Samuel Neaman Institute
For National Policy Research

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

Fourth edition

2013

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

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

Fourth edition

Submitted to:

Israel National Council for Research & Development

2013

The following people took part in preparing Science, Technology and Innovation Indicators in Israel: An International Comparison (third publication in the series):

Samuel Neaman Institute for National Policy Research (SNI)

Dr. Daphne Getz	Senior Research Fellow, Head of the Center for Science, Technology & Innovation Policy and Manager of the Data Center of Samuel Neaman Institute
Prof. Dan Peled	Department of Economics, University of Haifa, and Senior Research Fellow at SNI
Tsipy Buchnik	Research assistant in science, technology and innovation indicators and scientific and technological labor force
Ilia Zatcovetsky	Research assistant in science, technology and innovation indicators and in expediting integration of the haredi ("ultra-Orthodox") population into the labor market
Ella Barazani	Information specialist; main areas of activity: bibliometrics and databases
Dr. Eran Leck	Researcher; main areas of activity: R&D Outputs evaluation (Patents)

Israel National Council for Research and Development

Shlomo Hershkowitz	Consultant and coordinator for the Israel National Council for Research and Development

Israel Central Bureau of Statistics

Nava Brenner	Director of National Expenditure on R&D, Social Services Accounts Sector
Evyatar Kirschberg	Director of Business Sector R&D and Innovation Survey
Yaffa Schiff	Head of Examinations Division
Ora Shai	Head of Social Services Sector, National Accounts

For further information about this publication, contact Dr. Daphne Getz:
Phone: 972-4-8298154/5 Email: daphne@sni.technion.ac.il.

The Samuel Neaman Institute for National Policy Research is pleased to present the fourth 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.

Thanks

We would like to thank Nava Brenner and Evyatar Kirschberg of the Israeli Central Bureau of Statistics for providing up-to-date data, collaborating with us and answering any and all questions competently and professionally.

Thanks to Soli Peleg, who dedicated her time and offered her experience to read, remark and give insight on this project.

Special thanks to Mr. Shlomo Hershkowitz, our consultant from the Ministry of Science, Technology and Space, for the constructive comments that helped improve the project.

Lastly, we would like to thank all those who have assisted, advised and contributed to this project all throughout this project.

Dr. Daphne Getz

and the Neaman Institute team

CONTENTS

1. Introduction 13

1.1 General Preface 13
1.2 Data for S&T Policymaking 15
1.3 Goals of This Report 17
1.4 Methodological Background and Review of Topics in This Report 17
1.5 Trends in Key Indicators of Science, Technology, and Innovation 18

.2 Gross Expenditure on R&D 20

2.1 Aggregate View 21
2.1.1 National Gross Expenditure on R&D (GERD) 21
2.1.2 R&D Intensity 22
2.1.3 GERD by Sectors 24
2.2 The Business-Enterprise Sector 29
2.2.1 An Aggregate Look at BERD (Business-Enterprise Sector R&D) 30
2.2.2 Segmentation of BERD by Main Branches and Technology Intensivity 34
2.3 The Government Sector 37
2.3.1 Governmental Aid for Civilian R&D in Science and Technology 41
2.3.2 State Budget Support for R&D 42
2.3.3 Chief Scientist of the Ministry of Industry and Trade (OCS) 43
2.4 The Higher-Education Sector 45

.3 Scientific and Technological Human Capital 49

3.1 Aggregate View 50
3.2 Secondary Schooling 52
3.2.1 Eligibility for Matriculation Certificate 52
3.2.2 Matriculation by Subjects 55
3.2.3 Science and Technology Teachers 56
3.2.4 PISA and TIMSS by Cross-Country Comparison 58
3.3 Higher Education 61
3.3.1 The Psychometric Exam 61
3.3.2 First-Year University and College Students 62
3.3.3 Degree Recipients 64
3.4 Academic Staff 66
3.5 R&D Human Resources in the Business-Enterprise Sector 72
3.6 Careers of Doctorate Holders 75

.4 Economic Indicators 78

4.1 Product 79
4.1.1 Gross Domestic Product 79
4.1.2 Business Output 79
4.2 Indicators of Economic Growth 81
4.2.1 Increase in Total Factor Productivity 81
4.2.2 Labor Productivity 83
4.2.3 ICT Capital….. 87
4.3 Venture Capital 92

4.4 Employment and Wages in Technology-Intensive Industries 95
4.4.1 Wages……….. 95
4.4.2 Jobs………….. 96
4.4.3 Vacant Posts.. 98
5. Science and Technology Outputs 101
5.1 Patents 101
5.1.1 Applications Submitted to the Israel Patent Authority 101
5.1.2 Applications with International Patent Offices 102
5.2 Scientific Publications 108
5.2.1 Indicators of Research Productivity 108
5.2.2 Indicators of Research Quality 111
5.2.3 Conclusion….. 113
6. R&D and Innovation by Selected Industries and Research Institutions 114
6.1 Manufacturing industries 114
6.2 Information and Communication Technology (ICT) Industries 117
6.2.1 R&D expenditure in the ICT industries 119
6.2.2 Output……….. 120
6.2.3 Exports……… 122
6.2.4 Employment… 123
6.3 Scientific Research and Development Industries (Division 73) 124
6.4 Biotechnology 128
6.5 Survey of Business Sector Innovation in 2006–2008 132
6.5.1 Data from the Israel Innovation Survey 134
6.5.2 Technological Innovation 135
6.5.3 Non-Technological (Organizational and Marketing) Innovation 135
6.5.4 innovation in the Research and Development Industry 136
6.5.5 Cross-Country Comparison 137
6.6 Research and development at Government Research Institutes and Public and Private Research Institutes and Units 144
6.6.1 Type of Research 145
6.6.2 Parsing of Research by Socioeconomic Objectives 146
6.6.3 Research Institute Personnel 146
6.6.4 Collaboration between Research Institutes and Other Research Establishments in Israel and Abroad 147
6.7 Separately Budgeted University Research and Development 148
7. Globalization 151
7.1 International trade 152
7.1.1 Exports of goods 153
7.1.2 Exports of services 155
7.1.3 Trade balance 156
7.1.4 Technological Balance of Payments 160
7.2 Corporate international relations 162
7.2.1 IN Firms……… 162
7.2.2 International R&D centers 166
7.2.3 OUT Firms…… 171
7.2.4 Foreign Direct Investment 174

7.2.5 Venture Capital and Sale of Start-Ups 176
7.3 Globalization in Science and Technology 178
7.3.1 Patents........ 178
7.3.2 Publications........ 180
7.3.3 Students........ 182

.8 Technological Readiness 186

8.1 Communication and Internet access 187
8.2 E-government 189
8.2.1 The UN E-Government Readiness Index 190
8.2.2 Four Indices: Web Measure, Telecommunication Infrastructure, Human-Capital, and On-Line Participation 191
8.3 Public Attitudes toward Science and Technology 192

9. Bibliography 197

Figures

Figure 1.1: Key Indicators of Science, Technology, and Innovation, International Comparison 19
Figure 2.1: Israel Civilian GERD, 1990–2011 (NIS billions, 2005 prices) 22
Figure 2.2: GERD as Percentage of GDP, 2000–2010[a] 23
Figure 2.3: Per-Capita GERD, 2000–2010 ($PPP*) 24
Figure 2.4: GERD by Performing Sector, 1989–2011 26
Figure 2.5: Distribution of Rates of GERD by Performing Sector, Cross-Country Comparison, 2011* (Digits in parentheses express GERD in Million PPP Dollars - Current prices) 27
Figure 2.6: GERD Rate by Source Sector,[1] Cross-Country Comparison, 2009 29
Figure 2.7: GERD Performance by Business-Enterprise Sector, Israel and Selected Countries, Pct., 2000–2010 31
Figure 2.8: Distribution of Sources for BERD Performed by Business-Enterprise Sector, 2009 (Pct.) 32
Figure 2.9: Government Sourcing of R&D Performed by Business-Enterprise Sector, 2000–2009 33
Figure 2.10: Share of R&D Performed by Higher Education and Sourced by Business-Enterprise Sector, 2000–2009 33
Figure 2.11: BERD by Main Branches, 1995–2010 35
Figure 2.12: BERD by Area of Activity, 2010 36
Figure 2.13: Sectorial Distribution of Government Sourcing of R&D (mNIS, Current Prices), 2007–2009 37
Figure 2.14: Government Sourcing of R&D as Pct. of GDP, Cross-Country Comparison, 2009 38
Figure 2.15: Government Funding of Civilian R&D, by Objectives, as Pct. of Total GOVERD, 2000–2010 40
Figure 2.16: Government Support of R&D in OECD Countries, by Selected Objectives, 2010 41
Figure 2.17: Government Support of R&D as Pct. of State Budget (in Small Graph: Distribution by Ministry, 2010) 42
Figure 2.18: R&D Budgets for All OCS Support Programs (mNIS, 2011 prices) 43
Figure 2.19: Distribution of OCS Grants by Technological Classification 44
Figure 2.20: OCS Support for Low-Tech Industries (Pct. and mNIS) 45
Figure 2.21: Distribution of Higher Education Expenditure on R&D by funding sector (Pct.), 1995–2007 47
Figure 2.22: HERD Intensity (HERD as Pct. of GDP), 2000–2011 48
Figure 3.1: Tertiary Education (Type A+B) among Permanent Population Aged 25–64, 2009, Pct. 51
Figure 3.2: Employment Rate among Persons Aged 25–64 with Higher Schooling, 2009 (Pct.) 52
Figure 3.3: Pct. of Twelfth Graders Tested and Eligible for Matriculation Certificates Meeting University Entrance Requirements (in Parentheses: Number of Pupils by Category), 1996–2010 54
Figure 3.4: Twelfth-Graders: Examinees and Eligible for Matriculation Certificates, by Track and Major, 2010 55
Figure 3.5: Distribution of Matriculation Examinees by Subjects and Number of Credits, 2010 56
Figure 3.6: Distribution of Science and Technology Teachers by Subjects, 2010 57
Figure 3.7: PISA 2009 Scores, Israel and Selected Countries 60
Figure 3.8: Average Psychometric Exam Scores of First-Year University and College Students, by Majors, 2009/10 62
Figure 3.9: Share of New Higher-Education Students Majoring in S&T Disciplines, by

Degree, 1999-2009 64
Figure 3.10: Degree Recipients in Israel in Science and Engineering, by Degree Level, 1994/95–2010/11 65
Figure 3.11: Degree Recipients in Science and Engineering, by Degrees, 2010/11 66
Figure 3.12: Total University Teaching and Research Staff, Full-Time-Post Equivalent, 1995/96–2010/11 67
Figure 3.13: University Senior Academic Staff by Scientific Discipline, 2010/11 68
Figure 3.14: Women in University Senior Academic Staff by Disciplines, 1999/2000, 2004/05, and 2010/11, Pct. 69
Figure 3.15: Distribution* of University Senior Academic Staff by Age, 2010/11 (in Parentheses—Average Age in Discipline) 70
Figure 3.16: University Senior Academic Staff—Time Devoted to Research and Type of Research, 2009/10 71
Figure 3.17: R&D Personnel in the Business-Enterprise Sector, 2000–2010 (Thousands) 73
Figure 3.18: R&D Personnel (Full-Time Posts) in Business Enterprises Engaging in R&D, Headcount and Per Thousand Employed in Business-Enterprise Sector, 2000–2011 74
Figure 3.19: Business-Enterprise Sector R&D Headcount by Education (Thousands), 1997–2010 74
Figure 3.20: Doctorate Holders in Israel (Thousands), Segmented by Sex and Age, 2009 75
Figure 3.21: Doctorate Holders in Israel (Thousands and Pct.), by Academic Discipline, 2009 76
Figure 3.22: Doctorate Holders in Israel, Cross-Country Comparison, 2009 76
Figure 3.23: Employed Doctorate Holders by Proximity of Post to Discipline Studied, Cross-Country Comparison, 2009 77
Figure 3.24: Pct. of Doctorate Holders Who Left the Country in the Past Decade 77
Figure 4.1: Share of High-Tech and Medium-High Technology Manufacturing in GDP 79
Figure 4.2: Share of Knowledge-Intensive Industries in Business Output 80
Figure 4.3: Average Increase in Total Factor Productivity, Selected Industries, Percent (2004–2011) 82
Figure 4.4: Average Increase in Total Factor Productivity, Percent (2005–2010) 83
Figure 4.5: Per-Worker Output in Manufacturing Industries by Technology Intensity, 1995–2010 (NIS ,000 per year) 84
Figure 4.6: Per-Worker Output in Selected Service Industries, 1996–2009 (NIS ,000 per year) 85
Figure 4.7: Per-Worker Output in Computer and R&D Service Industries Relative to Total Business Services, 2009 vs. 2001 85
Figure 4.8: Output and Employment in High-Tech and Middle-High Technology Manufacturing as Percent of Total Manufacturing Output and Employment (2000–2010) 86
Figure 4.9: ICT Capital Stock (Equipment and Software), mNIS , 2005 Prices 88
Figure 4.10: Share of ICT Capital Stock in Total Net Capital Stock, 2000–2011, by Main Industry Groups 88
Figure 4.11: Distribution of ICT Capital Stock by Main Industry Groups 89
Figure 4.12: ICT Capital Investments (excl. Software, mNIS , 2005 prices) and Distribution by Industry Groups 90
Figure 4.13: ICT Capital Investment as Pct. of Total Capital Investment 91
Figure 4.14: Software Investment as Pct. of Total ICT Capital Investment, 2009 91
Figure 4.15: ICT Capital Investment as Pct. of Total Capital Investment, by Industry Groups, 2009 92
Figure 4.16: Venture Capital Raised by Israeli Firms (mUSD) 93
Figure 4.17: Venture Capital Fund Investments (USD 1 per USD 1,000 of GDP), 2010... 94

Figure 4.18: Gross Monthly Wage in High-Tech Manufacturing vs. National Average...... 95
Figure 4.19: Gross Wage in R&D and Computer Services vs. National Average—Cross-Country Comparison 96
Figure 4.20: Share of High-Tech Employment in National Employment and High-Tech Jobs (,000), 1995–2011........ 97
Figure 4.21: Share of Employees in Selected High-Tech Industries among Employees Countrywide—Cross-Country Comparison, 2009 98
Figure 4.22: Vacant Posts and Total Posts in Manufacturing, by Technology Intensity, 2010–2011 Avg. 99
Figure 4.23: Share of Vacant Posts in Total Posts, High-Tech Manufacturing and Manufacturing at Large........ 99
Figure 4.24: Vacant Posts in Total Posts, Business Services and Selected Industries... 100
Figure 5.1: Patent Applications in Israel, by Origin, 1990–2011 102
Figure 5.2: Patent Applications to EPO Relative to National R&D Expenditure, 1997–2010 (USD millions, 2000 prices, PPP)........ 105
Figure 5.3: Patent Applications to USPTO Relative to National R&D Expenditure, 1998–2011 (USD millions, 2000 prices, PPP) 106
Figure 5.4: Applicants' Triad Patents, 2000, 2005, 2010 107
Figure 5.5: Israeli Publications, 2000–2010, Normalized to All Publications Worldwide . 108
Figure 6.1: Current Expenditure, Fixed Investment in R&D, and Government Funding, by Technology Intensity, 2009–2010........ 114
Figure 6.2: Current R&D Expenditure in Manufacturing Industries, by Type of Activity, 2010........ 115
Figure 6.3: R&D Employee Posts in Manufacturing Industries, by Technology Intensity, 2010 116
Figure 6.4: Current R&D expenditure in Selected Manufacturing Industries in Israel, 1995–2010........ 116
Figure 6.5: Distribution of ICT Expenditure on R&D (in parentheses next to year: share of ICT industries' R&D expenditure in total business-enterprise R&D [BERD])..... 119
Figure 6.6: ICT Gross Output, NIS Millions, 2005 Prices, 1997–2011........ 120
Figure 6.7: ICT Gross Output, NIS Millions, current 2005 prices, 2005–2011........ 121
Figure 6.8: Share of ICT in Business-Enterprise-Sector Gross Output 121
Figure 6.9: ICT Exports, USD Millions, by Industries, 2005–2011........ 122
Figure 6.10: ICT Employee Posts (,000) and Their Share in Total Business-Enterprise Sector Posts (Pct.), 2005–2011 123
Figure 6.11: Share of ICT industries in Business-Enterprise Sector Employment, Cross-Country Comparison (Pct.), 2009 124
Figure 6.12: R&D Expenditure in Business Service Industries, Cross-Country Comparison, 2008 125
Figure 6.13: R&D Expenditure by R&D Industry and Its Share in Total Expenditure, 1997–2009........ 126
Figure 6.14: Distribution of Establishments and Employee Posts in R&D Division, by Types of Establishments, 2008 127
Figure 6.15: Distribution of Establishments in Scientific Research and Development Division (73) by Area of Activity........ 127
Figure 6.16: Number Of Biotechnology firms (N), 2010[1]........ 128
Figure 6.17: Segmentation of Biotechnology Establishments' Income by Type and Purpose, 2010[1]........ 129
Figure 6.18: Segmentation of Biotechnology Establishments' R&D Expenditure by Type of Expenditure, 2010[1]........ 129
Figure 6.19: Segmentation of Biotechnology Establishments' R&D Expenditure by Funding Source, 2010[1]........ 130
Figure 6.20: Biotechnology R&D Expenditure and Its Share in BERD Expenditure, 2010........ 131

Figure 6.21: Employee Posts in Biotechnology, by Education (N), 2002 and 2010 131
Figure 6.22: Business-Enterprise Innovation Expenditure, by Sectors and Types of Expenditure (NIS millions) 134
Figure 6.23: Innovation in the Research and Development Industry, 2006–2008 137
Figure 6.24: Innovation Expenditure, EUR Billion, 2008 137
Figure 6.25: Innovative Enterprises (Technological/Non-Technological) (%) 138
Figure 6.26: Innovative Enterprises, by Type of Innovation 139
Figure 6.27: Innovative Enterprises, by Type of Enterprise (Manufacturing/Services) (%) 140
Figure 6.28: Turnover from new or significantly improved products new to the market, (% of total turnover of innovative enterprises) 140
Figure 6.29: Enterprises Reporting Technological Innovation in Conjunction with Extramural Players (%) 142
Figure 6.30: Enterprises Reporting Performance of Intramural and/or Extramural R&D among Those Reporting Technological Innovation (%) 143
Figure 6.31: expenditure on self-performed R&D, by types of research (NIS million), 2009) 145
Figure 6.32: Segmentation of research institutes' R&D expenditure by socioeconomic objectives, 2009 (%) 146
Figure 6.33: Distributes research collaborations on the basis of collaborating establishments, 2009 148
Figure 6.34: Separately Budgeted University R&D Expenditure, by Funding Source, 2009 149
Figure 6.35: Separately Budgeted University R&D Expenditure, by Disciplines, 2009 ... 149
Figure 6.35: Separately Budgeted University R&D Expenditure, by Institution and Disciplines, NIS Million, 2009 150
Figure 7.1: Manufacturing Exports by Technology Intensity (mUSD) 153
Figure 7.2: Manufacturing Exports by Technology Intensity, mUSD and Share in Total Manufacturing Exports, 1995–2011 154
Figure 7.3: Manufacturing Exports by Technology Intensity, International Comparison, 2009 154
Figure 7.4: Exports of Services by Type of Service, mUSD, 2006–2011 155
Figure 7.5: Exports of Technology-Intensive Services by Type of Service, International Comparison, 2010 156
Figure 7.6: Contribution to Trade Balance by Technology Intensity, Pct. 157
Figure 7.7: Contribution to Trade Balance by Technology Intensity, 2009 158
Figure 7.8: Trade Balance in High-Tech Goods, mUSD, 1995–2011 159
Figure 7.9: Israel's Technological Balance of Payments, mUSD and Pct. of GDP 160
Figure 7.10: Israel's Technological Balance of Payments, by Main Types of Services (Pct. and mUSD, 2007–2011) 161
Figure 7.11: Technological Balance of Payments, Pct. of GDP, 2010 161
Figure 7.12: Imports and Exports of Technological Services, Pct. of GDP, 2010 162
Figure 7.13: Share of IN Firms in Total Output of Selected Divisions, 2002 vs. 2008 163
Figure 7.14: Share of IN Firms in Total Employment and Employment, Selected Divisions, 2002, 2008, and 2009 164
Figure 7.15: Share of IN Firms in Business R&D, OECD Countries, 2009 164
Figure 7.16: R&D Intensity in IN and Domestically Owned Business Enterprises, 2009. 165
Figure 7.17: R&D Exports to Parent Companies as Pct. of IN Firms' R&D Exports, 2009 166
Figure 7.18: R&D Expenditure by International R&D Centers (m NIS, 2005 Prices)....... 166
Figure 7.19: Employment in International R&D Centers (,000s) 167
Figure 7.20: Share of International R&D Centers in R&D Expenditure and Employee Posts in R&D Establishments, 2010 167
Figure 7.21: Apportionment of R&D Employee Posts and Other Posts, 2010 168

Figure 7.22: Research and Development Establishments by Type and Size, 2008 169
Figure 7.23: Share of Employment in International R&D Centers and Other R&D Establishments, 2003–2008 169
Figure 7.24: R&D Establishments in R&D Division, by Year of Founding (Pct. of All Establishments of Same Type 170
Figure 7.25: R&D Establishments and Employee Posts, by Area of Activity and Type of Establishment, 2008 171
Figure 7.26: Exports of Goods by Foreign Subsidiaries, Selected Divisions (mUSD and Pct), 2002 vs. 2009 172
Figure 7.27: Exports of Services by Foreign Subsidiaries, Selected Divisions (mUSD and Pct), 2002 vs. 2009 172
Figure 7.28: R&D Expenditure by OUT Firms (Total and by Divisions), 2006–2009 174
Figure 7.29: R&D Expenditure by Foreign Subsidiaries (by Divisions), 2009 174
Figure 7.30: Israel Foreign Direct Investment (FDI) Position as Pct. of GDP 175
Figure 7.31: Israel FDI Positions, 2010 176
Figure 7.32: Venture Capital Investments in Israeli High-Tech Establishments, by Source of Capital, 1999–2011 (mUSD) 177
Figure 7.33: Israeli VC Investments in Foreign Firms, 2002–2010 (mUSD) 178
Figure 7.34: Cooperative Patents (Pct. of Patent Applications, by Priority Date) 179
Figure 7.35: Foreign-Owned Patents (Pct. of PCT Patent Applications Submitted by Israeli Applicants), 2007–2009 179
Figure 7.36: Patents Approved by USPTO, by Inventors' Citizenship, 1991–2011 180
Figure 7.37: Publications by Israeli Researchers in Conjunction with Researchers Abroad, 2007–2011 181
Figure 7.38: International Cooperation, by Disciplines (2011) 181
Figure 7.39: Israeli Students Abroad, by Destination Countries (2010 vs. 2006) 182
Figure 7.40: Israeli Students in OECD Countries, by Destination Country (2010) 183
Figure 7.41: Israeli Students in OECD Countries 183
Figure 7.42: Israel-Citizen Students in the U.S., Total and Percent of All Foreign Students in the U.S. 184
Figure 7.43: Israel–U.S. Student Mobility Balance 185
Figure 8.1: Internet Users and Facebook Subscribers as Share of Population, 2011 188
Figure 8.2: Non-Users of Computer and Internet, Abed 20+, by Reason 189
Figure 8.3: The UN E-Government Readiness Index, Israel, 2003–2012 (In Parentheses: Israel's Ranking in Year) 190
Figure 8.4: The UN E-Government Readiness Index, 2012 (20 leading countries among 192 participants) 191

