technology.

If so, this indicator shows that telephone communication (cellular and land-line) has become ubiquitous among Israeli households. In our next publications, the topics of examination should include the penetration of more advanced technologies, such as broad-band, and the economic aspects of telecommunication for households (the costs of land-line, cellular, and Internet service).

Figure 9.4: Percent of Households that Own Telephone Lines, 1997–2008



Sources: Central Bureau of Statistics, OECD.

Examining the time dimension of the penetration of new and advanced technologies, we find that the new technology is reaching more and more segments of the population. However, various barriers—technological, economic, and other—seem to be preventing the use of advanced technologies by all households. The situation in Israel resembles that in other countries: while the digital gap has been narrowing over time in the overall sense, the lower deciles are evidently finding it hard to keep up with progress and adopt the new technologies, therefore emerging from the process disempowered and disadvantaged.

9.2 E-Government

The development of ICT has trickled into the government services as well. Many governments realize that these technologies can be used to develop more effective, available, and efficient services at lower cost. Consequent to this development, the term "e-government" has been coined as a companion to "e-business." This term refers to the use of ICT by government in order to stay touch with citizens and provide better and more available service.

E-government is immensely important in several ways:

- enhancement of efficiency—ICT can help to protect and process information received from citizens and to share information and services among government offices and from them outward.
- improvement of service—making government available to citizens from citizens' point of view. Such service is reflected in the provision of information to citizens and the performance of operations by citizens directly, online, and around the clock.
- promotion of various aspects of policy—the Internet provides citizens with information (laws, regulations, entitlements, etc.) in diverse matters such as education, healthcare, and the environment, to name only a few.

E-government has undergone much development in the past decade and has been discussed in many OECD and UN studies. In 2002, the UN launched a comparative survey that has been performed in almost every year since then. Many countries participate in it (192 countries did so in 2008), including Israel. The purpose of the survey is to produce a comparative estimate of member states' ability to improve their government services by means of ICT so that citizens may obtain services online. Thus, the survey is tool that may be used to compare and monitor governments' progress in delivering e-government services.[53]

9.2.1 <u>The UN E-Government Readiness Index</u>

To make countries comparable, the UN has developed a comprehensive tool called the UN E-Government Readiness Index. It is a composite of four indices:

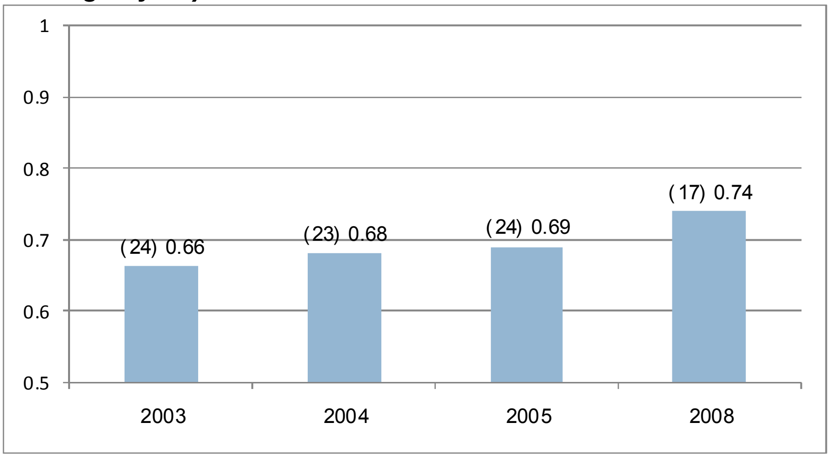
- Web measure index—ranks countries based on the coverage, sophistication and availability of e-services and e-products. The index categorizes countries in five stages of their e-government presence: emerging, enhanced, interactive, transactional, and networked.
- Telecommunication infrastructure index—a weighted average of five measures of ICT infrastructure capacity per 100 persons: number of personal computers, number of Internet users, number of telephone lines, number of broad-band subscriptions, and number of mobile phones.
- Human-capital index –a weighted average of the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio.
- On-line participation index—composed of three categories: on-line information, on-line advice, and on-line decision making. This index examines twenty-one

[53] Source: Israel Government Services and Information Portal, "E-Government Report 2009—2008 E-Government Summary."

government services for on-line presence, availability, and extent of citizen involvement.