Tables

Table 1.1: Key Indicators of Science, Technology, and Innovation in Israel— 2000, ... 18
Table 2.1: GERD Performance and Sourcing, by Sectors, 2009 (mNIS, Current Prices) 25
Table 2.2: GERD by Source Sector, 2000–2009 (mNIS, Current Prices) 28
Table 2.3: Distribution of Research Fund Grants by Recipient Firms' Sales Turnover, Pct. 45
Table 2.4: Sourcing of HERD, 1995–2009 (mNIS, Current Prices) 46
Table 3.1: Twelfth-Graders: Examinees and Eligibles for Matriculation Certificates Meeting University Entrance Requirements, 1996–2010 53
Table 3.2: Matriculation Examinees in Selected Subjects ass Pct. of All Examinees 56
Table 3.3: Characteristics of Science and Technology Teachers, Jewish School System, 2009 57
Table 3.4: TIMSS—Israel and 20 Leading Countries in Mathematics and Science, 2011 61

Table 3.5: First-Year Students in Degree Programs, by Majors, 2000/01 vs. 2010/11 63
Table 3.6: Degree Recipients in Israel in Science and Engineering, by Degree Level, 1994/95–2010/11 65
Table 3.7: R&D Personnel (Full-Time Posts) in Business Enterprises Engaging in R&D, Headcount and Per Thousand Employed in Business-Enterprise Sector, 2000–2011 73
Table 4.1: ICT Capital Stock (incl. Software) 87
Table 4.2: ICT Capital Investment, incl. Software, mNIS and Pct. of Total Capital Investment 90
Table 4.3: Venture Capital Fund Investments, by Stage (Pct.) 93
Table 4.4: Israeli Venture Capital Fund Investments, by Area of Activity (Pct.) 94
Table 4.5: Average Monthly Gross Wage in High-Tech vs. National Average 95
Table 5.1: Patent Applications to USPTO, by Inventor's Country, 1998–2011 103
Table 5.2: Patent Applications to EPO, by Inventor's Country, 1997–2010 103
Table 5.3: Patent Applications to USPTO per Million of Population, by Inventor's Country, 1998–2011 104
Table 5.4: Patent Applications to EPO per Million of Population, by Inventor's Country, 1997–2010 104
Table 5.5: Patent Applications to EPO Relative to National R&D Expenditure, 1997–2010 (USD millions, 2000 prices, PPP) 105
Table 5.6: Patent Applications to USPTO Relative to National R&D Expenditure, 1998–2011 (USD millions, 2000 prices, PPP) 106
Table 5.7: Leading Countries in Publications per 100,000 Inhabitants, 2011 109
Table 5.8: Percent of S&T Publications in Total Publications in Country, Cross-Country Comparison, 2007–2011 110
Table 5.9: Ratio of Average Citations in S&T Disciplines in Israel to Average Citations per Discipline, Cross-Country Comparison—Normalized to Discipline (Global), 2007–2011 111
Table 5.10: S&T Publications as Percent of All Publications in Discipline, Cross-Country Comparison, 2007–2011 112
Table 5.11: Leading Countries in Quality Ranking (Average Citations per Publication, Normalized to World), 2007–2011 113
Table 6.1: R&D Expenditure by Manufacturing Industries, Cross-Country Comparison, 2009 117
Table 6.2: Firms Reporting Technological Innovation, by Types of Innovations and Economic Sectors (%) 135
Table 6.3: Technological and Non-Technological Innovation 136
Table 6.4: Enterprises Presenting Technological Innovation and Innovation New to Their Markets, by Enterprise Size (%) 141
Table 6.5: Enterprises Reporting Technological Innovation in Conjunction with Extramural Players, by Countries 142
Table 6.6: Enterprises Reporting Non-Technological Innovation, by Types of Innovation (%) 143
Table 6.7: Research Institute Personnel, by Levels Of Education 146
Table 7.1: Trade Balance in High-Tech Goods, mUSD, 1995–2011 159
Table 7.2: R&D jobs in international R&D centers of the total R&D jobs in R&D Enterprises, 2010 168
Table 7.3: Israeli Doctoral Candidates in Science and Engineering who Attend U.S. Institutions (Total and Pct. of Doctoral Candidates of All Origins) 185
Table 8.1: Israel in the E-Government Readiness Index, by Index Components 192

1. Introduction

1.1 General Preface

Israel's has been forced from its establishment to base its economic and military strengths on scientific knowledge and advanced technologies. Indeed, Israel has achieved prodigiously in its sixty-five years, becoming a world leader in various domains of high-tech. Furthermore, the way Israel weathered the global economic crisis that erupted in 2008 proves not only the advantage of basing its economy on knowledge but also the immense importance of policies that promote scientific and technological (S&T) endeavor and encourage the development of human capital as an essential infrastructures. However, as indicated by tracking various measures over time and across countries, shown in this publication, **Israel may quickly find it difficult to maintain its world leadership status in S&T fields and in the economic leveraging of this status.**

The indicators in this report show that while Israel maintains its leading position in various parameters of science and technology, several of its advantages over other countries, including some that are taking their first steps in these domains, are narrowing down. Global processes beyond Israel's control explain some of these trends, but worrisome changes in Israeli policy and government support of higher education and R&D may have contributed to this situation.

Israel's research universities, tasked with producing human capital and knowledge for S&T activity, endured severe budget cuts for many years and began to enjoy a corrective process only since 2010. Direct government support of R&D has also contracted perceptibly in recent years, thus significantly reducing the beneficial impact of Israel's array of creative support programs for business R&D, which made it a model for emulation by many countries. The slashing of government support triggered a major increase in the share of R&D in Israel that is funded from business sources (the highest rate in the Western world). Such funding, however, is by nature oriented to commercial business goals at the expense of basic research that affects the country's scientific and technological capabilities in the long run.

For example, Israel's share in world scientific publications fell from 1.25 percent to 0.96 percent within a decade. Israel's rate of R&D expenditure in GDP, 4.3 percent, remains high by world standards but below the country's record in this respect only five years ago (4.8 percent), and the gap between Israel and other countries has narrowed as many countries have adopted policies aimed to increase R&D investment. The population of baccalaureate students in Israel's research universities, a platform for continued study toward advanced degrees and the development of S&T research capabilities, has been declining or stagnating (although enrollment in degree-awarding colleges has risen briskly). The share of Israeli baccalaureate students majoring in medical and S&T disciplines has fallen from 40 percent to 35 percent within a decade. The research universities are suffering from steady aging of academic staff, difficulties in recruiting new faculty, and high student–staff ratios that impair teaching quality. The output of Israel's information and communication technology (ICT) industry—once the locomotive of the economy—has hardly changed in recent years, and its share in Israel's total business-sector output has been falling (although the ratio of ICT output to GDP in Israel is still high by OECD standards). An enormous share of domestic R&D investment (46 percent) is funded from foreign sources, principally multinational firms' R&D centers in Israel; obviously, at least some of the benefits from these investments will be reaped by parent companies abroad. Israel continues to develop technology companies that are sold to foreign firms at a relatively early stage. In *Forbes* magazine's ranking of the 2000 largest companies in the world in terms of sales, Israel is represented by only one technology company (among eleven Israeli firms on the list) compared to Switzerland (three technology companies out of forty-five Swiss firms on the list in 2000), Sweden (three of twenty-five), and Singapore (two of eighteen).

Conversely, there have also been changes for the better, indicating the preservation if not the improvement of Israel's array of scientific and technological capabilities. These are reflected in a more balanced spread of R&D investments across industrial sectors, the opening of R&D centers of multinational firms that recognize the quality of Israel's scientific labor force, government efforts to attract faculty, researchers, and advanced-degree holders in S&T disciplines in an attempt to mitigate brain drain, and, Israel's admission to the OECD in 2012.

Israel's success in leveraging scientific and technological R&D into economic growth is the product of circumstances and massive public investments in research and higher education in the country's first decades, before most industrial countries adopted similar strategies. Most developed countries have by now assimilated the awareness that new technologies and their applications are key to economic growth and welfare. Accordingly, Israel faces steadily growing competition in the markets for technology-intensive goods and services and for R&D activities that themselves are becoming tradable in the global economy. This growing rivalry is manifested in competition for foreign investments that provide essential capital for continued technological development and for workers who acquired S&T and managerial training in Israel.

A cohesive long-term national policy on scientific and technological R&D is essential for coping successfully with ongoing changes in the international arena, for funding and allocating the heavy investments required for advanced scientific research, and for providing the needed human skills for such activities. No less important are the economic and social challenges that accompany an economy that bases its development on science and high-tech, which by nature are unavailable and accessible equally to all members of society. Such a policy should provide a blueprint for the mobilization of the requisite resources and their allocation to various scientific and technological fields, and to research and training. The formulation of such a policy must be based on an up-to-date and comprehensive picture of all S&T activities nationwide and their economic costs and benefits.

Many entities in Israel have been and are involved in S&T policy making, funding the activities prescribed by such policies, and in monitoring of the economy's performance in these fields. These entities must have access to reliable and up-to-date data on R&D and S&T. To develop such a database, the Samuel Neaman Institute for National Policy Research at the Technion, the National Council for Research and Development (NCRD), and the Israel Central Bureau of Statistics (CBS), jointly produce this report. An informal entity has been established recently: the Science and Technology Forum, headed by the Chair of NCRD with the participation of all bodies having national-level responsibilities for research and development and for higher education. In March 2013, the Forum presented to the Prime Minister an alarming report on Israel's scientific and technological positioning, along with an appendix containing data based, among other sources on this study.

CBS is responsible at the national level for gathering various kinds of data on S&T developments in Israel, those who engage in it, investments in such activities, along with other data on the economy of the state. NCRD is authorized to provide advice to the government for setting national policy on research and development. The Samuel Neaman Institute engages in ramified research activity on diverse scientific themes and their influence on Israel's society and economy. This report, then, is a reflection of ongoing activity that aims to describe and analyze the resources pledged to scientific and technological research in Israel, and the outcomes of these activities.

1.2 Data for S&T Policymaking

Many studies have shown that the creation and dissemination of S&T knowledge and the training of workers and researchers in these fields are effective drivers of economic growth, and produce exceptionally high social returns. Policymaking for enhancing competitiveness and developing scientific and technological capabilities is now a central goal in all industrialized countries. The European Union invests enormous amounts in developing indicators for monitoring these processes and in designing incentives schemes for promoting them.

It is widely agreed that S&T research processes are acutely prone to market failures, and consequently to sub-optimal investments in research and development absent government intervention. Such market failures follow from difficulties in appropriating the full returns from RD investments due to knowledge spillovers, extremely high costs and uncertain duration and returns, and information asymmetries between investors/entrepreneurs and potential funding providers. Governments attempt to offset these hurdles by offering various structural and support programs for scientific research activity and R&D. Such government provided stimuli are all the more necessary in a country lacking in natural resources, detached and remote geographically from its potential markets, and politically isolated.

Israel is going through a painful process of downsizing the public sector governmental support of many activities. The implications of this downsizing on the state's scientific and technological capabilities are not clear. A significant reform in the government funding of research universities, adopted in 2010, is now challenged by recent government budgetary problems. How will such difficulties affect university faculty recruiting and students enrollment is not clear. How will changes in government support for R&D affect the ability to raise capital for private investments in high-tech firms in Israel? Will Israel be able 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 see it as their desirable home?

A necessary condition for the formulation of a S&T policy that can address such problems in a rapidly changing environment is an up-to-date picture and ongoing monitoring of the development of S&T research activities in Israel. This would make it possible to spot the directions of such activities and provide timely encouragement where deemed necessary, and identify the entities active in creating basic and applied S&T knowledge, their sources of funding, and the human resources needed for their continued success. An up-to-date data of this kind would allow channeling public resources to where they generate the highest social return, give investors and potential research benefactors clues for better allocation of their funds, and allow providers of higher-education and their students to plan their choices in an informed manner.

1.3 Goals of This Report

This report seeks to provide data for policymakers and actors in the government, research and academic institutions, and the business sector allowing them to review S&T activity in Israel systematically. Using such data will allow them to develop and apply quantitative methodologies for the description and surveillance of the country's general scientific infrastructure and the extent of activity in the relevant fields. The data reporting methods used in this report follow accepted international standards, and is modified where necessary to reflect Israel's special conditions and characteristics

1.4 Methodological Background and Review of Topics in This Report

In general, much f this report follows a benchmarking approach. Cross-country comparison of S&T indicators is a tool for evaluating government policies and their outcomes. By using it, one may identify factors that support and inhibit particular activities. However, such indicators are not an end product but a point of entry for discussion among policy makers and members of the public. The indicators in this report provide a basis for qualitative and quantitative examination of S&T activity and its impact on the economy.

Importantly, a process such as this must be comprehensive and on-going for being an effective aid in policy setting and policy evaluations.

This report on indicators of science, technology, and innovation in Israel—the fourth since the series began in 2006—is arranged around seven main themes:

- National civilian R&D expenditures: measuring the extent of R&D in Israel in financial and other terms, while distinguishing between performers and funding sources of R&D, (Chapter 2);
- S&T Human Capital: those engaged various areas of S&T, their training and higher education characteristics, (Chapter 3);
- Indicators of economic outcomes of R&D and innovation, (Chapter 4);
- Other forms of outputs measures of S&T development: scientific publications and citations, and patenting activities, (Chapter 5);
- R&D and innovation measures in selected industries and research institutes, (Chapter 6);
- Globalization of R&D and S&T activities: indicators on S&T international interactions -- the extent of international trade in high-tech goods and services, R&D centers of multinational and foreign firms, foreign investments in high-tech, and international research relations, (Chapter 7);
- Technological readiness: communication infrastructures and information technologies, their assimilation in society and government, and the public's attitudes toward S&T issues (Chapter 8).

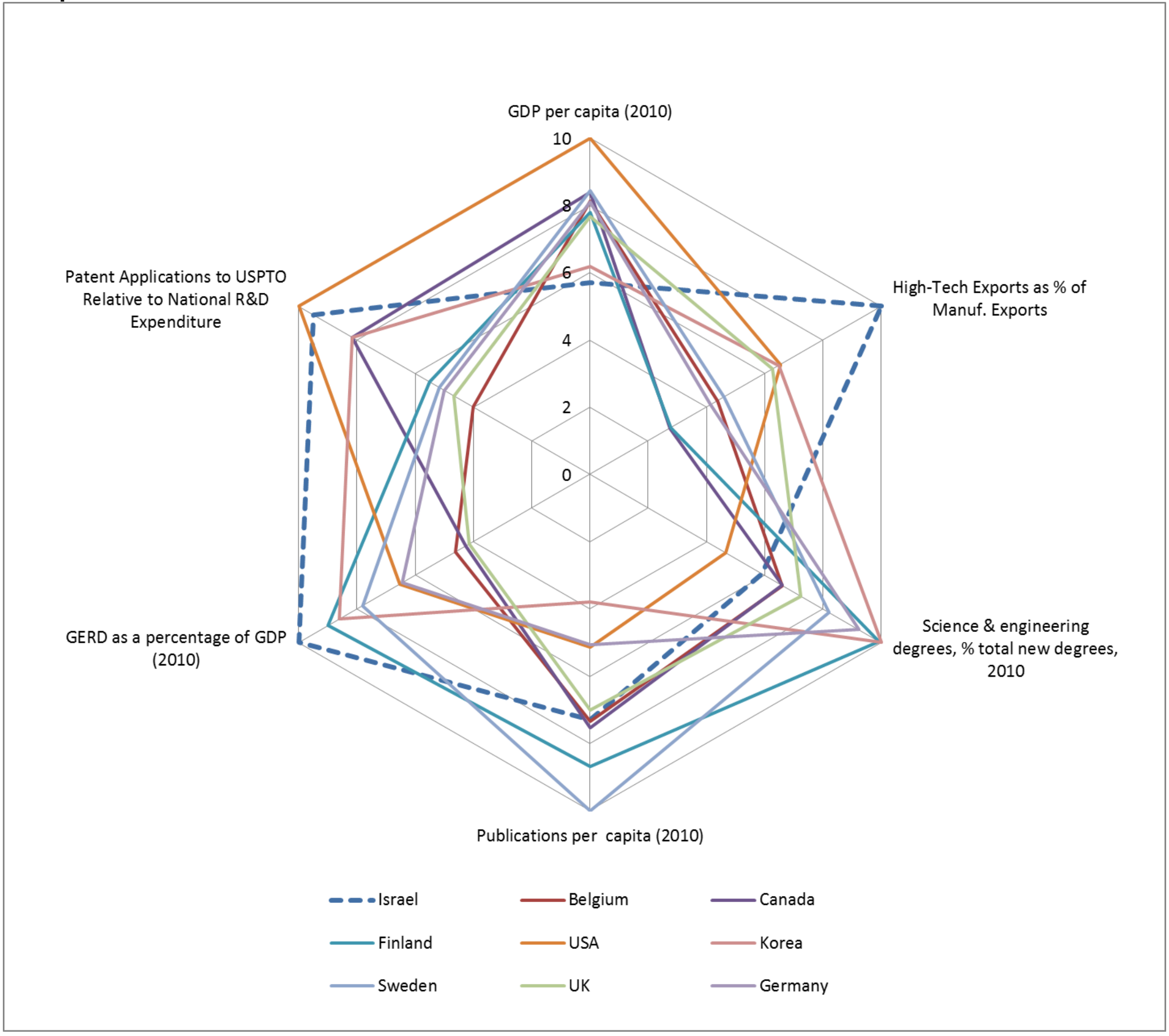
1.5 Trends in Key Indicators of Science, Technology, and Innovation

Table 1.1: Key Indicators of Science, Technology, and Innovation in Israel— 2000, 2003, 2009 and 2011

	2000	2003	2009	2011
General				
Population (000s)	6,369	6,748	7,552	7,837
GDP (mil NIS, 2005 prices)	541,749	546,580	704,632	777,087
Per-capita GDP (PPP $)	22,997	21,862	25,439	26,969
Innovation and R&D resources				
GERD as a percentage of GDP	4.29%	4.29%	4.49%	4.38%
GERD per capita population (current prices, PPP, $)	1,002	950	1,144	1,224
GBAORD of total R&D expenditure (%)	24%	23%	15%	
BERD of total R&D expenditure (%)	77%	74%	80%	80%
HERD as percent of GDP	0.65%	0.73%	[1]0.58%	0.50%
R&D budgets of the Chief Scientist (mil NIS)	2,244	1,981	1,833	1,447
Human capital				
Pct. of Twelfth Graders Eligible for Matriculation Certificates	[2]50.3%	56.4%	54.2%	[3]55.9%
Share of New Higher-Education Students Majoring in S&T Disciplines	34.1%	27.9%	26.6%	[3]25.5%
R&D Personnel (FTP) Per Thousand Employed in the Business-sector	22.43	21.12	22.83	23.16
Globalization				
R&D Expenditure by International R&D Centers (m NIS)		[4]6,480	11,364	[3]10,393
Share of International R&D Centers in R&D Expenditure			44.0%	[1]40.3%
Employees of international R & D centers (in thousands)		[4]12.1	29.4	[3]28.2
The rate of venture capital raised from foreign entities or foreign entities with Israeli involvement	59%	58%	55%	[3]71%
R&D jobs in international R&D centers of the total number of R&D jobs			33.7%	[1]36.1%
Economic outputs				
Output per employee: high technology industries relative to total manufacturing	1.42	1.26	1.22	1.19
Share of high and medium-high technology industries in GDP	7.9%	6.4%	7.1%	[3]7.3%
High-tech industries Export of total industrial exports (%)	53%	46%	42%	47%
Share of exports in computer and r&d services from total services exports		[4]44%	[3]46%	51%
Share of High-Tech Employment in National Employment	8.4%	8.6%	9.5%	9.4%
Share of ICT Capital Stock in Total Net Capital Stock	7.8%	8.0%	10.1%	10.7%
R&D outputs				
Number of patent applications in the U.S. of Israeli inventors	2,509	2,539	4,727	5,436
Number of patent applications in the U.S. (of Israeli Inventors) to R&D expenditure	0.40	0.40	0.55	0.57
Applicants' Triad Patents	221	[4]332		[3]425
Israeli publications as a rate of the world's scientific publications	1.27%	1.29%	1.01%	0.96%

[1]2008
[2]1996
[3]2010
[4]2005

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



2. Gross Expenditure on R&D

- In 2011, national civilian R&D expenditure was NIS 38.2 billion (current prices), up 4.4 percent from the previous year.
- The share of national civilian R&D expenditure in GDP was 4.3 percent in 2010, the highest among OECD countries despite a decrease from 4.8 percent in 2007.
- In 2009, the business-enterprise sector performed 80 percent and sourced 36 percent of national civilian R&D expenditure .
- 46 percent of national civilian R&D expenditure was sourced from abroad, one of the highest rates in the world due to the larger share of multinational firms' development centers in Israel. The government sourced only 15 percent (including Planning and Grants Committee allocations).
- 81 percent of civilian R&D expenditure by government in Israel is intended for the promotion of manufacturing technologies and university research (via the Planning and Grants Committee), as against only 41 percent on average for similar purposes among OECD countries.
- The share of R&D and computer services (Divisions 72 and 73) in Israel's national civilian R&D expenditure (56 percent in 2009) is very high by international standards.

The examination, analysis, and comprehension of national civilian R&D expenditure and its components are immensely important because these are the accepted aggregate metrics for use in classifying national R&D activity in the fields of scientific research and technological development. The assumption is that R&D expenditure is an investment meant to produce new knowledge, products, or processes. In measuring national civilian R&D expenditure, one distinguishes between performing sectors and sources of funds sectors. Sources of funds and performance are divided into four sectors: government, business, higher education, and nonprofits. R&D investment performed by the government sector is meant mainly to produce new knowledge or dedicated R&D for social purposes such as healthcare, agriculture, and the environment, and is not oriented to business. Business investment in R&D, in contrast, usually aims to create new processes and new products that are expected to increase output or deliver an investment return.

Most statistical bureaus around the world, including Israel's Central Bureau of Statistics, have adopted the methodology in the Frascati Manual, published by the OECD Statistics Directorate, for the definition, measurement, and collection of statistical data on R&D activities. Another manual that offers working definitions is the Oslo Manual, which includes guidelines for the collection and use of data on innovation in manufacturing and services. For data on human resources in science and technology, the Canberra Manual is used.

The adoption of these definitions by numerous international agencies facilitates cross-country comparisons that enhance our understanding of research infrastructure development processes and aid the performance of policy analyses. Since Israel was admitted to the OECD in May 2010, its Central Bureau of Statistics has aligned its statistics with those that this organization issues.

Per recommendation of the OECD, this chapter classifies national R&D expenditure by performing sectors and source sectors. It begins by surveying Israel's R&D data at the aggregate level between 1990 and 2011 or the last year for which data exist. The indicators presented below are comparable with those of other countries. Following is an in-depth focus on the three main sectors that perform/finance R&D: business, government, and higher education. Finally, the data and trends in Israel are compared with those in selected countries, mostly OECD member states.

Several remarks about the publicly available data are in order. (a) All indicators for Israel relate to civilian R&D only. The Government of Israel also sources and performs defense R&D on a considerable scale; it is not included in this publication. (b) In the time series, the data are shown in 2005 prices. When the data are sectored in percent terms, the proportions of the sectors differ when calculated on the basis of current as opposed to constant prices. The differences trace to the deflation of the various sectors' data by sectoral price indices, which change at different rates over time. For this reason, we chose to calculate the shares of different sectors in R&D expenditure in current prices despite the mismatch that this creates vis-à-vis the expenditure data themselves, which are shown in constant prices unless otherwise stated.

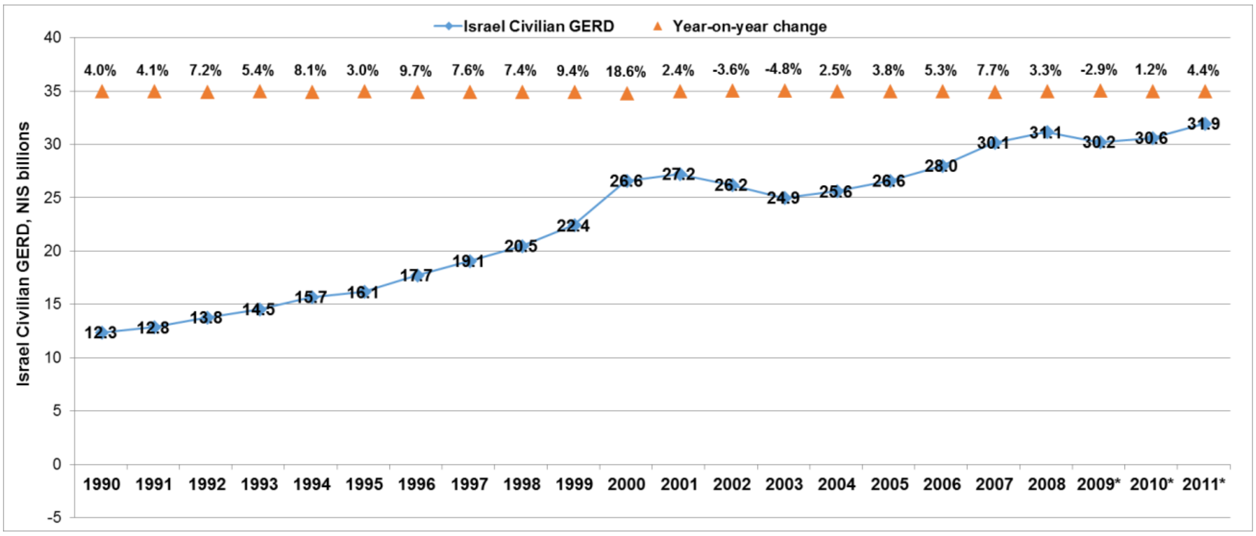
2.1 Aggregate View

2.1.1 National Gross Expenditure on R&D (GERD) [5]

National expenditure on civilian research and development (GERD) was NIS 38.2 billion in 2011 (current prices), 4.38 percent of Gross Domestic Product—4.4 percent greater than expenditure in 2010, indicative of recovery from the 2008 crisis. Figure 2.1 presents Israel's GERD in 1990–2011 and its year-on-year changes (in constant 2005 prices). The slowdown in the growth of this indicator due to the 2008 economic crisis is evident. GERD contracted by 2.9 percent in 2009 and rebounded by only 1.2 percent in 2010.

[5] GERD—Gross Domestic Expenditure on Research and Development.

Figure 2.1: Israel Civilian GERD, 1990–2011 (NIS billions, 2005 prices)



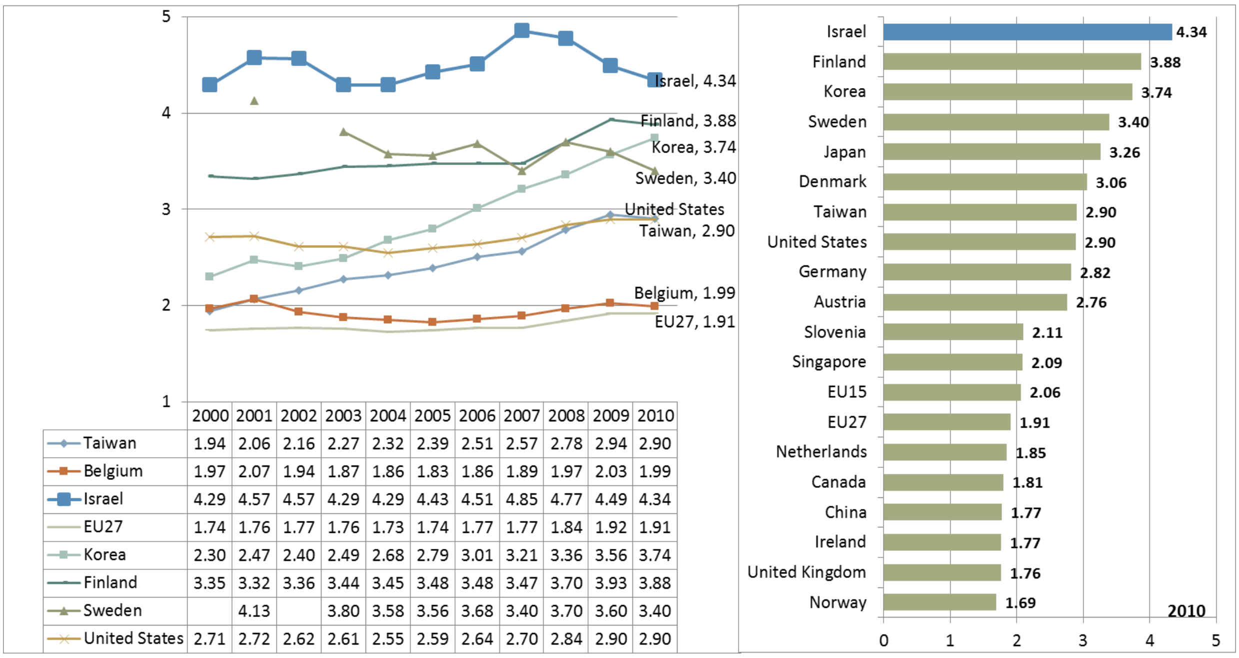
* Provisional data

Source: Analysis of CBS data by Samuel Neaman Institute

2.1.2 R&D Intensity

By calculating R&D intensity—the share of GERD in GDP—it becomes possible to compare Israel with other countries that are different from it in physical and economic size. Figure 2.2 presents this metric for the 2000–2010 period. Even though the data for Israel do not include national expenditure on defense R&D, Israel ranks first in the standings, reflecting its strength by global standards and the importance of research, development, and innovation activity in its economy. In Israel, this indicator has been trending down since 2007 in comparison with countries such as South Korea, Germany, and Finland, which exhibit upward trends in R&D intensity. South Korea stands out in particular; its R&D intensity climbed from 2.30 percent in 2000 to 3.74 percent in 2010—a 63 percent increase in one decade.

Figure 2.2: GERD as Percentage of GDP, 2000–2010[a]



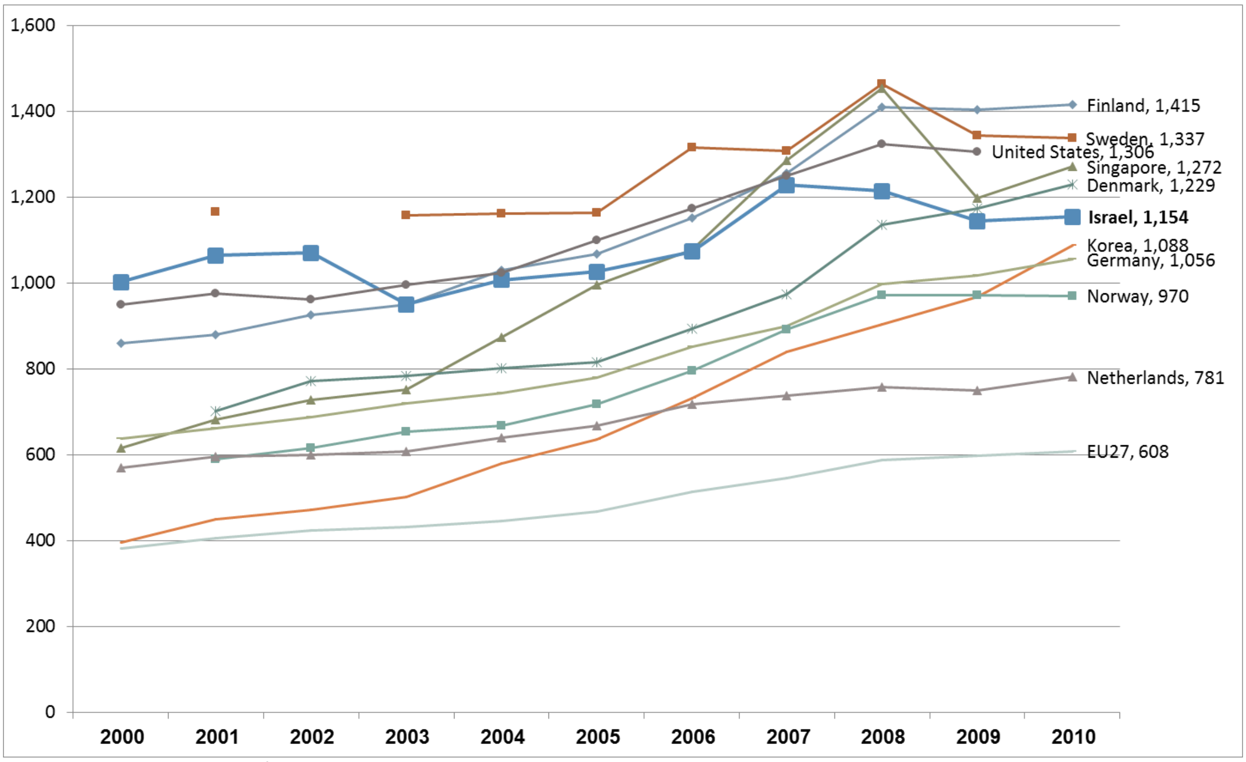
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Taiwan	1.94	2.06	2.16	2.27	2.32	2.39	2.51	2.57	2.78	2.94	2.90
Belgium	1.97	2.07	1.94	1.87	1.86	1.83	1.86	1.89	1.97	2.03	1.99
Israel	4.29	4.57	4.57	4.29	4.29	4.43	4.51	4.85	4.77	4.49	4.34
EU27	1.74	1.76	1.77	1.76	1.73	1.74	1.77	1.77	1.84	1.92	1.91
Korea	2.30	2.47	2.40	2.49	2.68	2.79	3.01	3.21	3.36	3.56	3.74
Finland	3.35	3.32	3.36	3.44	3.45	3.48	3.48	3.47	3.70	3.93	3.88
Sweden		4.13		3.80	3.58	3.56	3.68	3.40	3.70	3.60	3.40
United States	2.71	2.72	2.62	2.61	2.55	2.59	2.64	2.70	2.84	2.90	2.90

Note: data for Israel do not include national expenditure on defense R&D
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

Another indicator that facilitates cross-country comparison is per-capita GERD. Israel's trends in both indicators, gross and per-capita, are similar; the per-capita indicator has also been drifting downward since 2007. Since the cross-country comparison shows Israel as the leader in terms of GERD in GDP, one would expect to find the same in per-capita national expenditure. However, Israel is in fifth place ([6]$PPP 1,154), trailing Finland ($PPP 1,415), Sweden ($PPP 1,337), Singapore ($PPP 1,272), and Denmark ($PPP 1,229). A conventional explanation for this is that Israel's per-capita GDP is below the OECD average and the decrease is steeper than that in other countries because its rate of population increase surpasses that of countries such as Finland and Sweden. Also, defense R&D is not included; if it were, Israel would probably be among the leaders.

[6] "PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including GDP." Retrieved from http://www.oecd.org/std/prices-ppp/purchasingpowerparities-frequentlyaskedquestionsfaqs.htm

Figure 2.3: Per-Capita GERD, 2000–2010 ($PPP*)



Note: Measured in PPP $
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

2.1.3 GERD by Sectors

The Frascati Manual divides GERD into four main performing sectors and five main source sectors: business-enterprise, government, higher education, private nonprofit, and (source only) abroad.

Israel's Central Bureau of Statistics (hereinafter: CBS) defines the first four of these sectors as follows:

- **Business enterprise**: private and governmental enterprises and entities of business nature in various areas of the economy;
- **Government**: general government including central-government offices (among which: the Planning and Grants Committee), 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.

The next table presents the interrelations of R&D sourcing and performance in Israel (2009) parsed by the five main economic sectors. The matrix shows how R&D

performance that is financed by the sector appearing on any given row is distributed across different performing sectors; it also shows how the sector in each column finances the R&D that it performs .

Table 2.1: GERD Performance and Sourcing, by Sectors, 2009 (mNIS, Current Prices)

		Performer sector					
	NIS millions, current prices	**Total**	**Business**	**government**	**Higher education**	**Private Non-Profit Institutions**	**Rest of the world**
Financing sector	**Total**	34,439	27,387.10	1,314.10	4,501.90	1,209.90	-
	Business	12,511	12,696.10	71.6	434.7	222.8	-
	government	4,998	1,281.00	1,226.10	2,151.80	446	-
	Higher education	608	-	2.2	604.2	1.2	-
	Private Non-Profit Institutions	542	-	2.2	391.7	141.2	-
	Rest of the world	15,780	13,410.00	11.9	919.5	398.8	-

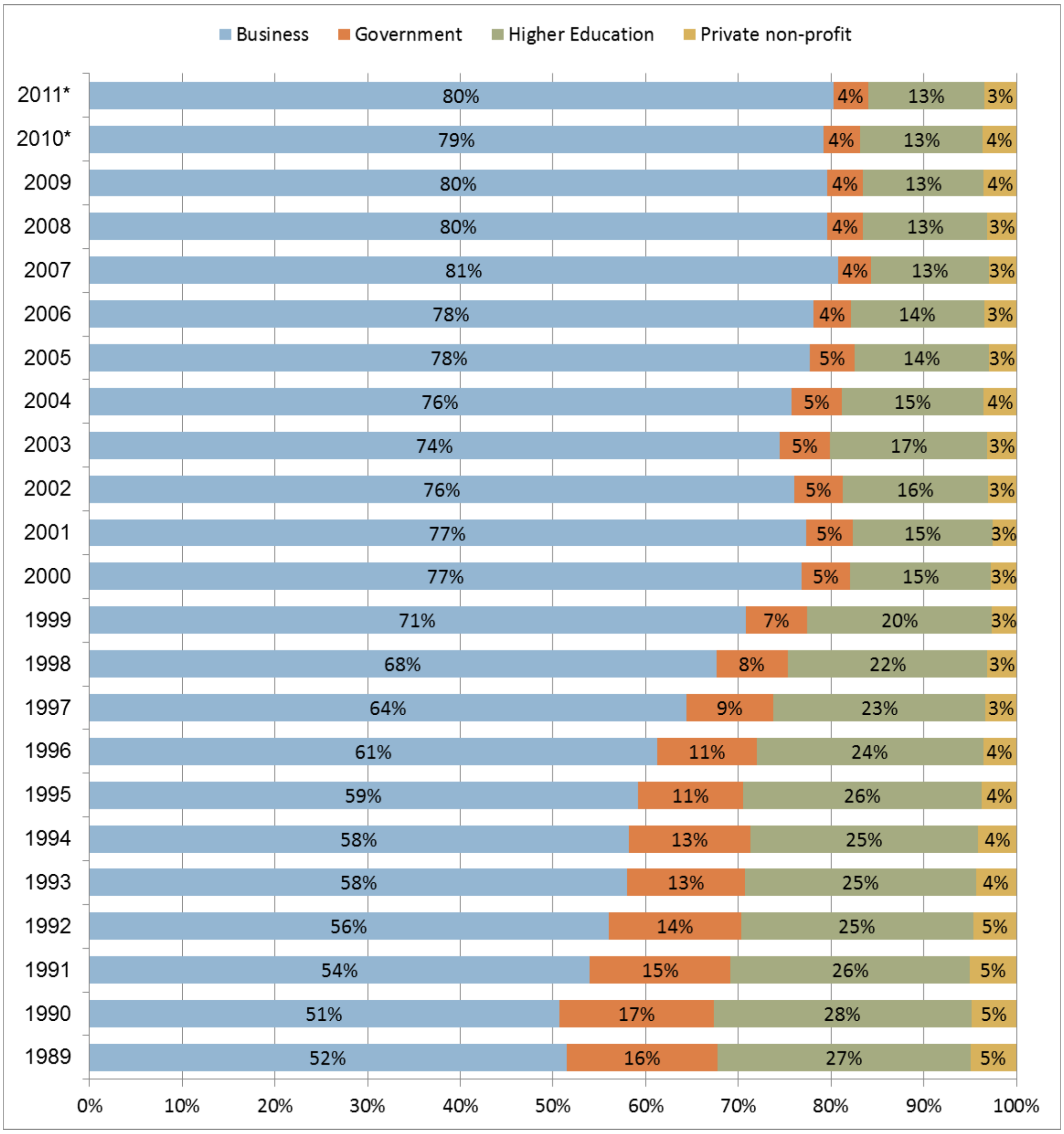
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The hefty share (46 percent) of sources from abroad in R&D performed by the business enterprise sector is especially conspicuous; it reflects the large scale of activity of foreign companies' R&D centers in Israel. The abroad component in sourcing university-performed R&D is also very significant (22 percent). The ratio of R&D performance to R&D sourcing in the business-enterprise and private-nonprofit sectors is around 2, as against more than 7 in higher education and 0.25 in the government sector.

Figure 2.4 shows the distribution of the performance of Israel's GERD among the four performing sectors in 1989–2011. During this time, the share of the business-enterprise sector in R&D performance increased considerably, from NIS 13,330 million in 1997 to NIS 25,505 million in 2011 (both in 2005 prices)—up 4.7 percent on compound annual average[7]. In the government sector, in contrast, the compound annual average increase in GERD during that time was 0.9 percent. The share of government in R&D expenditure slipped from 17 percent in 1990 to 9 percent in 1997 and 4 percent in 2011 (calculated on the basis of values in current prices). GERD performed by higher education was also basically unchanged over the years, declining from 23 percent in 1997 to 13 percent in 2011. Research performed by higher education is not keeping up with the massive increase in GERD performed mainly by the business-enterprise sector. The distribution of R&D among basic research, applied research, and development may be materially affected by the massive upturn in the share of the business-enterprise sector in the performance of R&D in Israel.

[7] CAGR: compound average growth rate (CAGR), $\mathrm{CAGR}(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$

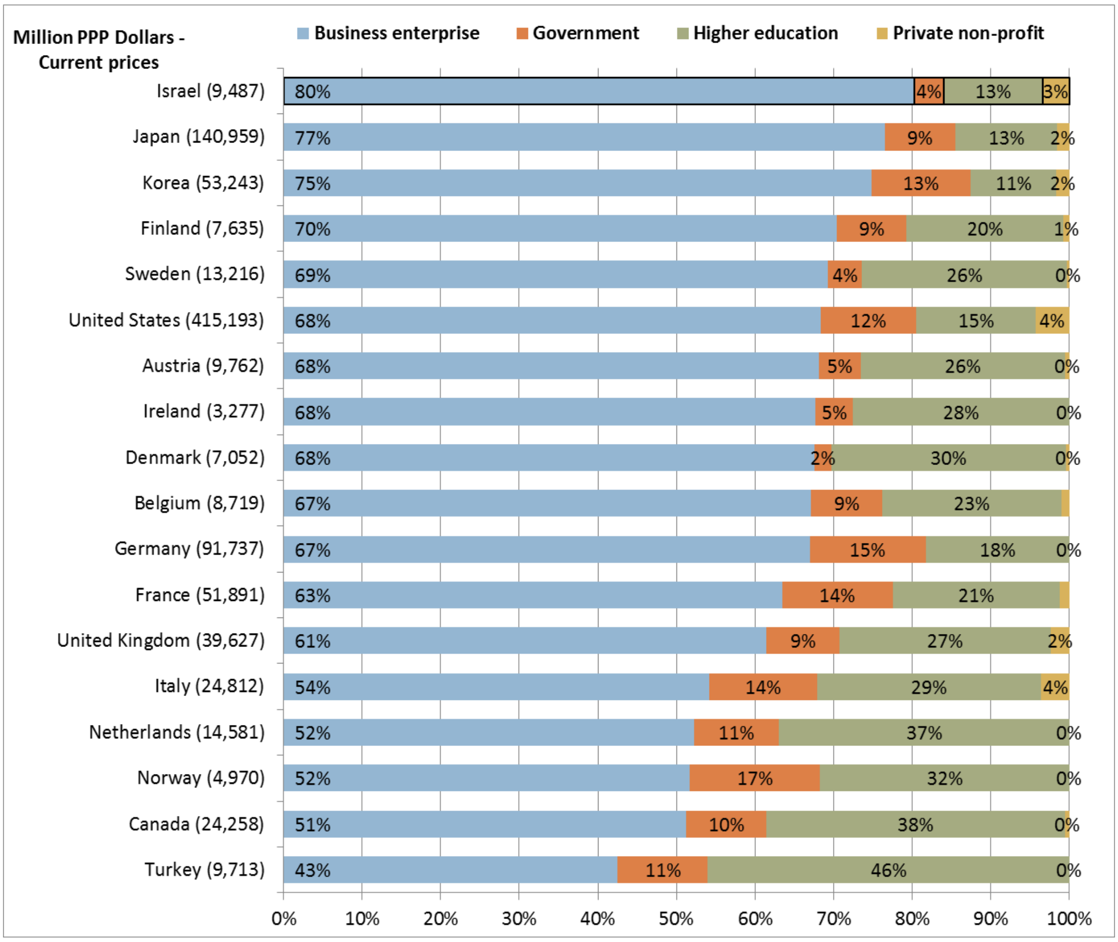
Figure 2.4: GERD by Performing Sector, 1989–2011



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The next figure presents the distribution of rates of GERD by performing sector among different countries in 2011. Although Israel stands out for the high share of its business-enterprise sector in GERD performance (80 percent), this rate exceeds 60 percent in most countries. In the other sectors—government, higher education, and private nonprofit—the share of GERD is low in Israel by international standards. In most countries other than South Korea (11 percent), Japan (13 percent), Israel (13 percent) and the United States (15 percent), the share of higher education in GERD exceeds 20 percent.