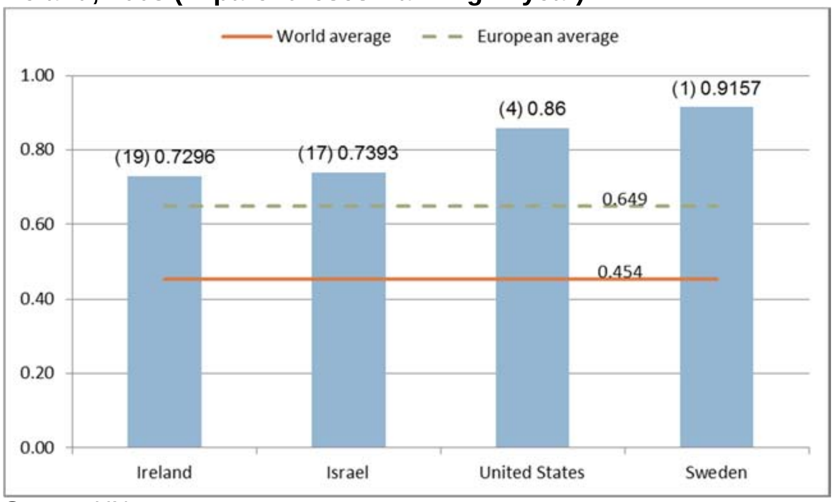
In the 2008 Readiness Index, Israel ranked seventeenth among 192 participating countries with a relative score of 73.9 percent. This marks a 7 percent improvement from 2005, when Israel ranked twenty-fourth with a relative score of 69.03 percent.

Figure 9.5: The UN E-Government Readiness Index, Israel, 2003–2008 (In parentheses: ranking in year)



Source: UN.

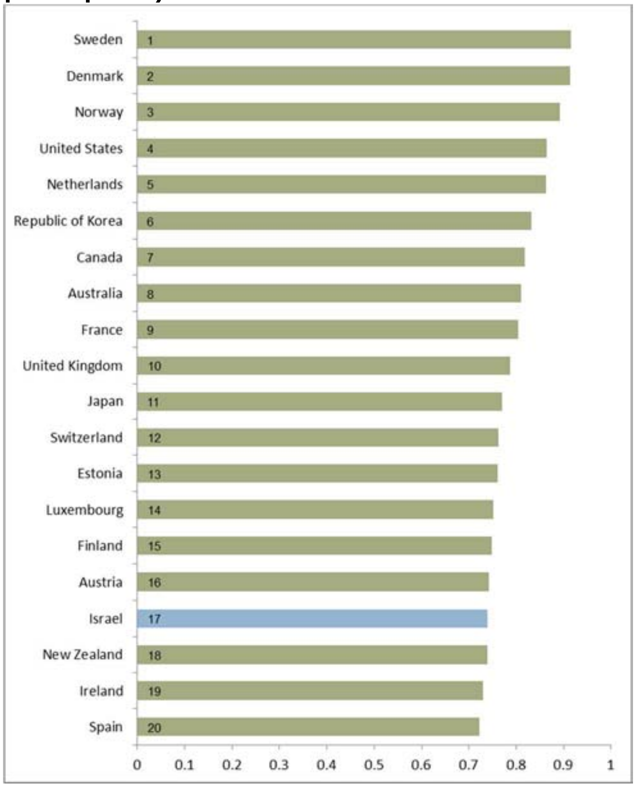
Figure 9.6: The UN E-Government Readiness Index, Israel vs. Sweden, U.S., and Ireland, 2008 (In parentheses: ranking in year)



Source: UN.

The leading countries in 2008 were Sweden, Denmark, Norway, and the United States. Israel was in seventeenth place, surpassing countries such as New Zealand, Ireland, Germany, Singapore, and Belgium. In a regional comparison among the countries of western Asia, Israel was the leader.

Figure 9.7: UN E-Government Readiness Index, 2008 (20 leading countries among 192 participants)

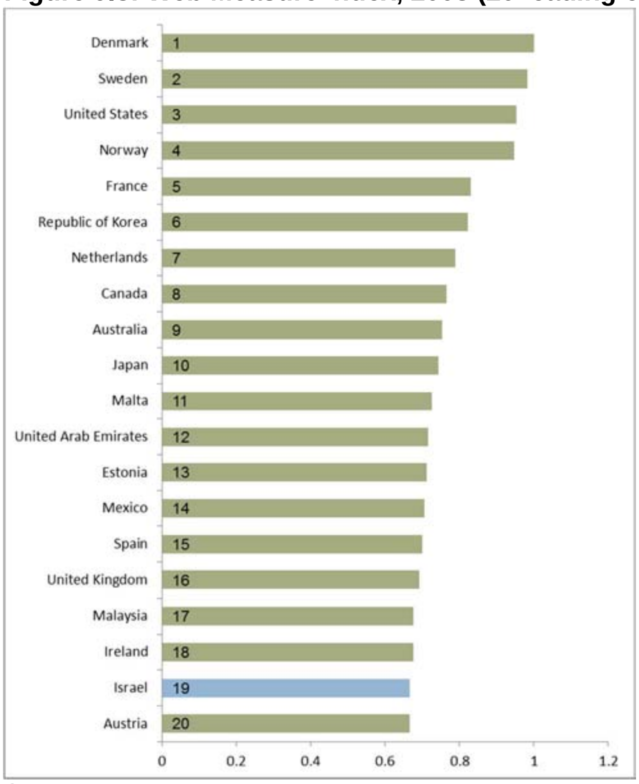


Source: UN.

9.2.2 The Web Measure Index

In the Web measure index, Israel ranked nineteenth with a relative score of 66.6 percent.

Figure 9.8: Web Measure Index, 2008 (20 leading countries among 192 participants)

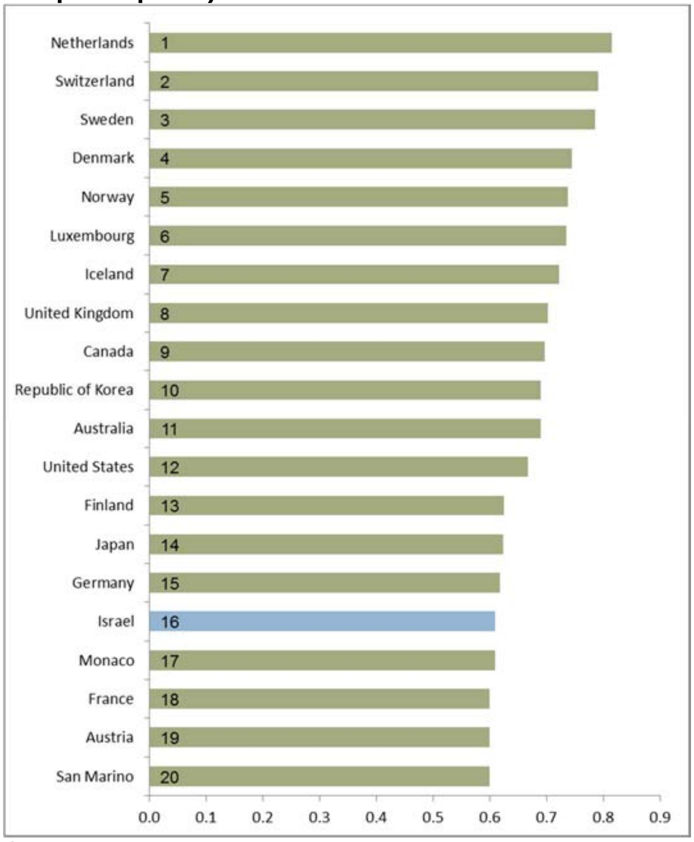


Source: UN.

9.2.3 Telecommunication Infrastructure Index

In the telecommunication infrastructure index, Israel ranked sixteenth with a relative score of 60.85 percent.

Figure 9.9: Telecommunication Infrastructure Index, 2008 (20 leading countries among 192 participants)



Source: UN.