Figure 2.5: Distribution of Rates of GERD by Performing Sector, Cross-Country Comparison, 2011* (Digits in parentheses express GERD in Million PPP Dollars - Current prices)



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

Analysis of the differences in GERD between performing and source sectors demonstrates the extent of the various sectors' development of their own ability to perform R&D, the professionalization of R&D and the infrastructures that are needed to perform it, and awareness of the importance of R&D for progress toward the sector's goals even if the sector assigns performance to someone else. The sectoral distribution resembles that described in R&D by performing sector, except here we add a reference to sources of funding from abroad. The CBS definition of the "abroad" sector is based on the Frascati Manual: "Abroad comprises all institutional units that are not Israel residents that carry out transactions with units that are Israel residents or that have other economic relations (e.g., claims between residents and nonresidents) with Israel residents. Abroad also includes certain institutional units that are physically located within the geographical limits of the state, e.g., embassies, consulates, and military bases, including international organizations." Until 2007, multinational firms and R&D centers that belonged to them and operated in Israel were included in business-enterprise sourcing and not sourcing from abroad. From

2007 on, greater detail in the survey questions yielded a new data series on sourcing by the business-enterprise sector, resulting in a different and much larger estimate of financing from abroad than in previous years.

Table 2.1 presents GERD in Israel by source sector in current prices in 2000–2009. Government sourcing includes government transfers to universities via the Planning and Grants Committee of the Council for Higher Education (PGC). The higher-education column includes only R&D that research universities perform and finance from their own sources (tuition fees and non-earmarked donations), donations, grants, and other capital transfers.

Notably, since the data in the table are expressed in current prices, the financial values cannot be compared over the years; the reference is only to the share of each sector in the financing of GERD in each particular year. Also, as noted above, the division between the business-enterprise sector and abroad changed in 2007. (This is emphasized in the table in gray(.

In 2009, the business-enterprise sector sourced 36 percent of total GERD in Israel, as against 52 percent in 2008 and 56 percent in 2007. Government sourcing of GERD was almost unchanged: 15 percent in 2009 and 14 percent in 2008 and 2007. Higher education institutes and private nonprofits financed 2 percent of GERD in 2007–2009 and 43 percent of sourcing came from abroad in 2009 as against 31 percent in 2008 and 27 percent in 2007.

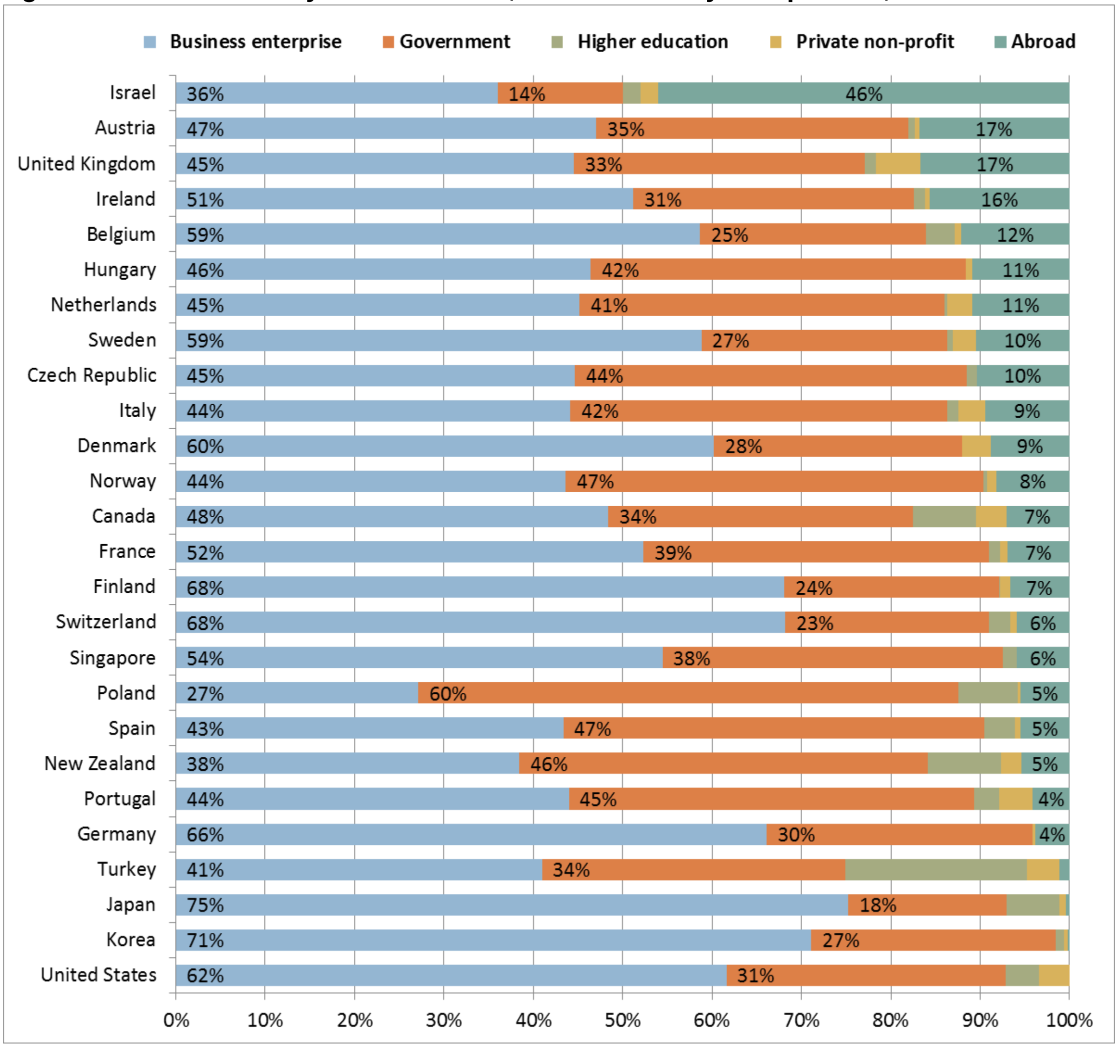
Table 2.2: GERD by Source Sector, 2000–2009 (mNIS, Current Prices)

	Total		**Business**		**Government**		**Higher Education**		**Private non-profit**		**Abroad**	
	mNIS	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**
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	**26,561**	**100%**	20,316	76%	4,254	16%	700	3%	464	2%	827	3%
2006	**28,810**	**100%**	22,377	78%	4,373	15%	736	3%	470	2%	854	3%
2007	**33,175**	**100%**	18,448	56%	4,522	14%	553	2%	545	2%	9,106	27%
2008	**34,525**	**100%**	17,929	52%	4,812	14%	689	2%	544	2%	10,549	31%
2009	**34,439**	**100%**	12,511	36%	4,998	15%	608	2%	542	2%	15,780	46%

Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The next figure presents a cross-country comparison of GERD distribution by source sector. Israel's 46 percent share of sources from abroad in 2009 is an outlier, the highest among the countries listed in the table. Tied for second place are Austria and the UK at 17 percent. The reason is Israel's uniquely large concentration of international R&D centers. For elaboration, see Section 7.2.2, “International R&D Centers.” In contrast, Israel ranks very low in the share of the government sector in sourcing (15 percent), as against 35 percent on average in the other countries.

Figure 2.6: GERD Rate by Source Sector,[1] Cross-Country Comparison, 2009



1. The table is sorted by rates of investment from abroad.
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

2.2 The Business-Enterprise Sector

In the 1990–2000 decade, the share of the business-enterprise sector in GERD increased significantly in most developed countries. This reflects, in part, the transition to a knowledge-based economy, in which a major component of activity is meant for the creation, use, application, and assimilation of knowledge. This component is a material source of corporate growth and profitability (e.g., Microsoft and Internet companies such as Google and Yahoo). In the past decade, however, these indicators seem to have leveled off and, in some countries, even declined in years of economic crisis.

The increase in business involvement in R&D activity has been accompanied by a decline in the share of government sourcing of GERD. When one studies data for the business-enterprise sector in Israel and, above all, when one compares Israel with other countries, one should bear in mind that the Israel data do not include defense R&D expenditure, which is financed by government and performed largely by the business-enterprise sector. Israel is the leader among OECD countries in business R&D as a share of GDP (3.44 percent), far ahead of the runners-ups.

2.2.1 An Aggregate Look at BERD (Business-Enterprise Sector R&D)

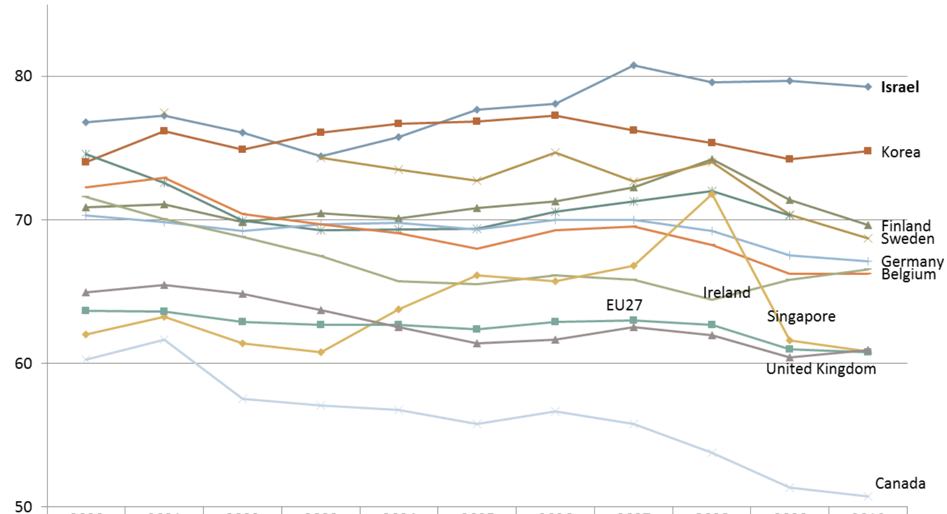
The relative importance of the business-enterprise sector in domestic R&D activity may be examined in two basic respects: the share of GERD that this sector performs and the share of GERD that it sources. In Israel, the business-enterprise sector is the main performer. Most sourcing of GERD is divided between it and abroad.

Business R&D in Israel is special because it includes R&D centers that are sourced largely by multinational firms. Until 2007, the sourcing of multinational firms' R&D expenditure was included in business-enterprise sector sourcing and could not be isolated from the sectoral total. In 2007, this sourcing was transferred to and included in abroad. In 2011, the Israeli business-enterprise sector performed NIS 30.6 billion (in current prices), 80 percent of total GERD. In 2009, it performed NIS 27.4 billion and sourced 43 percent of this amount, i.e., NIS 11.8 billion (current prices). Another 53 percent (NIS 14.4 billion) was sourced from abroad and 4 percent was sourced by government .[8]

The share of civilian R&D performed in Israel by the business-enterprise sector (80 percent) is high by international standards, as the next figure shows. In the past decade, few countries showed meaningful change in this indicator.

[8] For the indicator of GERD sourcing, data in current prices exist only up to 2009; therefore, the comparison is performed in these units.

Figure 2.7: GERD Performance by Business-Enterprise Sector, Israel and Selected Countries, Pct., 2000–2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Israel	76.8	77.3	76.1	74.4	75.8	77.7	78.1	80.8	79.6	79.7	79.3
Korea	74.0	76.2	74.9	76.1	76.7	76.9	77.3	76.2	75.4	74.3	74.8
Finland	70.9	71.1	69.9	70.5	70.1	70.8	71.3	72.3	74.3	71.4	69.6
Sweden		77.5		74.4	73.5	72.7	74.7	72.7	74.1	70.4	68.7
United States	74.6	72.6	70.0	69.3	69.4	69.4	70.6	71.3	72.0	70.3	
Germany	70.3	69.9	69.2	69.7	69.8	69.3	70.0	70.0	69.2	67.6	67.2
Belgium	72.3	73.0	70.4	69.7	69.1	68.0	69.3	69.5	68.3	66.3	66.3
Ireland	71.6	70.1	68.8	67.5	65.7	65.5	66.1	65.9	64.5	65.8	66.6
Singapore	62.0	63.3	61.4	60.8	63.8	66.2	65.7	66.8	71.8	61.6	60.8
EU27	63.7	63.6	62.9	62.7	62.7	62.4	62.9	63.0	62.7	61.0	60.8
United Kingdom	65.0	65.5	64.8	63.7	62.6	61.4	61.7	62.5	62.0	60.4	60.9
Canada	60.3	61.7	57.6	57.1	56.8	55.8	56.7	55.8	53.8	51.3	50.8

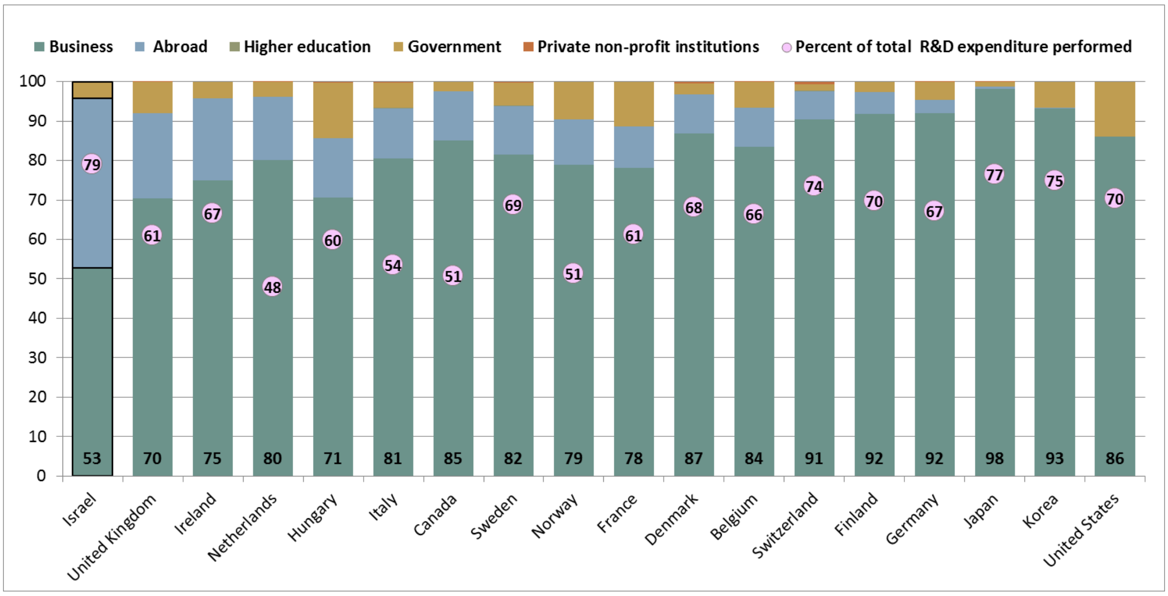
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The method used to calculate GERD sourced by the business-enterprise sector has been revised: sourcing by multinational firms is now included in sourcing from abroad[9]. R&D by ordinary multinational firms in Israel is classified as being sourced by the business-enterprise sector unless it was commissioned and sourced by the parent company. Since all activity at the R&D centers is commissioned and financed by the parent company, it is charged to sourcing from abroad. The next figure shows the distribution of the sourcing of BERD. In Israel, the proportion of BERD sourced by foreign firms is very high by international standards.

Israel is different in the distribution of sourcing: 43.0 percent of BERD is sourced by its business-enterprise sector, low by international standards. In contrast, 52.7 percent is sourced from abroad, the highest rate among the countries listed in the figure. Some 4.3 percent of business R&D is sourced by government, a paltry share relative to countries such as France (11.3 percent), Norway (8.9 percent), and the UK (6.6 percent).

[9] Notably, the data presented here are different from those in previous publications due to last-minute updates.

Figure 2.8: Distribution of Sources for BERD[10] Performed by Business-Enterprise Sector, 2009 (Pct.)

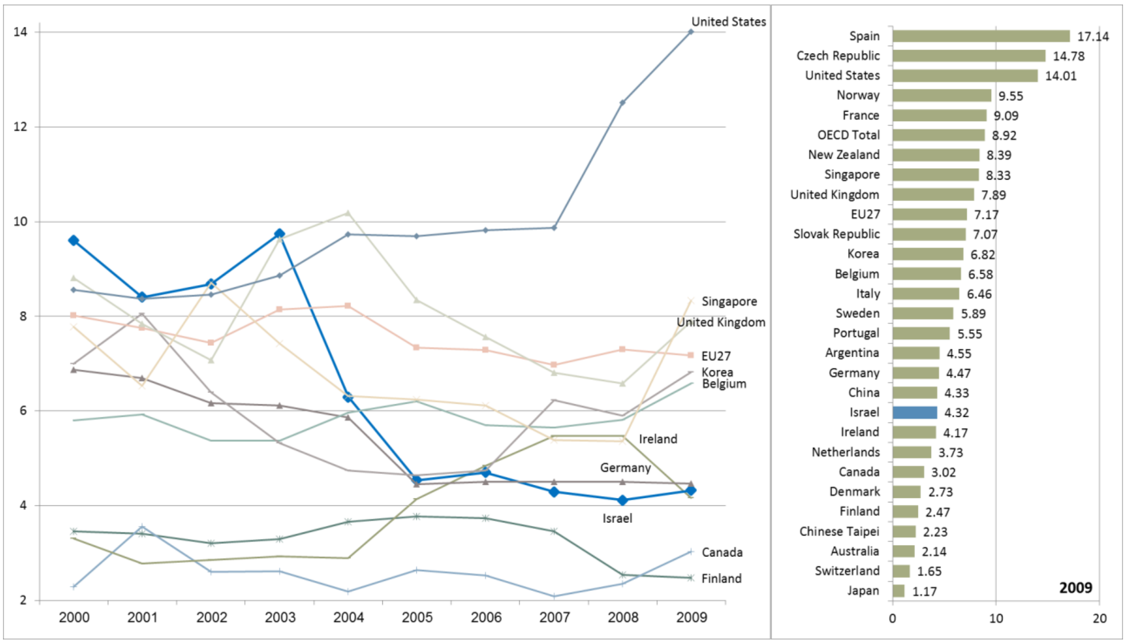


Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

In a knowledge-based economy, relations between the business-enterprise sector and other sectors—e.g., government sourcing of BERD and business-sector sourcing of HERD (higher-education R&D)—are important. In the past decade, the Israeli business-enterprise sector has enjoyed lavish government support, particularly via the R&D encouragement programs of the Chief Scientist of the Ministry of Industry and Trade (OCS). (See Subsection 2.3.2, "State Budget Support for R&D.") The next figure presents the share of direct government sourcing (excluding tax benefits) for BERD in Israel by cross-country comparison. Included in government transfers to the business-enterprise sector are direct and gross support only. Indirect support, such as tax breaks or recognition of accelerated depreciation is not included even though it is quite meaningful in certain countries. From 2003 to 2005, this indicator declined steeply (partly due to a cutback in the OCS budget). From 2005 onward, the indicator was basically unchanged. By cross-country comparison for 2009, Israel ranked below countries such as Spain, the Czech Republic, the U.S., and Norway, and resembled Germany, Ireland, and Canada. As stated, the indicator for Israel does not include national defense R&D expenditure. The U.S., the UK, and France have high proportions of defense R&D and include them in their GERD data.

[10] BERD = Business-enterprise sector Expenditure on Research and Development.

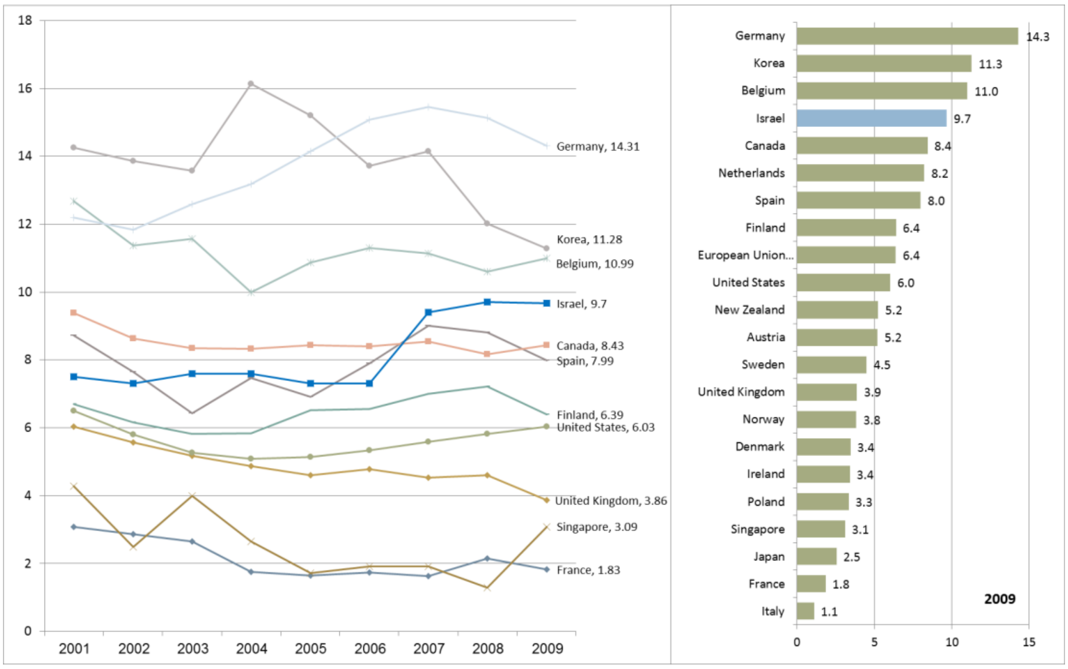
Figure 2.9: Government Sourcing of R&D Performed by Business-Enterprise Sector, 2000–2009



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The share of university R&D sourced by business allows us to estimate the extent of cooperation between these sectors. In 2009, 9.7 percent of business-sourced R&D was performed by higher-education institutes was. This metric was largely unchanged in 2001–2006 but posted a hefty 33 percent increase over 2006 in 2007, improving Israel's situation by cross-country comparison. The leading countries in this indicator are Germany (14.3 percent), South Korea (11.3 percent), and Belgium (11 percent).

Figure 2.10: Share of R&D Performed by Higher Education and Sourced by Business-Enterprise Sector, 2000–2009



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

2.2.2 Segmentation of BERD by Main Branches and Technology Intensivity

Thus far, we have related to BERD in the aggregate. For policy purposes, however, its segmentation among industries should also be analyzed. CBS (using the 1993 International Standard Industrial Classification) parses national R&D expenditure into four main branches: manufacturing; R&D, computer, and related services; financial services; and other, as specified below[11]:

- **Manufacturing** (Divisions 13–39) includes all manufacturing establishments that employ five persons or more. Within manufacturing, there is segmentation by sub-industries and 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[12] firms, and technological incubators.

Until the 1990s, most BERD focused on manufacturing industries, economic industries that produce goods sold in Israel and abroad, such as plastics, chemical

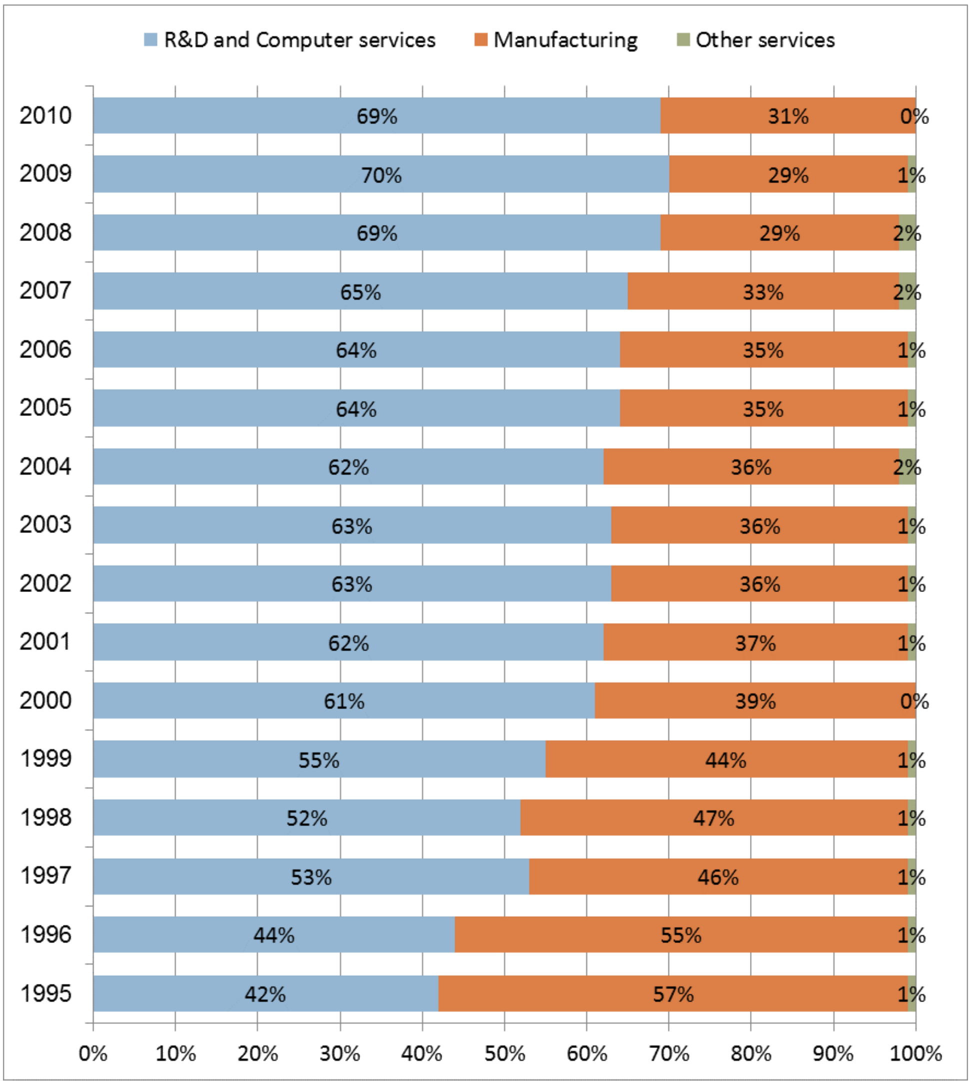
[11] In November 2012, CBS published a new Standard Industrial Classification. The data in this publication are based on the 1993 classification.

[12] 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.

products, and electronic communication equipment. In the past two decades, BERD has been trending up, as the next figure shows. The epicenter of this activity has shifted from manufacturing industries to service industries, with emphasis on two types of business services—computer services (Division 72) and research and development (Division 73). In Israel, as stated, BERD as a percent of GDP is very high by international standards and the software and R&D industry accounts for most of it.

Most BERD is performed by the manufacturing, software, and R&D divisions. (The Financial Services and Other Services divisions account for less than 2 percent and are not presented here for this reason.) In 2010, BERD was NIS 28 billion, distributed across manufacturing (31.6 percent), R&D (39 percent), and computer services (29 percent). This distribution was largely constant between 2000 and 2010. Most manufacturing R&D takes place in high-tech industries

Figure 2.11: BERD by Main Branches, 1995–2010

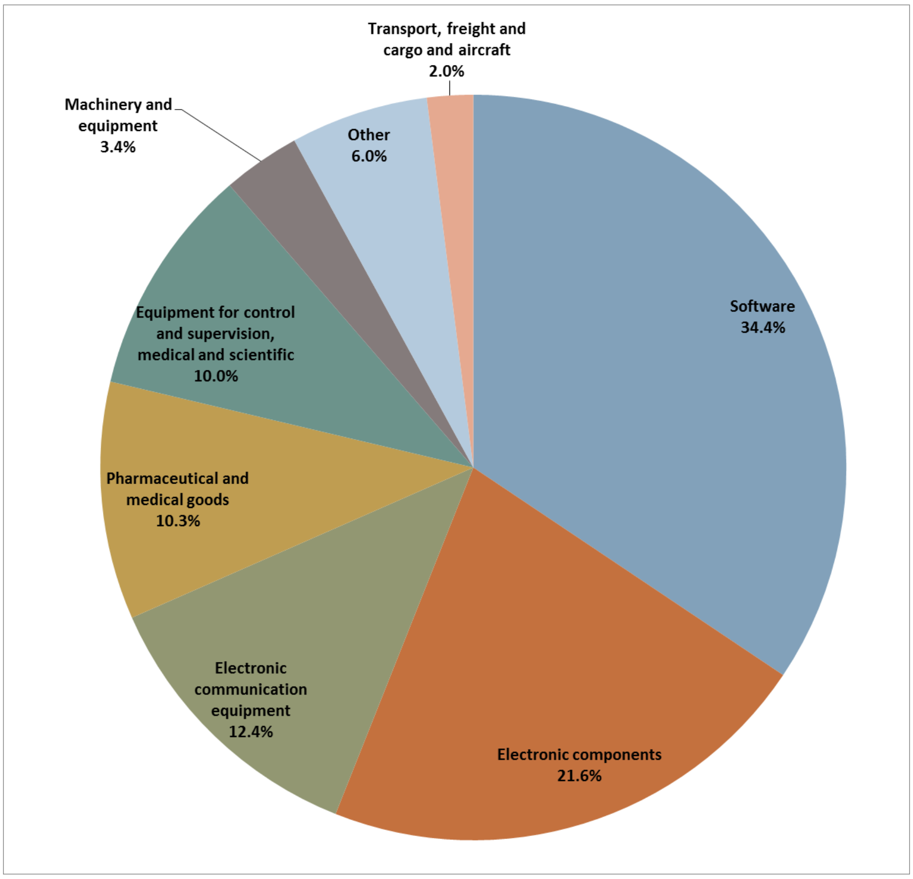


Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

In a survey on BERD in 2010, CBS asked establishments and firms, for the first time, to segment their current R&D expenditure by areas of activity such as software, pharmaceuticals, and electronic components. These data are important because firms in a given industry may perform R&D in other fields as well and because, in Israel, firms in the R&D industry engage in activity in different fields. The next figure parses current BERD by areas of activity.

Here again, the concentration of R&D investment in software is evident. The data show that this field accounts for 34.4 percent of total BERD, followed by computer services (identified with the software field) at 27.1 percent.

Figure 2.12: BERD by Area of Activity, 2010



Note: The data do not include buildings-and-equipment investments for R&D.
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

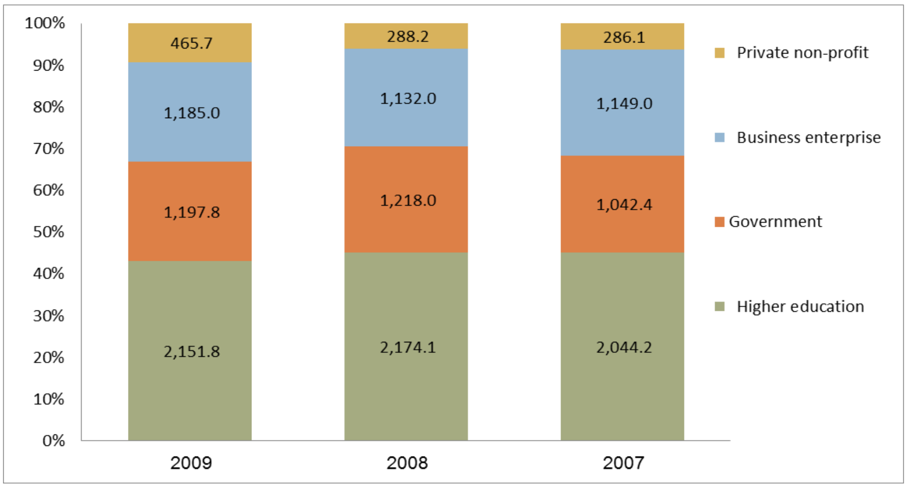
For an additional breakdown of BERD by industries, see Chapter 7, "R&D and Innovation according to Selected Industries and Research Institutes."

2.3 The Government Sector

Government support of R&D includes R&D performance and sourcing in areas for which the government is responsible. The implementation of support programs for R&D, technological development, and scientific research is part of government policy for the promotion of Israel's future in a welter of fields: the economy, manufacturing, services, social affairs, the environment, healthcare, etc.

Government (comprising central government offices, public nonprofit organizations, municipal authorities, and national institutions) performed 3.7 percent of GERD and sourced 15 percent in 2009. Again, these figures relate only to civilian R&D; the large-scale defense R&D that the government sources and performs is not included in this document. The next figure shows the sectoring of government sourcing: 42 percent to the higher-education sector, 24 percent to the business-enterprise sector, 24 percent to the government sector, and 9 percent to private nonprofits.

Figure 2.13: Sectorial Distribution of Government Sourcing of R&D (mNIS, Current Prices), 2007–2009

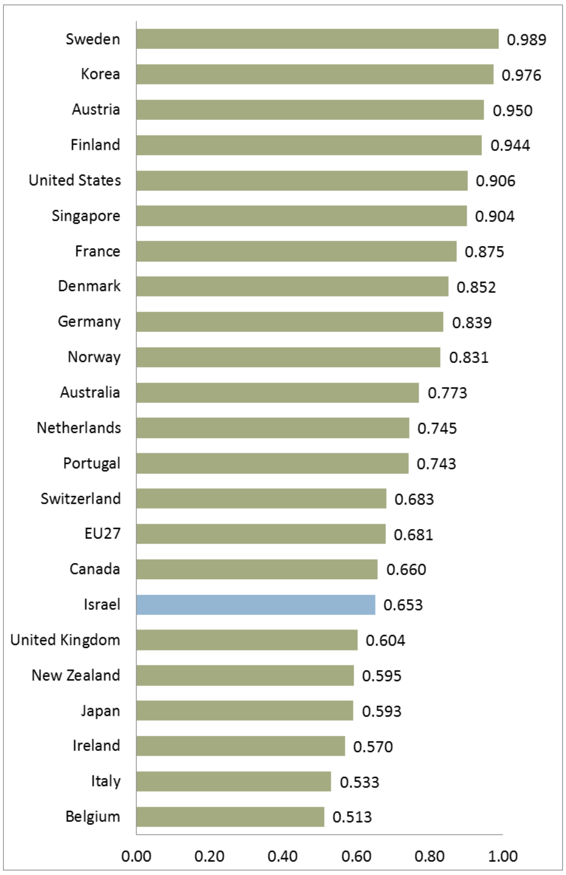


Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

An accepted comparative indicator for the extent of government sourcing of R&D is the share of GOVERD (government GERD) in GDP, otherwise known as the intensity of government R&D. In Israel, GOVERD includes the PGC budget, which represents government expenditure on research at institutes of higher education. [13]

[13] The PGC (the Planning and Grants Committee of the Council for Higher Education) is in charge of apportioning state budget funds for higher education among the universities and colleges that operate in Israel.

Figure 2.14: Government Sourcing of R&D as Pct. of GDP, Cross-Country Comparison, 2009



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

Now we observe the distribution of government R&D subsidies by fields. Using the updated 2002 Standard Classification of the Frascati Manual,[14] we segment GOVERD by thirteen objectives that they are meant to attain:

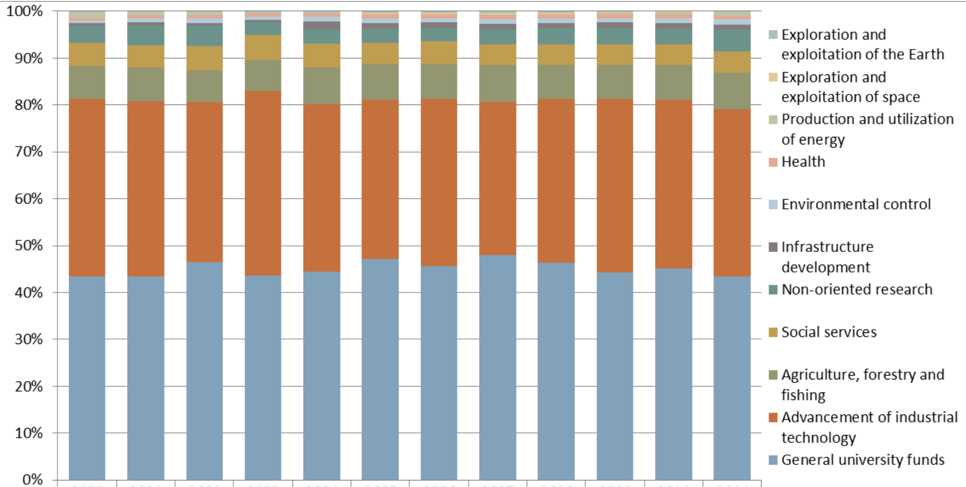
1. **Exploration and exploitation of the earth**—includes hydrology, oceanic, geologic, and atmospheric studies; also includes meteorological research (apart from that performed by satellite).
2. **Infrastructure and general planning of land use**—includes R&D for research on infrastructures and urban 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.

[14] 2002 Frascati Manual, OECD, pp. 144–147.

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.
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.

Figure 2.15: Government Funding of Civilian R&D, by Objectives, as Pct. of Total GOVERD, 2000–2010



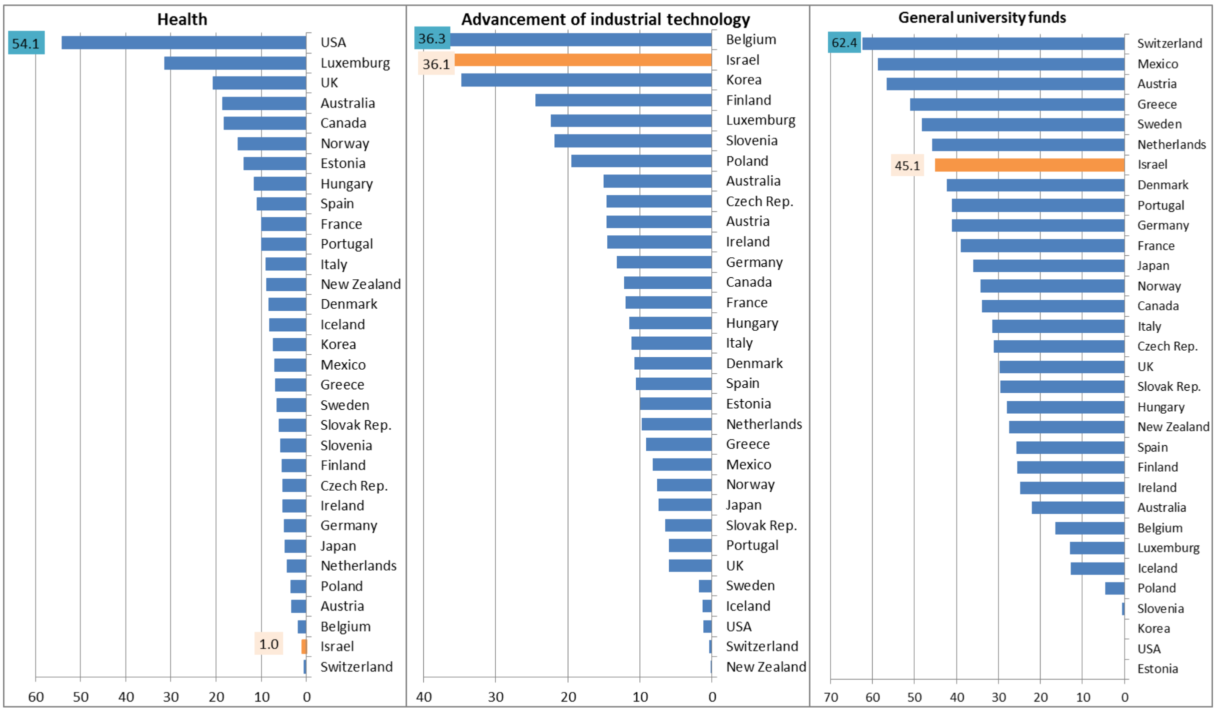
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Exploration and exploitation of the Earth	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.2	0	0.0
Exploration and exploitation of space	0.1	0.1	0.1	0	0	0.3	0.2	0.3	0.3	0.2	0.2	0.0
Production and utilization of energy	1.0	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.4	1.0
Health	0.5	0.7	0.7	0.6	0.8	0.8	0.8	0.9	0.9	0.9	1.0	0.7
Environmental control	0.5	0.9	1.0	0.8	1.0	1.0	0.9	1.0	0.9	0.9	1.0	1.1
Infrastructure development	0.5	0.7	0.5	0.5	1.7	1.2	1.1	1.1	1.1	1.2	1.1	1.0
Non-oriented research	3.8	4.1	4.5	2.7	3.0	3.1	2.9	3.2	3.4	3.4	3.4	4.8
Social services	4.8	4.8	5.2	5.4	5.1	4.4	4.9	4.5	4.4	4.4	4.3	4.6
Agriculture, forestry and fishing	7.1	7.2	6.6	6.5	7.8	7.6	7.4	7.9	7.3	7.3	7.4	7.7
Advancement of industrial technology	37.9	37.4	34.2	39.4	35.7	34.0	35.6	32.6	34.9	37.0	36.1	35.6
General university funds	43.4	43.4	46.5	43.6	44.5	47.2	45.7	48.0	46.4	44.3	45.1	43.5

Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

Figure 2.15 shows distribution of GOVERD in Israel by objectives in 2000–2010 (excluding defense R&D). Most GOVERD over the years has been earmarked for research at universities via PGC (45.1 percent in 2010) and the advancement of industrial technologies (36.1 percent in 2010). The share of expenditure on healthcare and the environment doubled in the past decade but remains less than 1 percent of total GOVERD.

By cross-country comparison, Israel is unique among OECD countries in its segmentation of government support. Figure 2.16 compares Israel with various countries in government support of R&D for several objectives in 2010. Israel's government is among the most lavish supporters of industrial R&D at 36.1 percent, exceeded only by Belgium at 36.3 percent. Other OECD countries that resemble Israel in size pledged smaller shares of their budgets to this purpose in 2010: Finland 24.5 percent, the Netherlands 9.8 percent, and Sweden 1.8 percent.

Figure 2.16: Government Support of R&D in OECD Countries, by Selected Objectives, 2010



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

Israel also has one of the largest shares of transfers to university research among OECD members—lower than Switzerland (62.4 percent in 2010), Sweden (48.3 percent), and the Netherlands (45.8 percent) but higher than Finland (25.5 percent), Ireland (24.9 percent), Belgium (16.5 percent) and even G-7 countries such as Germany (41.1 percent), Japan (36.0 percent), and the UK (29.8 percent).

Israel ranks at the bottom in government support of research in healthcare, environmental quality, and infrastructure development. In 2010, 1.0 percent of the total R&D promotion budget was referred to healthcare, as against 4.2 percent in the Netherlands, 5.4 percent in Finland, 6.5 percent in Sweden, and 54.1 percent in the U.S.