The telecommunication infrastructure index is based on five components that relate to the ability of each country's existing infrastructure to provide e-government services:

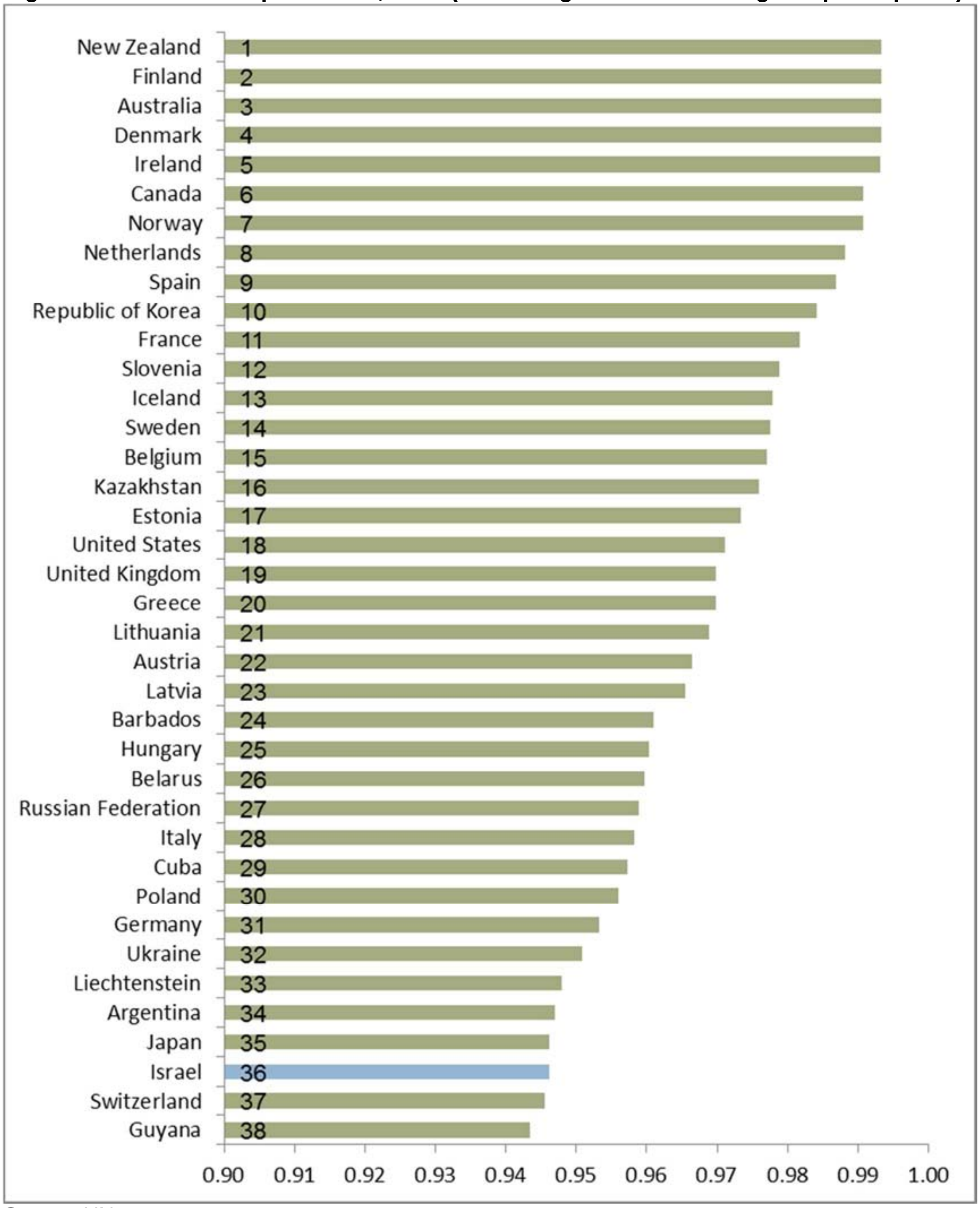
Table 9.1: Israel's Telecommunication Infrastructure Index, by Components

Component	**Israel's results (per 100 inhabitants)**	**Israel's ranking in survey**
Internet users (N)	27	54
Personal computers	73	9
Telephone lines	44	28
Mobile phones	123	6
Broad-band subscriptions	21	14

Source: UN.

9.2.4 Human-Capital Index

Figure 9.10: Human-Capital Index, 2008 (38 leading countries among 192 participants)



Source: UN.