The distribution of government support for R&D in Israel is typified by acute concentration. In 2010, the two main areas of activity in Israel accounted together for 81.2 percent of total support. Only Switzerland had a more concentrated distribution, 90.0 percent of its support funds accruing to the two largest objectives (transfers to universities at 62.4 percent and non-oriented research at 27.6 percent). Among other countries, rates of 76.3 percent (Sweden), 65.7 percent (the Netherlands), 60.5 percent (Belgium), and 50.0 percent (Finland) were found.

2.3.1 <u>Governmental Aid for Civilian R&D in Science and Technology</u>

Government policy may have a very significant affect on the development of R&D. The effect may be positive, promoting domestic R&D, or negative, thwarting the development of new directions in research or preserving firms and industries that make submaximal contributions to the economy. Hence the importance of tracking government aid for science, technology, and innovation in any analysis of R&D trends.

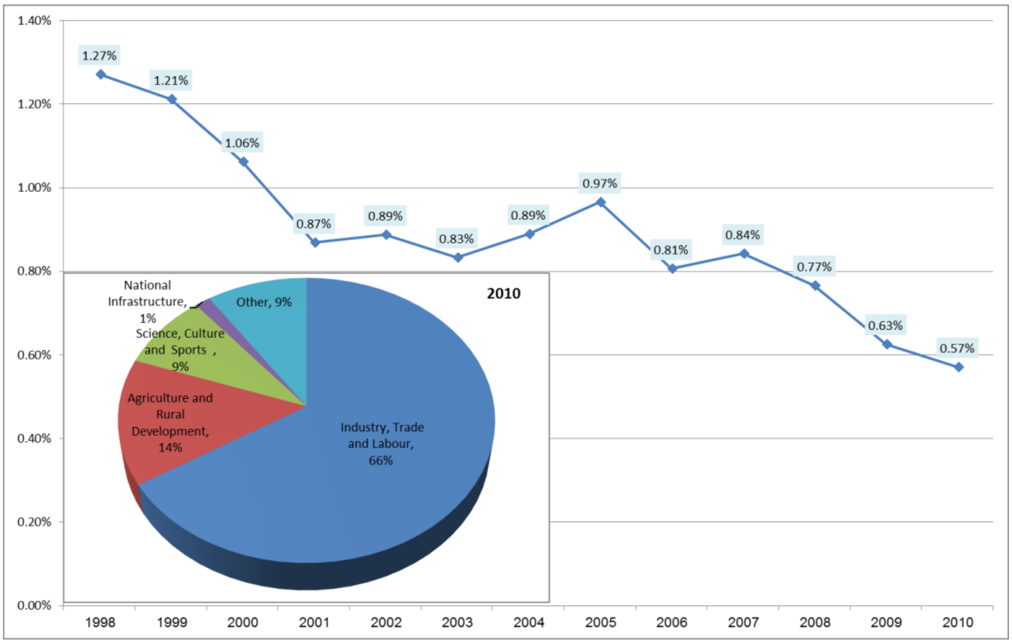
In Israel, the government supports and promotes R&D in several ways: direct support of R&D projects via OCS, sourcing of R&D for government purposes at academic and business research institutes, and tax benefits for recognized R&D expenditure under the Encouragement of Industrial Research and Development Law. This section presents data for only some of these tracks because full statistical data for the others are lacking.

2.3.2 State Budget Support for R&D

One of the main vehicles of R&D support is direct budget subventioning of R&D activities performed or commissioned by various government offices. The figure below presents this support as a percent of the state budget in 1998–2010. During this time, as the figure shows, the share of government support via the state budget contracted almost every year.

Importantly, these sums do not include transfers to PGC. As Figure 2.17 shows, around two-thirds of the total state budget allocation to government offices for the encouragement of R&D in 2010 accrued to the Ministry of Industry and Trade; the rate of allocation was similar in other years. This is because OCS, part of the Ministry of Industry and Trade, is the main implementer of government policy in this field under the Encouragement of Industrial Research and Development Law.

Figure 2.17: Government Support of R&D as Pct. of State Budget (in Small Graph: Distribution by Ministry, 2010)

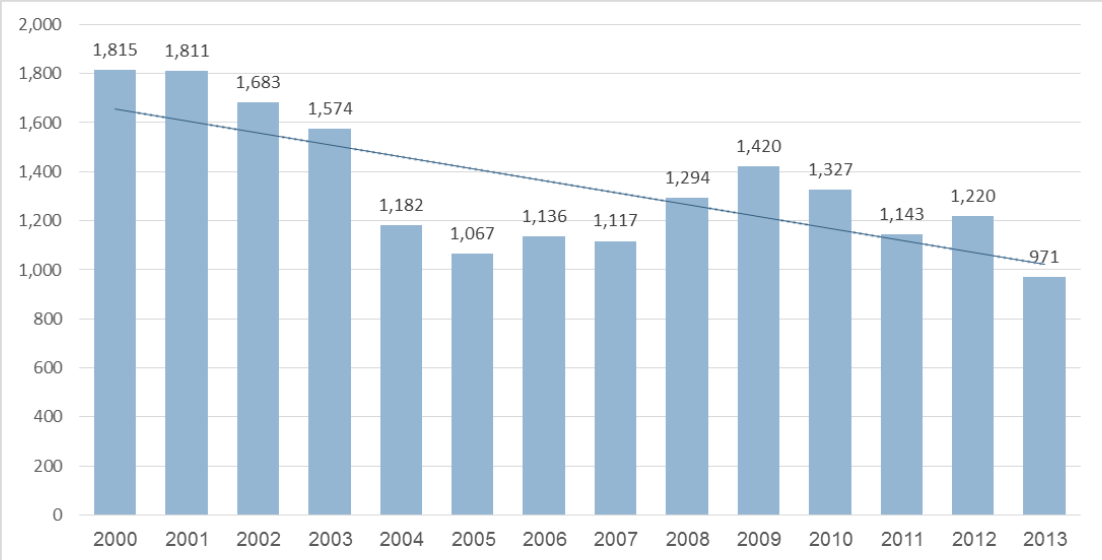


Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

2.3.3 Chief Scientist of the Ministry of Industry and Trade (OCS)

Grants from OCS are one of the main vehicles of government support for R&D. In the past decade, however, this kind of support has been contracting both in scale (Figure 2.17) and in share of the state budget. Summary reports on OCS activity show that OCS received 0.8 percent of the total state budget in 2000 and less, 0.4 percent, in 2011.

Figure 2.18: R&D Budgets for All OCS Support Programs (mNIS, 2011 prices)

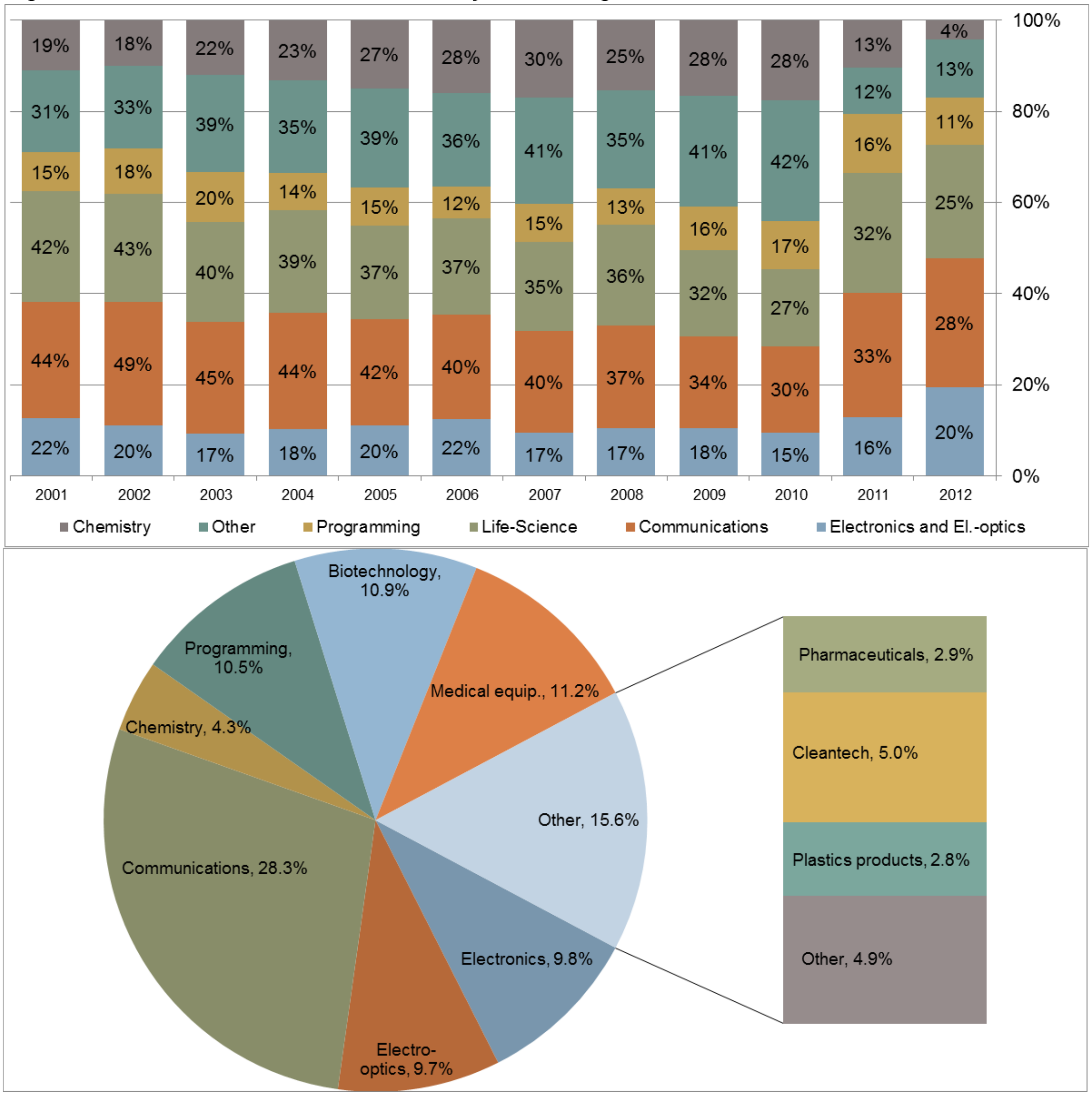


Source: Summary Report of the Chief Scientist Activity[15]

Communications R&D is the area of activity that receives the most support from OCS. However, the share of support for research in this field has been trending down in the past decade—from 40 percent of grant value in 2002 to 28 percent in 2011. Grants for electronics and electro-optics R&D have also been contracting—from 20 percent in 2002 (22 percent in 2001) to 16 percent in 2011. Conversely, the share of support for life-science research has been rising, from 18 percent in 2002 to 26 percent in 2011 (Figure 2.18). Several programs for the promotion of research in these fields (e.g., NOFAR) have been launched during these years.

[15] R&D support programs, Office of the Chief Scientist, Ministry of Industry, 2011-2012 http://www.moital.gov.il/NR/rdonlyres/0BA7755A-4F76-4520-9A67-A4216C30E071/0/mopspreads.pdf

Figure 2.19: Distribution of OCS Grants by Technological Classification



Source: Summary Report of the Chief Scientist Activity

In recent years, the distribution of R&D fund grants relative to the subventioned firms' sales turnover has changed in certain ways. The share of firms that reported sales of up to $1 million, high to begin with, rose from 46 percent in 2005 to 52 percent in 2011. Notably, this share peaked at 61 percent in 2008; the subsequent decline evidently traces to the severe effects of the 2009 global crisis on small startup companies that specialize in research. (See elaboration in Chapter 3.) Among larger firms (those with sales turnover up to $20 million), the direction of the rate of support turned around—from decline in 2005–2008 (from 20 percent to 11 percent) to acceleration in 2009 (to 21 percent).

Table 2.3: Distribution of Research Fund Grants by Recipient Firms' Sales Turnover, Pct.

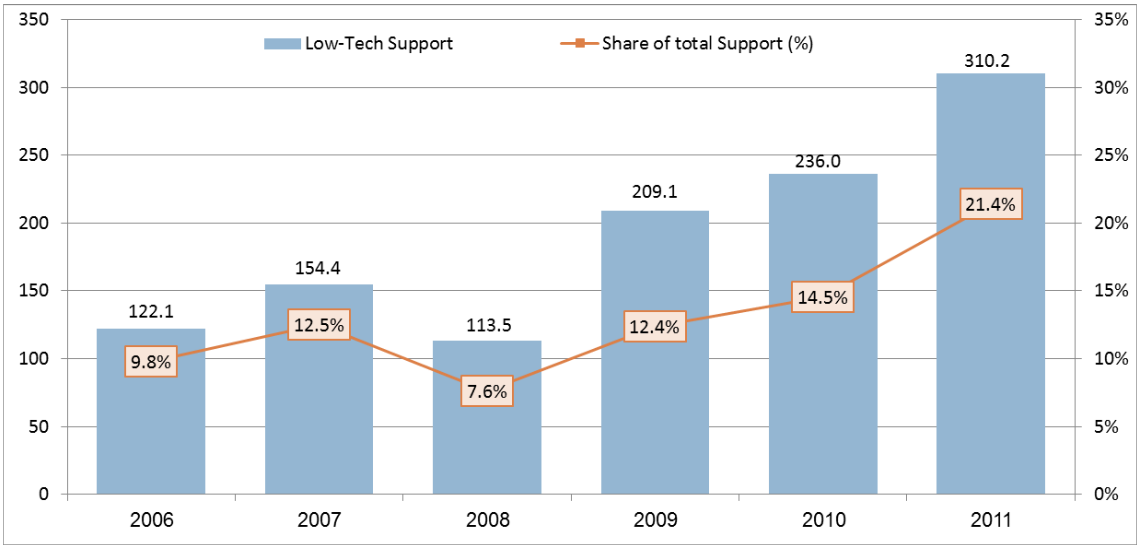
	2005	2006	2007	2008	2009	2010	2011
< USD 1 million	46%	47%	51%	61%	54%	52%	52%
USD 1 million–USD 20 million	20%	17%	15%	11%	21%	19%	17%
USD 20 million–USD 70 million	8%	10%	12%	10%	7%	10%	11%
USD 70 million–USD 100 million	4%	1%	1%	2%	2%	2%	3%
> USD 100 million	22%	25%	21%	16%	16%	17%	17%

Source: Summary Report of the Chief Scientist Activity

Table 2.3, itemizing these changes, also shows a steady decrease in the share of support for research performed by large firms (those with more than $100 million in annual sales)—from 22 percent in 2005 to 17 percent in 2011. This may be another indication of the contraction of R&D performance by large manufacturing firms.

In recent years, OCS has been encouraging companies in low-tech (traditional) industries to engage in technological R&D. In 2008, for example, such firms received NIS 113.5 million (7.6 percent of total support); by 2011, the sum nearly tripled—to NIS 310.2 million, 21.4 percent of the total budget.

Figure 2.20: OCS Support for Low-Tech Industries (Pct. and mNIS)



Source: Summary Report of the Chief Scientist Activity

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 performing 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 source 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 GOVERD. Some university research is also sourced by government offices, nonprofits, abroad, and national and binational foundations such as the BIRD (Israel-U.S. Binational Industrial Research and Development) Foundation (which is largely government-funded.)

The table below shows the scale and distribution of sources that accrued to universities for R&D expenditure. Notably, R&D sourcing is an integral part of research universities' activities; in budget terms, it is inseparable from the sourcing of teaching activity. In other words, the budget that PGC distributes among the universities is global; there is no separate earmarking of funds for research. To evaluate HERD (higher-education GERD), CBS estimates the extent of the university's current budget dedicated to R&D and adds earmarked R&D funds to it. This estimate appears in a separate column in the table, the one that includes government financing of R&D via PGC. Also, as the Frascati Manual recommends, university tuition fees and donations not earmarked for specific studies are considered universities' own sources and appear in the Higher Education column of the table.

Subchapter 6.6 presents additional data on special sourcing of university R&D.

Table 2.4: Sourcing of HERD, 1995–2009 (mNIS, Current Prices)

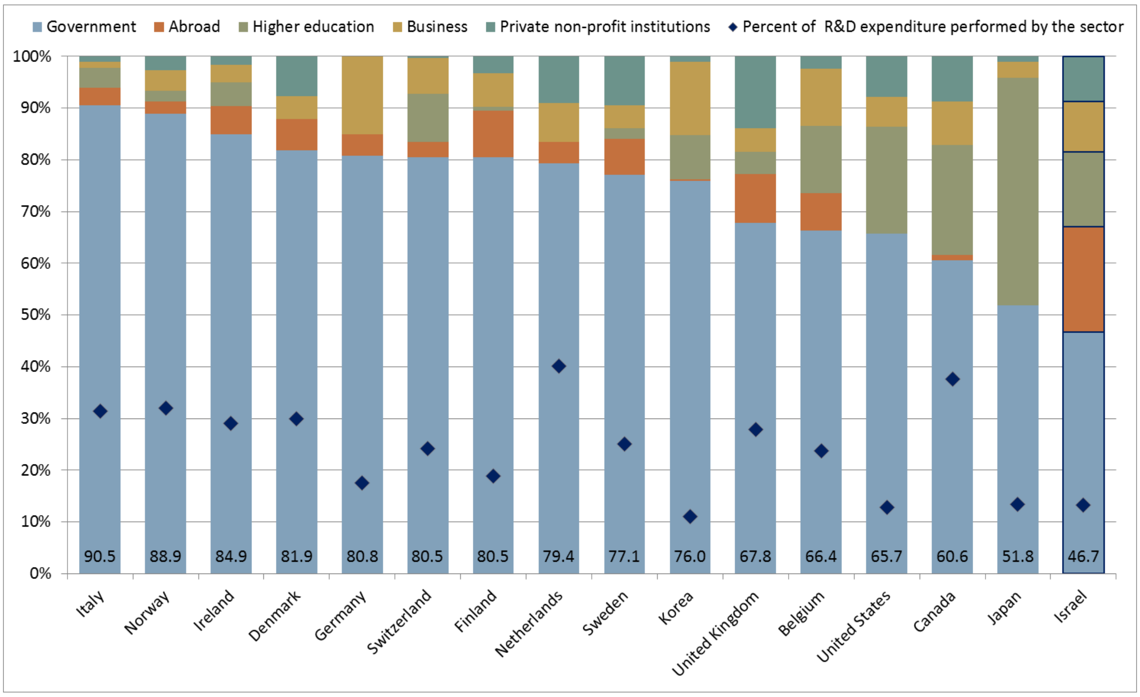
	Total		**Business**		**Government**		**:Thereof through general univ. funds**		**Higher education**		**non- Private profit**		**Abroad**	
	mNIS	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**	**mNIS**	**%**
1995	**1,900**	100%	43	2.3%	899	47.3%	747	39.3%	565	29.7%	111	5.9%	282	14.8%
1996	**2,223**	100%	91	4.1%	1,218	54.8%	1,026	46.2%	422	19.0%	104	4.7%	389	17.5%
1997	**2,539**	100%	110	4.3%	1,358	53.5%	1,187	46.7%	537	21.1%	114	4.5%	420	16.5%
1998	**2,772**	100%	100	3.6%	1,568	56.6%	1,325	47.8%	687	24.8%	73	2.6%	344	12.4%
1999	**3,209**	100%	132	4.1%	2,166	67.5%	1,437	44.8%	391	12.2%	93	2.9%	427	13.3%
2000	**3,302**	100%	122	3.7%	2,235	67.7%	1,558	47.2%	429	13.0%	93	2.8%	423	12.8%
2001	**3,497**	100%	170	4.9%	2,137	61.1%	1,850	52.9%	541	15.5%	116	3.3%	533	15.2%
2002	**3,820**	100%	187	4.9%	2,330	61.0%	1,924	50.4%	592	15.5%	126	3.3%	585	15.3%
2003	**3,935**	100%	298	7.6%	2,157	54.8%	1,882	47.8%	666	16.9%	256	6.5%	558	14.2%
2004	**3,718**	100%	283	7.6%	2,072	55.7%	1,794	48.3%	593	15.9%	242	6.5%	528	14.2%
2005	**3,830**	100%	279	7.3%	2,028	52.9%	1,771	46.3%	670	17.5%	333	8.7%	521	13.6%
2006	**3,852**	100%	280	7.3%	1,998	51.9%	1,728	44.9%	714	18.5%	335	8.7%	524	13.6%
2007	**4,205**	100%	394	9.4%	2,044	48.6%	1,798	42.8%	552	13.1%	366	8.7%	849	20.2%
2008	**4,656**	100%	450	9.7%	2,174	46.7%	1,924	41.3%	676	14.5%	405	8.7%	951	20.4%
2009	**4,502**	100%	435	9.7%	2,152	47.8%	1,906	42.3%	604	13.4%	392	8.7%	920	20.4%

Sources: Analysis of CBS data by Samuel Neaman Institute

Government sourced 42.3 percent of university R&D in 2009. This rate has been declining since 2001 (52.9 percent). In contrast, sourcing from abroad has been rising and comes to 20.4 percent. Sourcing from business has been unchanged at 9.7 percent in the past three years.

Government sourcing is very low in Israel (46.7 percent) relative to countries such as Norway (88.9 percent), Switzerland, and Finland (80.5 percent each). Sourcing from abroad in Israel, in contrast, is high by international standards. The share of business in sourcing HERD is a proxy for cooperation between the business-enterprise and higher-education sectors. This indicator has been rising in Israel recently. A thorough analysis of policies in S. Korea, Germany, and Belgium, where such cooperation is stronger, may be helpful in fashioning an appropriate policy for Israel.

Figure 2.21: Distribution of Higher Education Expenditure on R&D by funding sector (Pct.), 1995–2007

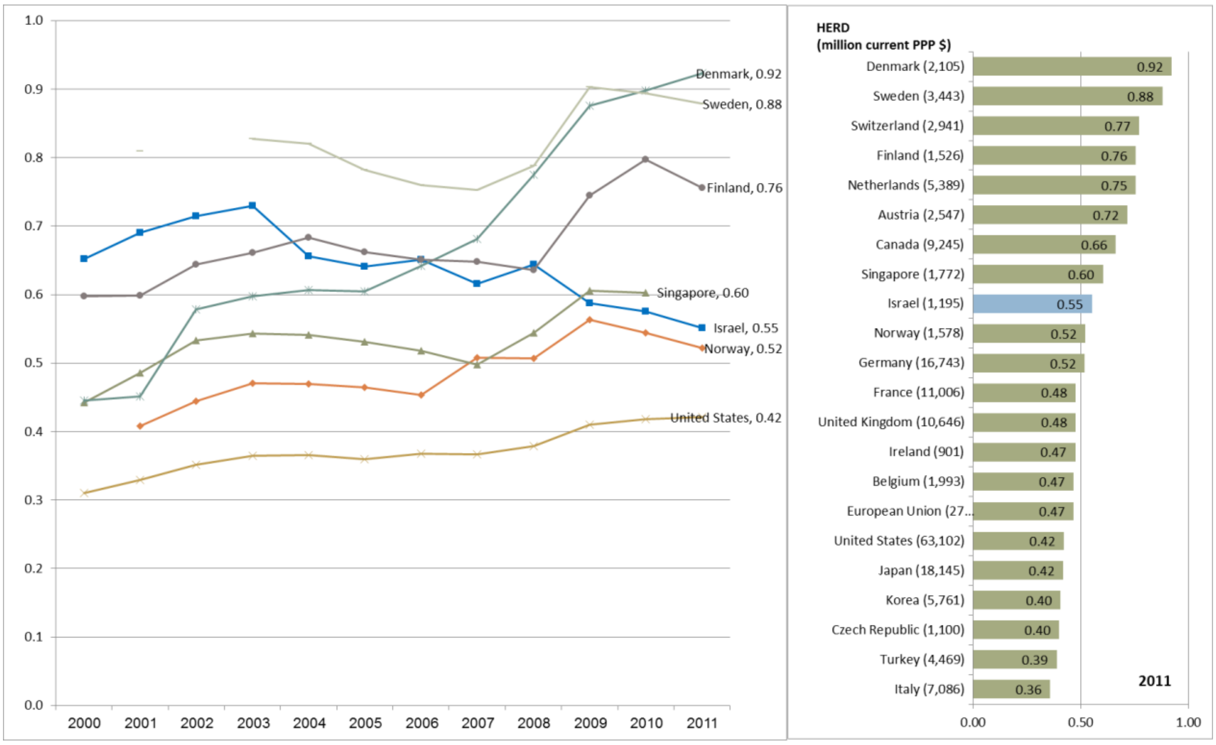


Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

HERD in 2011 was NIS 4,808 million in current prices. Its share in GERD has fallen considerably, from 28 percent in 1990 to 13 percent in 2011 (due to an increase in BERD) even though enrollment in masters and doctoral programs has doubled.

An accepted indicator in cross-country comparisons of R&D performance by higher education is HERD intensity, the share of higher-education R&D in GDP. In 2011, HERD intensity in Israel was 0.55 percent, down 20 percent from 2003. Comparison of Israel with selected countries shows that R&D intensity in Israel's higher-education system was relatively high until 2003, as noted above, but has been falling ever since. Concurrently, the rates in countries such as Denmark, Finland, the Netherlands, and Singapore have been rising vigorously in recent years. A broad cross-country comparison for 2011 found Israel (0.55 percent) below Denmark (0.92 percent), Sweden (0.88 percent), Switzerland (0.77 percent), Finland (0.76 percent), the Netherlands (0.75 percent), and Canada (0.66 percent).

Figure 2.22: HERD Intensity (HERD as Pct. of GDP), 2000–2011



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

3. Scientific and Technological Human Capital

- Forty-five percent of Israel's working-age population has tertiary schooling (2009), one of the highest rates among OECD countries.
- Eighty-two percent of Israelis who have higher education are employed. This places Israel in the bottom half of the standings, trailing countries such as Norway (90 percent), Switzerland (89 percent), and Sweden and the Netherlands (88 percent each).
- Fifty-six percent of Israeli twelfth-graders qualify for matriculation certificates; 46 percent satisfy university entrance requirements (2010). Fourteen percent took the five-credit matriculation exam in mathematics.
- In the international education tests, Israel achieved an impressive surge in the latest TIMSS exam in mathematics (2011), ranking seventh among forty-two countries (gaining seventeen places relative to the previous exam).
- In 2010, 25.5 percent of first-year degree students majored in science and technology; this rate has been trending downward since 2000 (37.1 percent).
- In 2008/09, 8,700 students earned first degrees in science and engineering—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 comprises 9,740 persons at universities and 3,530 at colleges (2010/11), almost unchanged in the past decade. The shortage of senior academic staff is growing as existing staff ages; the median age of rank-and-file professors is sixty-one.
- In Israel, 53,000 people hold R&D posts in the business-enterprise sector (2008); more than 60 percent of these jobs are in R&D and computer and related services.

Israel's pool of scientific and technological human capital is crucial for its R&D activity and definitive in cementing its standing in scientific research, a major engine of economic growth. The human-capital pool is composed of current human capital and a reserve in which the state invests, by providing education and higher schooling, to assure quality human capital in the future. Most basic research takes place in the higher-education system and is crucial for the development of the economy and tomorrow's research labor force. Israel's higher-education system is esteemed at home and abroad for its past achievements. Since it takes many years to observe changes in human capital, it is immensely important to track indicators of human-capital reserves so that Israel may remain at the cutting edge of knowledge and progress.

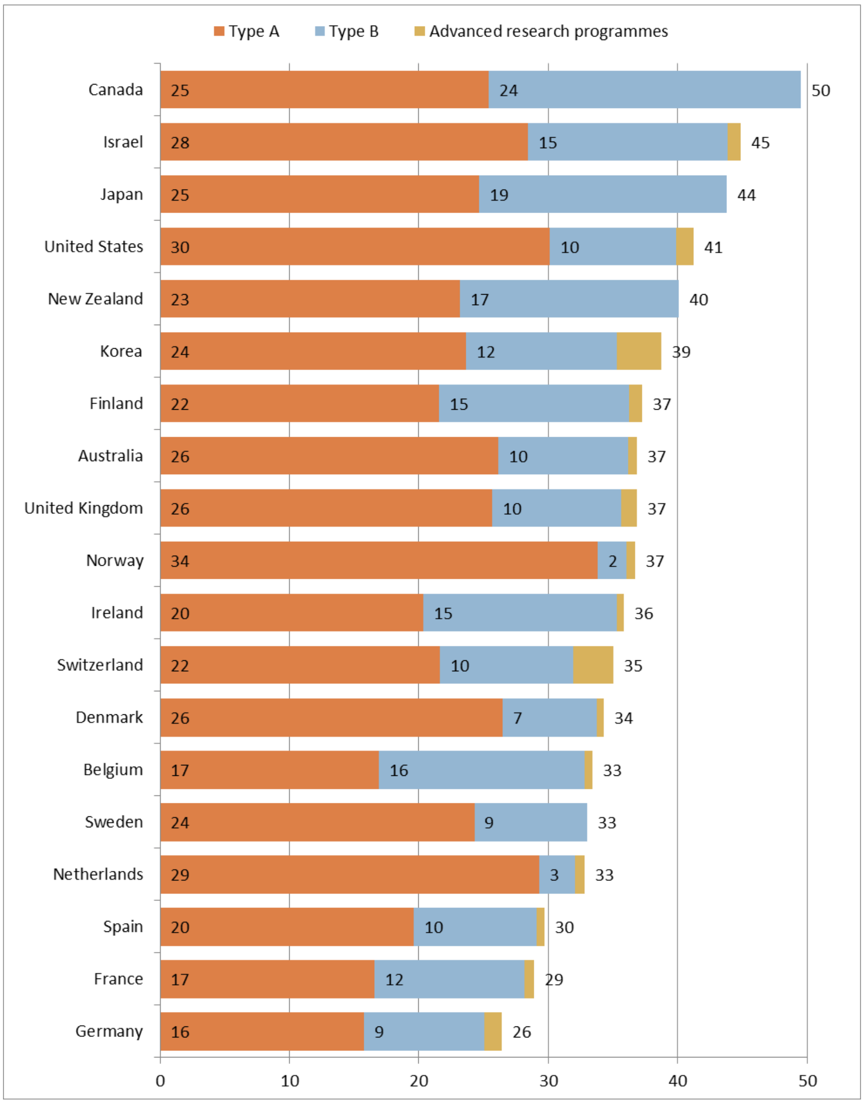
This chapter analyzes human capital indicators that lend themselves to cross-country comparison. Our previous report presented data on university graduates and persons employed in R&D, e.g., the number of researchers employed in the business-enterprise sector, university graduates in science and technology disciplines, 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 representing the reserve of scientific and technological personnel, data on science and technology studies in high school, the national level of science and mathematics studies as mirrored in international tests such as PISA and TIMSS, etc.

3.1 Aggregate View

An accepted indicator of the potential of a country's human capital is the level of schooling among its population at large. Figure 3.1 shows the proportion of the 25–64 age cohort that has tertiary (post-secondary or higher) schooling.[16] In Israel in 2009, 28 percent of the population had higher schooling, 15 percent had post-secondary schooling, and 1 percent held doctoral degrees. By cross-country comparison, Israel (45 percent) surpasses the U.S. (41 percent), Japan (44 percent), and Finland (37 percent). In the share of the relevant age group that has higher schooling, Israel (28 percent) resembles the U.S. (30 percent), the Netherlands (29 percent), Denmark (26 percent), Australia and the UK (26 percent each), and Norway (34 percent).

[16] Israel's post-secondary and higher education settings comprise 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.

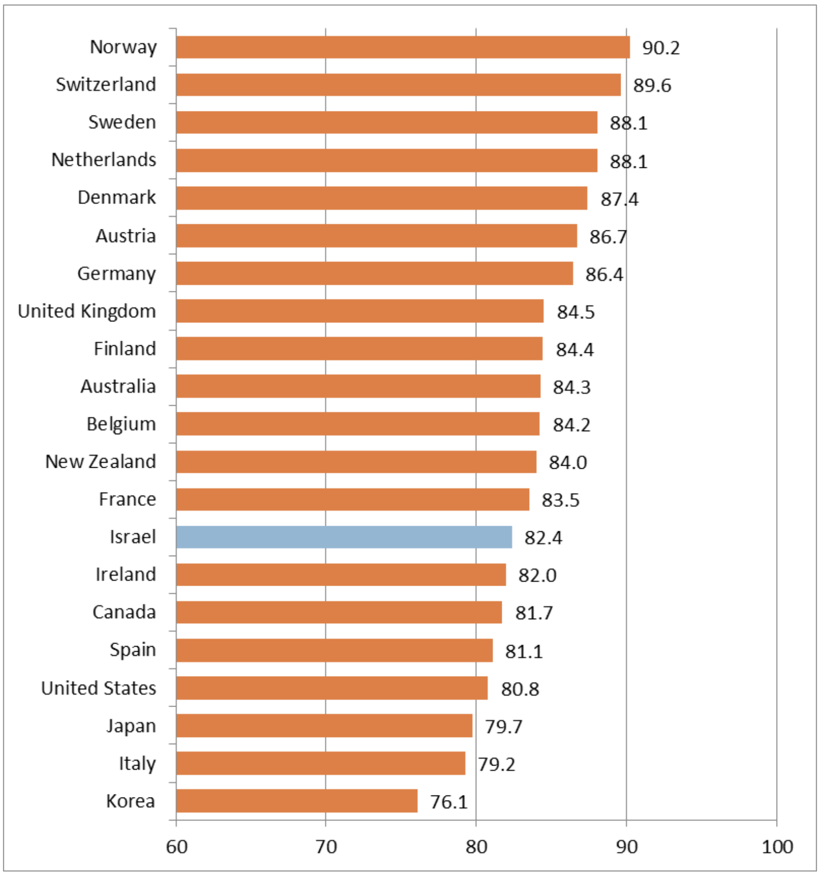
Figure 3.1: Tertiary Education (Type A+B) among Permanent Population Aged 25–64, 2009, Pct.



Notes: Tertiary-type A programs (ISCED 5A) are largely theory-based and are designed to provide sufficient qualifications for entry to advanced research programs and professions with high skill requirements, such as medicine, dentistry or architecture.
Tertiary-type B programs (ISCED 5B) are typically shorter than those of tertiary-type A and focus on practical, technical or occupational skills for direct entry into the labor market.
Source: Analysis of Education at a Glance: OECD indicators data by Samuel Neaman Institute

Schooling is usually considered a good form of "employment insurance." To determine whether the large size of Israel's well-educated labor force is reflected in its employment market, we need to compare Israel with other countries in terms of the employment rate of this population. In Israel, 82 percent of the highly schooled in the 25–64 age group are employed, lower than countries such as Norway (90 percent), Switzerland (89 percent), and Sweden and the Netherlands (88 percent each). The reason may be that some of Israel's highly schooled population originated in other countries (immigrants), possibly affecting employment in Israel.

Figure 3.2: Employment Rate among Persons Aged 25–64 with Higher Schooling, 2009 (Pct.)



Source: Analysis of Education at a Glance: OECD indicators data by Samuel Neaman Institute

3.2 Secondary Schooling

The education system is an essential player in preparing reserves for higher studies. Highly proficient pupils are enormously important because they will constitute the next generation in higher studies and in the country's scientific and technological development. A metric such as the proportion of pupils who qualify for matriculation certificates in the exact sciences (mathematics, physics, chemistry, etc.) may serve as a good proxy for highly proficient pupils who will take up positions in scientific and engineering occupations.

3.2.1 Eligibility for Matriculation Certificate

According to CBS data, 103,528 pupils attended twelfth grade in 2010, up 29 percent from 1996. Some 16.6 percent of all twelfth-graders did not take matriculation exams. Only 46 percent of the twelfth-graders earned matriculation certificates that met universities' threshold requirements (which 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 have not changed much since 2003, when 45.5 percent met the universities' threshold requirements. Notably, from 2001 onward, pupils have been able to take the math and English exams at "second chance" occasions. This explains the percent increase in eligibility for matriculation relative to 1996, when the share of those satisfying university threshold requirements was 40 percent.

Only some of those who meet university entrance requirements belong to the potential pool of students in science and technology because this group includes students who earn three credits in mathematics and, by and large, cannot be admitted to engineering and science programs. (See below for data on persons tested at an "intensified" level in individual scientific subjects and university requirements for technological subjects.) However, even students who fail to meet university entrance requirements may partake in higher studies at academic colleges, which have more relaxed entrance requirements. Such students may also make up the requirements later by taking missing matriculation exams and/or improving earlier scores. CBS data show that some 7,000 pupils—27 percent of those who took matriculation exams in 2002 and did not satisfy all requirements at the end of their studies—made up the missing exams in 2003–2010 by being re-examined and earned matriculation certificates. This boosted the share of matriculation eligibles in the 2011/12 graduating class by 10 percentage points.[17]

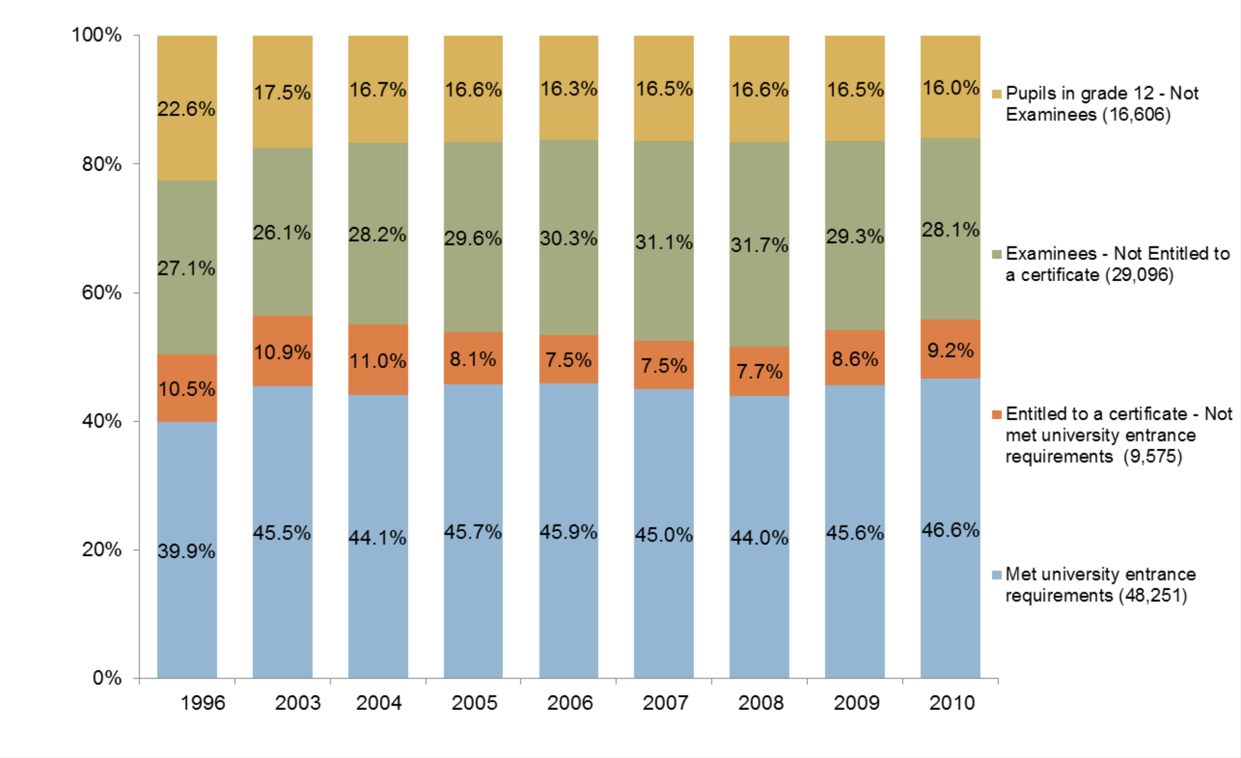
Table 3.1: Twelfth-Graders: Examinees and Eligibles for Matriculation Certificates Meeting University Entrance Requirements, 1996–2010

	Twelfth-grade students	**Examinees**		**Entitled to a certificate**		**Met university entrance requirements**	
		No.	**%**	**No.**	**%**	**No.**	**%**
1996	80,139	62,044	77.4%	40,340	50.3%	31,959	39.9%
2003	96,444	79,574	82.5%	54,378	56.4%	43,853	45.5%
2004	100,351	83,551	83.3%	55,249	55.1%	44,245	44.1%
2005	97,304	81,172	83.4%	52,383	53.8%	44,503	45.7%
2006	98,557	82,513	83.7%	52,650	53.4%	45,237	45.9%
2007	101,472	84,779	83.5%	53,250	52.5%	45,680	45.0%
2008	99,447	82,921	83.4%	51,381	51.7%	43,767	44.0%
2009	99,464	83,070	83.5%	53,913	54.2%	45,310	45.6%
2010	103,528	86,922	84.0%	57,826	55.9%	48,251	46.6%
growth rate 2010-1996	**29%**	**40%**		**43%**		**51%**	

Sources: Analysis of CBS data by Samuel Neaman Institute

[17] CBS press release, Sept. 5, 2011: "Around One-Fourth of Matriculation Examinees in 2002 Who Did Not Meet All Requirements at End of Studies Made Up Missing Exams by 2010." http://www.cbs.gov.il/reader/newhodaot/hodaa_template.html?hodaa=201106217

Figure 3.3: Pct. of Twelfth Graders Tested and Eligible for Matriculation Certificates Meeting University Entrance Requirements (in Parentheses: Number of Pupils by Category), 1996–2010

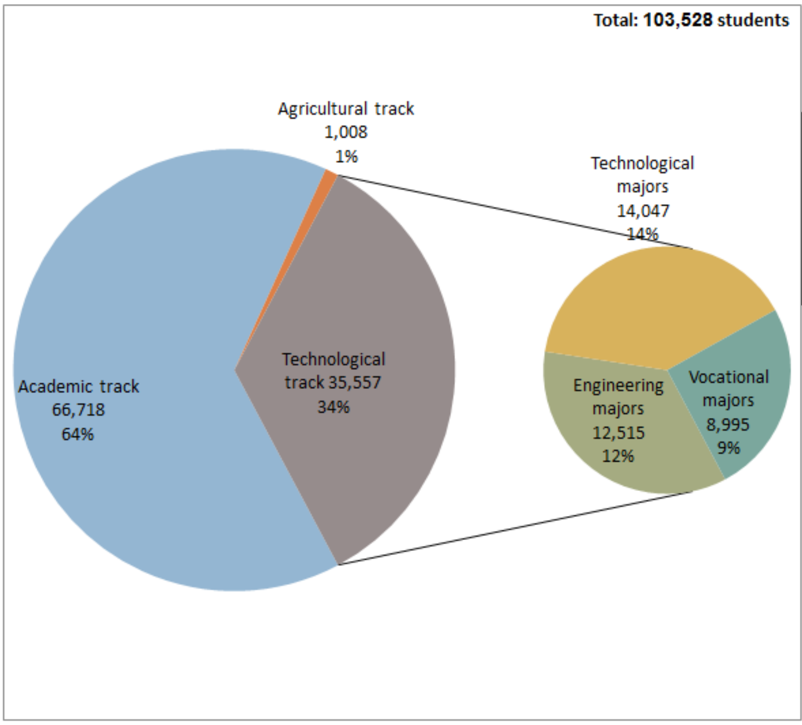


Sources: Analysis of CBS data by Samuel Neaman Institute

The Israeli education system has three tracks of study: academic, technological,[18] and agricultural. In the past, each track was clearly distinct from the other two. 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 had a strong scientific foundation. Vocational education focused on imparting technical skills and training for working life. Today, the concepts are somewhat blurred and may be used to describe similar systems. The next figure distributes pupils by tracks. Overall (all three tracks), the average rates of matriculation certificate eligibility and meeting university entrance requirements are 55 percent and 47 percent, respectively. In the technological track, 79.85 percent of those in engineering programs are entitled to matriculation certificates and 74 percent meet university entrance requirements.

[18] The technological track is comprised of 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, including business management, healthcare systems, education, tourism and leisure, lodging, etc.

Figure 3.4: Twelfth-Graders: Examinees and Eligible for Matriculation Certificates, by Track and Major, 2010



	Eligible for certificate	Met university entrance
	% of students	
Total *	**55.86%**	**46.61%**
Academic track	56.64%	48.07%
Agricultural track	54.76%	46.83%
Technological track	54.78%	44.17%
Engineering majors	79.85%	74.33%
Technological majors	45.58%	34.09%
Vocational majors	34.26%	17.94%

Note: * Total and also includes pupils with no defined track or not known track
Source: Analysis of CBS data by Samuel Neaman Institute

3.2.2 Matriculation by Subjects

Mathematics and English are required subjects for matriculation; the percent of examinees who take them has been high (85–95 percent) for years. Narrowing the inquiry to mathematics examinees at the five-credit level, on the assumption that this group represents the potential pool of future science and technology students, we find a very low proportion—only 14 percent in 2010, 2 percentage points lower than in 2008. The share of outstanding students (those scoring 85+) among those tested in mathematics at the five-credit level is even smaller, only 7.7 percent in 2010.