Israel ranked thirty-sixth on the human-capital index, with a relative score of 94.61 percent. This index is based on two components:

- adult literacy rate; Israel ranked nineteenth with a relative score of 97 percent.
- combined primary, secondary and tertiary gross enrolment ratio; Israel ranked twenty-fifth in the survey with a relative score of 89 percent.

9.2.5 On-Line Participation Index

The on-line participation index examines the quality and usefulness of the information and services that the state provides in order to co-opt citizens into public policy and services by means of ICT.

Israel ranked thirty-eighth in this index with a score of 31.8 percent (and was not among the thirty-five leading countries in any category).

9.3 The *Economist* Intelligence Unit (EIU) E-Readiness Survey

The readiness ranking carried out by the *Economist* Intelligence Unit (EIU) since 2000 estimates the assimilation of ICT in national economies. Seventy countries including Israel take part in the survey. To make them comparable, the EIU constructed an index comprising the following categories: ICT environment, business environment, sociocultural environment, legal environment, government policy and political vision, and assimilation of the technology by consumers and businesses.

In the 2009 index, Israel ranked twenty-seventh (out of 70 countries) with a relative score of 7.09 (on a 1–10 scale).

Government policy and political vision in the assimilation of technologies is defined as the government's readiness to supply its constituents—citizens and organizations—with a clear roadmap for the adoption of technology and to lead by example in its use of technology to create efficiencies.

To assess a government's performance, the following questions are asked: Does it employ technology to operate and provide public services with less resource investment? Does it spend on ICT to stimulate similar spending in the greater economy? Can more people interact with, and receive information from, the government regardless of their own access to technology? etc. The metrics for this criterion are ICT expenditure per capita, technological development policy, e-government policy, on-line procurements, on-line availability of government services for citizens and businesses, and the on-line participation index (taken from the U.N. survey).

In this category of government technology readiness, Israel was given a relative score of 6.90 (on a 1–10 scale), twenty-sixth among the countries surveyed. The leaders in this category were Denmark (9.65), the U.S. (9.55), Korea (9.20) and Singapore (9.18).

9.4 Public Attitudes toward Science and Technology

In our era of technology and telecommunication, the public's attitudes are a matter of much value. This section examines the status of science and technology (S&T) among the Israeli public and asks questions such as: how important is S&T to the public today? what information sources does the public use? How vital is the contribution of S&T to the country? etc. These indicators tell us whether the Israel public thinks the government policy on the advancement of and investment in these fields is adequate and whether it understands and is aware of the meaning of scientific information and its underlying values.

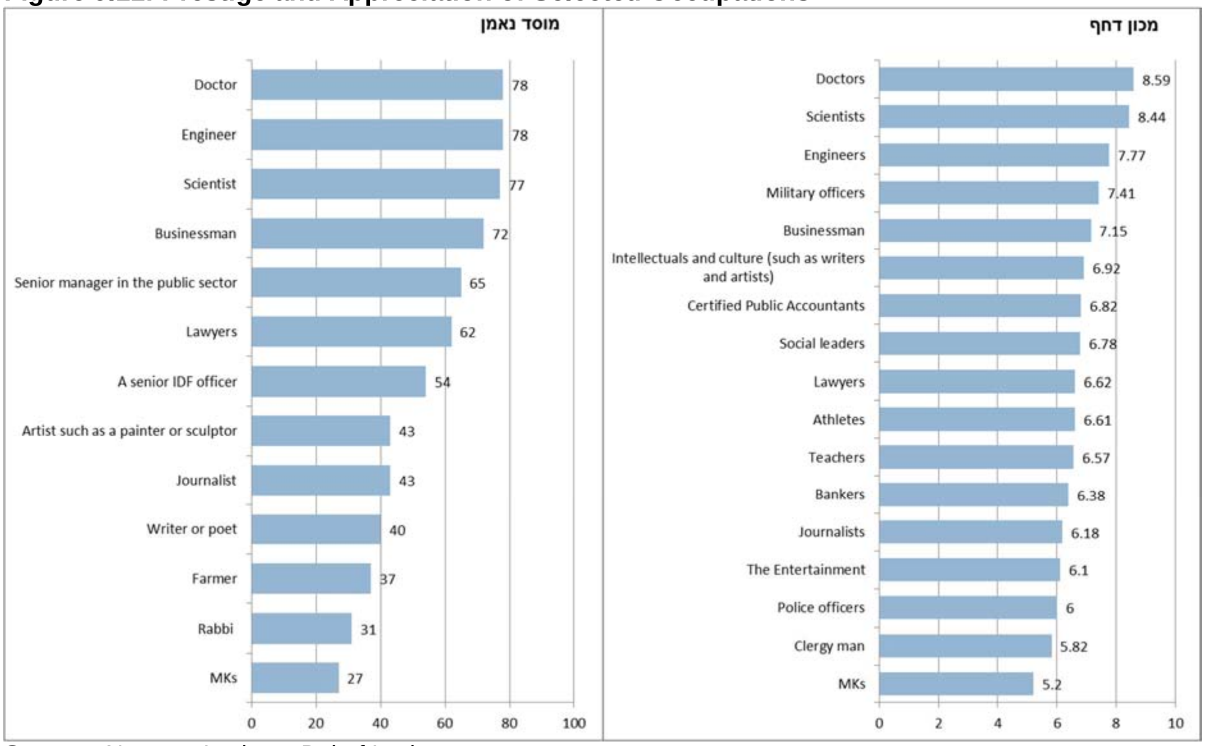
Below are the main findings of a survey performed by Dahaf Institute in 2009 among 500 respondents who constituted a representative sample of the adult population of Israel:

- About two-thirds of the respondents (66 percent) said that S&T knowledge is important to them in daily life.
- A majority of respondents also said that they take an interest in matters that appear to be connected with daily life: health, environmental quality, digitization, the Internet, and topics related to water.
- The public strongly justifies the public investment in university research, and the level of justification of public investment in manufacturing R&D is rising.
- The main sources of information are the Internet, television, people, and radio.
- Ninety-five percent of the respondents think the state should invest in academic research; 81 percent believe the state should invest in applied research at commercial firms.
- The public believes that most important investments the state can make in order to assure medium- and long-term economic growth are in education (93 percent) and university research.
- The respondents gave Israel a score of nearly 8 (on a 1–10 scale) for its achievements in S&T. Seventy-eight percent said that Israel's achievements, relative to its size, resemble or exceed those of most developed countries.
- Most respondents (82 percent) believe that globalization has made a major contribution (38 percent) or some contribution (44 percent) to Israel's achievements in S&T.
- The perceived implications of the "brain drain" phenomenon: 74 percent of the respondents estimate the brain drain as a large-scale phenomenon that is harmful to Israel; 75 percent of the respondents think Israel is not doing enough to prevent it.

Another indicator examined was the amount of prestige and appreciation that the public confers on various groups of occupations and its estimation of their contribution to national strength. The graph below presents the data from this survey, performed by Dahaf Institute for comparison with a similar study, “Science and Technology in the Israeli Consciousness,” conducted at the Samuel Neaman Institute in 2006 by Prof. Ephraim Yaar. In the Dahaf survey, the respondents were asked to assign each occupation an average score on a scale of 1–10. In Prof. Yaar’s study, the respondents were asked, “How strongly would you want your child to be…” and to array their views on a 0–100 scale.

Both studies elicited similar results: doctors, engineers, and scientists were at the top of the list. A troubling statistic that deserves attention is the ranking of teachers. Teachers ranked far below scientists and engineers but close to accountants, lawyers, and bankers, in contrast to the conventional wisdom that places teachers’ status far below these occupations in the public mind. In both studies, Members of the Knesset (parliament) were at the bottom of the list. A similar study performed in the U.S. by the NSF in 2006[54] reported medicine and engineering as the leading occupations. Teachers came in third and Members of Congress ranked sixth, ahead of engineers.

Figure 9.11: Prestige and Appreciation of Selected Occupations



Sources: Neaman Institute, Dahaf Institute.

[54] Science and Engineering Indicators 2008: Chapter 7. Science and Technology: Public Attitudes and Understanding, http://www.nsf.gov/statistics/seind08/c7/c7h.htm.

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