The proportion of matriculation examinees who take the exams in chemistry, physics, and biology is paltry: 10 percent, 14 percent, and 22 percent, respectively. Since these are elective subjects, most students who take them (79 percent of those in biology, 63 percent of those in physics, and 84 percent of those in chemistry in 2010) do so as “intensified” subjects and take the matriculation exams at the five-credit level.

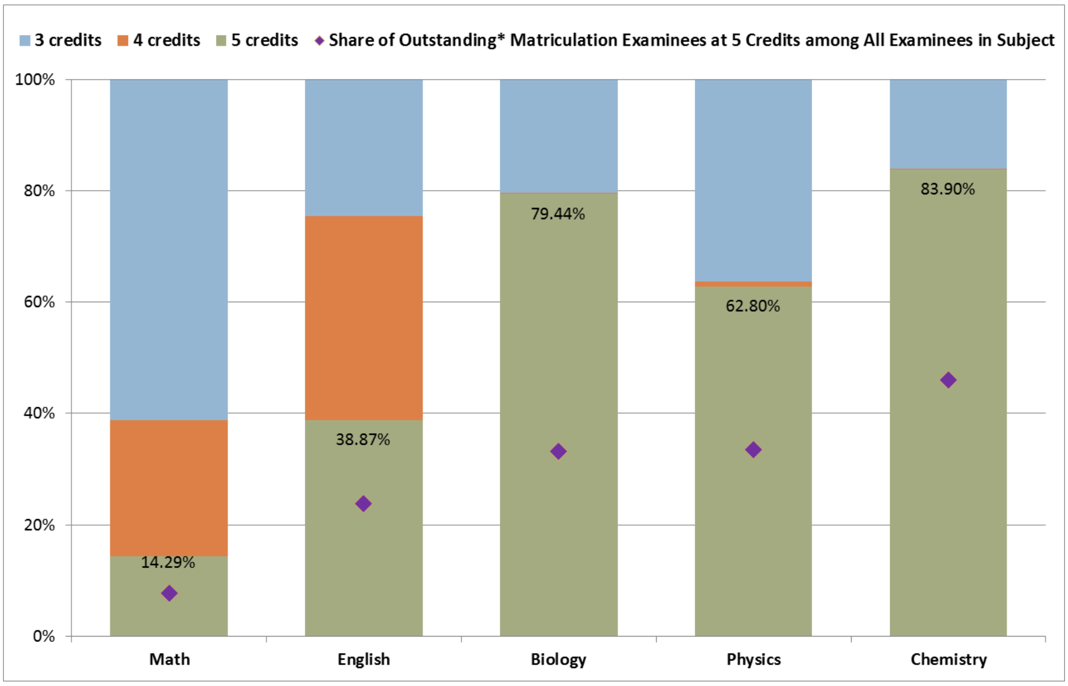
The next table shows the proportion of matriculation examinees in selected subjects among all examinees, their distribution by number of credits, and the share of outstanding students among them (scores of 85+) at the five-credit level in 2008 and selected years.

Table 3.2: Matriculation Examinees in Selected Subjects ass Pct. of All Examinees

	Math	English	Biology	Physics	Chemistry
1997	85.40%	92.20%	16.60%	12.00%	12.80%
1999	87.70%	92.50%	16.10%	11.00%	11.00%
2000	87.40%	90.80%	15.30%	11.30%	10.10%
2005	86.50%	86.20%	16.60%	10.60%	10.00%
2006	91.00%	85.70%	18.40%	12.50%	10.20%
2007	93.50%	88.10%	19.40%	13.20%	10.80%
2008	89.10%	85.10%	19.40%	13.40%	11.10%
2009	87.34%	86.57%	22.54%	14.10%	10.50%
2010	88.86%	86.53%	22.45%	14.11%	10.19%

Source: CBS

Figure 3.5: Distribution of Matriculation Examinees by Subjects and Number of Credits, 2010



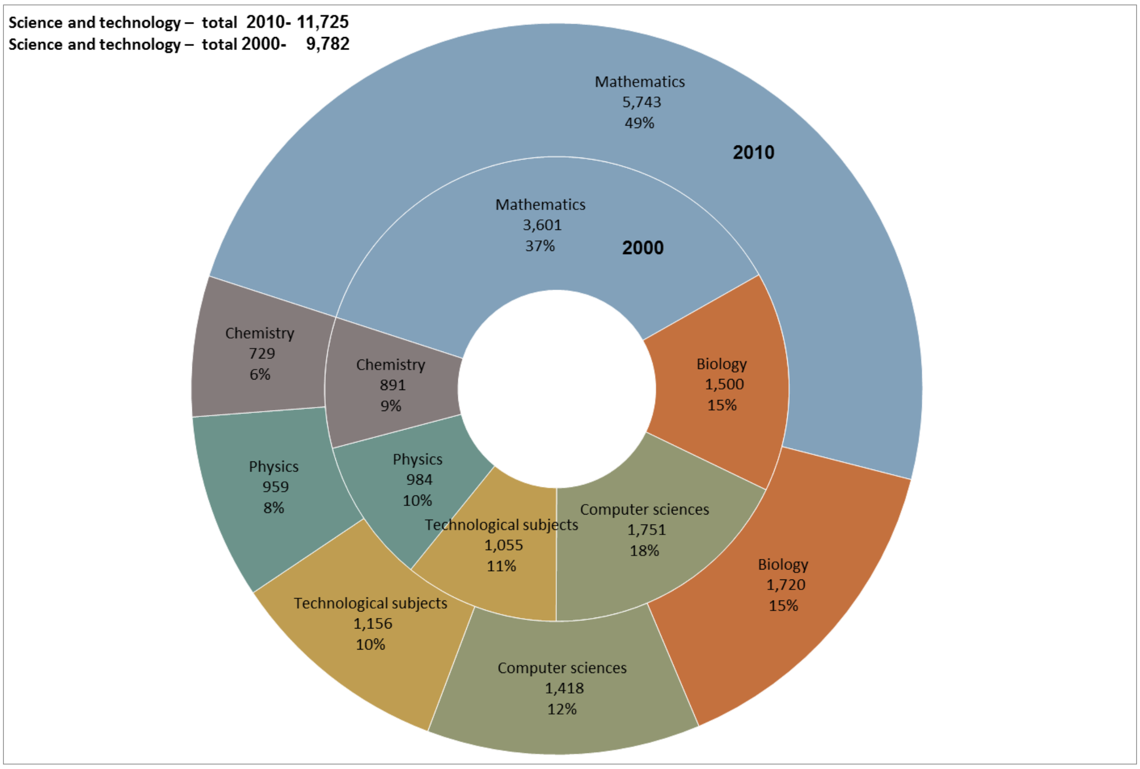
* 85+ score.
Source: Analysis of CBS data by Samuel Neaman Institute

3.2.3 Science and Technology Teachers

In 2010, Israel had 11,725 teachers of science and technology (including mathematics) at the senior high level (all systems), 27 percent of all teachers at that level—10 percent in mathematics and 17 percent in S&T subjects. The next figure presents the distribution of S&T teachers by subjects in 2010 and 2000. Half taught mathematics, 15 percent biology, and 12 percent computers.[19] Comparing 2010 with 2000, one may see that only the number and proportion of mathematics teachers increased significantly; the share of the other S&T subjects in the total population of S&T teachers declined or was unchanged.

[19] Ettie Weissblei, "Data on Teaching Personnel in Science and Technology Subjects," The Knesset, Research and Information Center, 2012 (Hebrew).

Figure 3.6: Distribution of Science and Technology Teachers by Subjects, 2010



Note: technological professions: engineering, architecture, electronics, biotechnology, etc.
Source: CBS, Educational indicators for training professionals in science and technology I Israel 1997/98-2009/10

The next table segments the characteristics of S&T teachers. The average age of these teachers was 45.3 in 2010 as against 42.4 in 2000, a 6.8 percent change. The proportion of S&T teachers over age 55 was 21.6 percent in 2010 as against 9.1 percent in 2000.

Table 3.3: Characteristics of Science and Technology Teachers, Jewish School System, 2009

		Teachers-Total	S&T Teachers-Total	Math.	Physics	Chemistry	Biology	Computer sciences	Technological subjects
Mean age	**2010**	44.8	45.3	44.3	48.6	46	45.6	43.8	47.9
	2000	42.8	42.4	42.6	45.2	43.1	42.5	40.2	43.7
	change	4.70%	6.80%	4.00%	7.50%	6.70%	7.30%	9.00%	9.60%
Over 55 years of age	**2010**	19.9	21.6	19.6	32.3	24.1	19.7	16.4	26.7
	2000	10.3	9.1	9.5	14.7	8.5	8.5	5.5	9.7
	change	93.20%	137.40%	106.30%	119.70%	183.50%	131.80%	198.20%	175.30%
Women	**2010**	69.3	64.9	70	37.5	77.2	78	59.7	29.1
	2000	65.1	61.1	66.5	37.8	75.6	76.3	59.9	18.9
	שינוי	6.30%	6.20%	5.30%	-0.80%	2.10%	2.10%	-0.30%	53.40%
Immigrants aged 35 and above among S&T teachers	**2010**	9	17.5	21.3	30.2	18.5	5.4	13.8	10.3
	2000	7.3	14.9	18.7	23.4	14.2	3.3	17.5	7.8
	change	22.80%	17.30%	13.70%	29.10%	30.20%	66.90%	-21.00%	31.80%

Source: CBS, Educational indicators for training professionals in science and technology I Israel 1997/98-2009/10

As for the education attainments of teachers in Israel from 1983 onward, in 2009, among all mathematics teachers who held first degrees, only 41 percent had degrees in mathematics or majored in teaching mathematics. Much the same was found among physics teachers: 34 percent held a first degree in physics or majored in teaching physics. The rates were higher in chemistry and biology, at 52.8 percent and 56 percent, respectively.

3.2.4 PISA and TIMSS by Cross-Country Comparison

The purpose of international studies—those in which many countries from all over the world participate—is to facilitate comparisons of pupil achievements in important subjects, study the connection between achievements and factors such as pupils' attitudes toward their schools and toward studying, and test the social, economic, and cultural influences on achievements in the country where the study is performed. The results of such studies make it possible to perform comparisons among sectors and groups in a given country's population and among different countries.

In recent years, Israel has been participating in several studies that take place every few years on a cyclical basis. The studies are managed by two international organizations: the OECD (Organisation for Economic Co-operation and Development), within which Israel participates in the PISA study, and the IEC (International Evaluation Agency), under which Israel participates in ICILS, PIRLS, TIMSS, and SITES.

The international organizations that develop these studies employ leading professionals in the field of educational evaluation and measurement for this purpose. The tests and questionnaires are constructed painstakingly and are highly reliable and valid. The educational settings and test questions are developed by worldwide experts in the contents with which the test deals. In a complex and multi-phased process, the test is adjusted to each country and administered to a sample of pupils. Those at the international organization analyze the test scores for the purposes of cross-country comparisons. In addition, each country's domestic scores are analyzed for comparison among domestic sectors and subgroups.[20]

PISA—Program for International Student Assessment[21]

This study, conducted by the OECD among many participating countries, examines fifteen-year-olds' literacy in three subjects: reading, mathematics, and science. PISA asks to what extent pupils who are nearing the end of compulsory schooling (in most countries) have acquired general cognitive tools and understand

[20] Ministry of Education—National Authority for Educational Measurement and Evaluation.

[21] http://cms.education.gov.il/EducationCMS/Units/Rama/MivchanimBenLeumiyim/Timss_Pirls_2011.htm

the subjects examined in a way that allows them to cope well and effectively with their surroundings, as opposed to the extent to which they acquired specific knowledge and contents that one curriculum or another requires. For this reason, the questions included in PISA examine knowledge from an applied perspective, i.e., knowledge that is crucial for the “adult world,” life skills, and ability to solve complex problems that entail integration among different disciplines, with emphasis on skills.

PISA is conducted cyclically. The three subjects (reading, mathematics, and science) are examined every three years, with special emphasis on one subject each time. Israel took part in PISA 2000 (in 2002), in which reading literacy was emphasized; in PISA 2006, with scientific literacy emphasized; and in PISA 2009, in which reading literacy was emphasized.

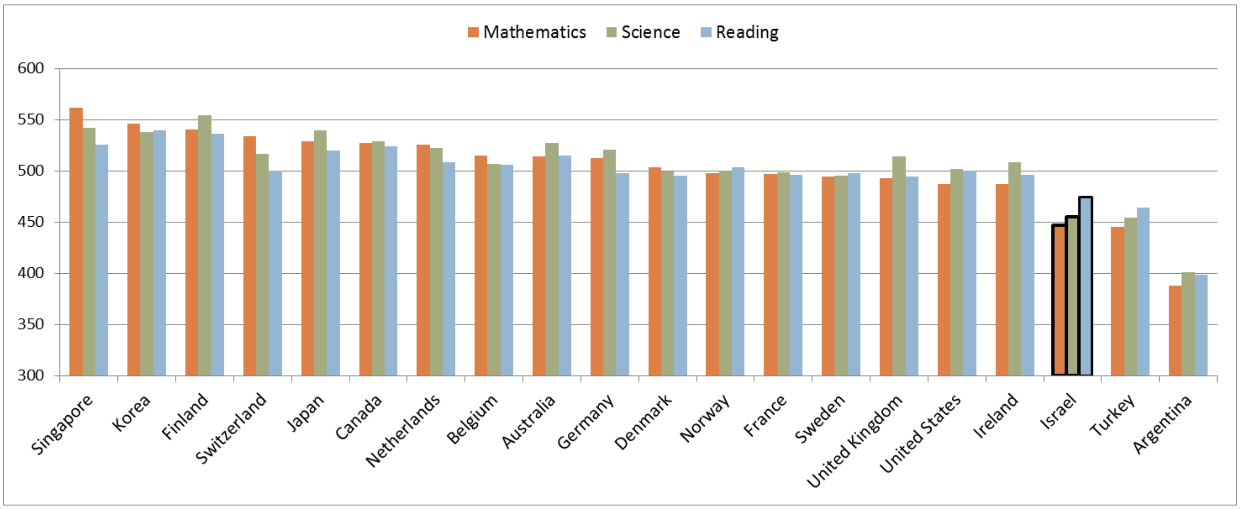
The PISA 2009 findings show that Israel, with a score of 474, ranked thirty-sixth among sixty-four countries in reading literacy and forty-first in mathematics and science (scores of 447 and 455)—below the OECD average in all subjects.

One of the indicators examined in PISA is the share of pupils who excel and those who struggle. In math literacy, the excellence rate (Level 5 proficiency and above) is 6 percent in Israel as against 13 percent on the OECD average. The “struggle rate” (below Level 2 proficiency) is 39 percent as against 22 percent, respectively.

Another indicator examined is achievement gaps among pupils from different socioeconomic backgrounds. Israel has large gaps on this account. In science literacy, for example, pupils of high socioeconomic background scored 526, those of medium background 474, and those of weak background 430.

PISA 2012 will focus on math literacy and examine reading and science literacy secondarily. These subjects aside, it will also investigate pupils’ literacy in two new domains: *problem-solving* and *economic literacy.* Another novelty in the upcoming PISA concerns how the exam will be given: for the first time, *some of it will be digital,* administered by computer.

Figure 3.7: PISA 2009 Scores, Israel and Selected Countries



Source: OECD, Education Ministry RAMA

TIMSS—Trends in International Mathematics and Science Study

TIMSS, an IEA study (International Organization for the Evaluation of Achievements in Education), investigates eighth-graders' proficiency in mathematics and science with reference to each participating country's specific curriculum. TIMSS allows long-term tracking of trends of progress in each country (by comparing different years in which the exam is given) and cross-country comparisons. TIMSS is a cyclical longitudinal study performed on a quadrennial basis; Israel took part in 1995, 1999, 2003, 2007, and 2011.

In TIMSS 2011, conducted in sixty countries, Israel made an impressive leap forward in achievements relative to 2007. In the eighth-grade math exam, Israel ranked seventh among forty-two countries, rising seventeen notches over 2007, when it was in twenty-fourth place only. In the eighth-grade science exam, Israel finished thirteenth as against only twenty-fifth in 2007.

The improvement in Israel's achievements between 2007 and 2011 was the third-largest among countries that participated in the two most recent cycles and the largest among countries that had achievements superior or similar to Israel's. It was a major improvement over previous years, at which time the country's performance was roundly criticized by players in and outside the domestic education system.

According to the Minister of Education, Gideon Saar, the improvement was abetted by various factors such as the tailoring of curricula to the requirements of the test and a new organizational culture. Others contend that such an acute change could not have taken place in the short time between the exams.

Table 3.4: TIMSS—Israel and 20 Leading Countries in Mathematics and Science, 2011

	Mathematics		Science		Israel		
	2011	2007	2011	2007		Math.	Science
1	Korea	Taiwan	Singapore	Singapore	1995	19	18
2	Singapore	Korea	Taiwan	Taiwan	1999	28	26
3	Taiwan	Singapore	Korea	Japan	2003	19	23
4	Hong Kong	Hong Kong	Japan	Korea	2007	24	25
5	Japan	Japan	Finland	England	2011	7	13
6	Russia	Hungary	Slovenia	Hungary			
7	Israel	England	Russia	Czech Rep.			
8	Finland	Russia	Hong Kong	Slovenia			
9	U.S.	U.S.	England	Hong Kong			
10	England	Lithuania	U.S.	Russia			
11	Hungary	Czech Rep.	Hungary	U.S.			
12	Australia	Slovenia	Australia	Lithuania			
13	Slovenia	Armenia	Israel	Australia			
14	Lithuania	Australia	Lithuania	Sweden			
15	Italy	Sweden	New Zealand	Scotland			
16	New Zealand	Malta	Sweden	Italy			
17	Kazakhstan	Scotland	Italy	Armenia			
18	Sweden	Serbia	Ukraine	Norway			
19	Ukraine	Italy	Norway	Ukraine			
20	Norway	Malaysia	Kazakhstan	Jordan			

Source: OECD, Education Ministry RAMA-
http://cms.education.gov.il/EducationCMS/Units/Rama/MivchanimBenLeumiyim/Timss_Pirls_2011.htm

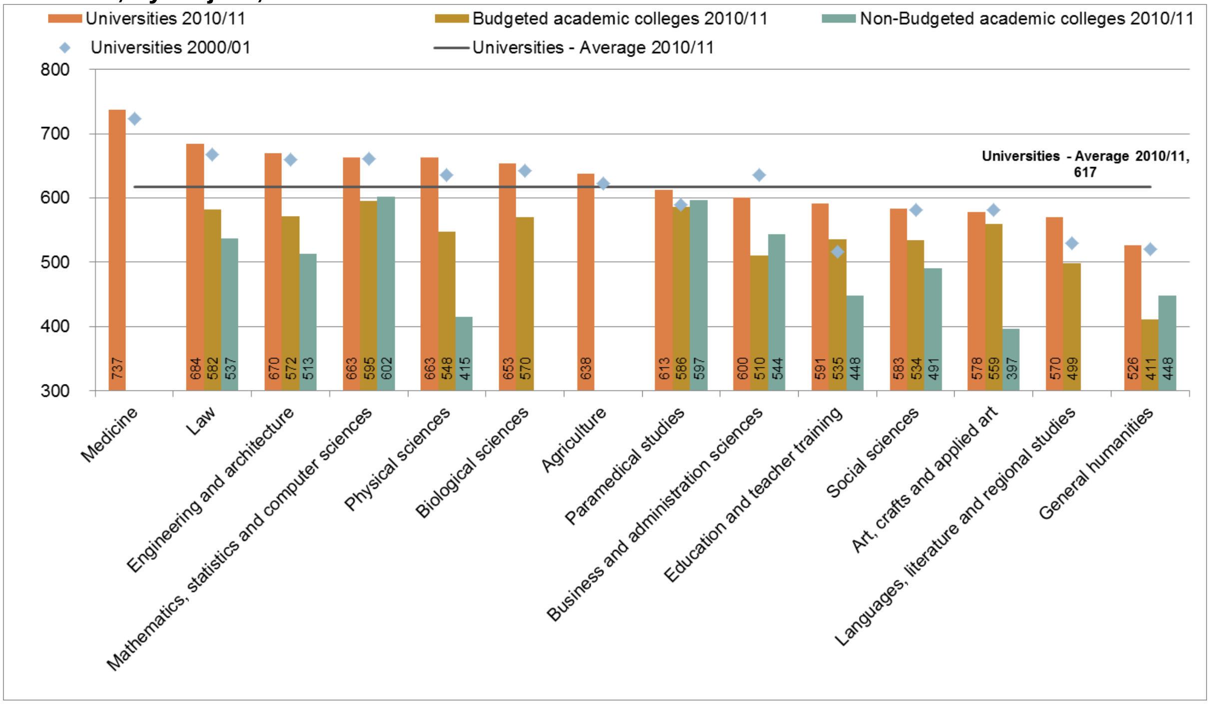
3.3 Higher Education

3.3.1 The Psychometric Exam

The psychometric exam is used as a screening tool for admission to Israel's universities and colleges, it being assumed that the score reflects the candidate's aptitude for higher studies. In many "sought-after" subjects, the psychometric score is a barrier to candidates who fail to satisfy the higher-education institutes' requirements.

The next figure shows the average psychometric scores of first-year students in degree programs, parsed by majors. At universities, the average psychometric score has changed little in most majors in the past decade, apart from business and management science, in which the average declined (from 636 to 600).

Figure 3.8: Average Psychometric Exam Scores of First-Year University and College Students, by Majors, 2009/10



Source: Analysis of CBS data by Samuel Neaman Institute

3.3.2 First-Year University and College Students

First-year student enrollment may give an indication of the future labor force. The next table shows the number and distribution of first-year students in degree programs by majors and the rate of change between 2000/01 and 2010/11. In 2010/11, there were 49,716 first-year students—46 percent at universities, 32 percent at budgeted academic colleges, and 22 percent at non-budgeted academic colleges. That year, about one-third of the students majored in life sciences and 16.7 percent majored in engineering and architecture.

The share of students in mathematics, statistics, and computer science fell from 12.7 percent in 2000/01 to 5.9 percent in 2010/11; the proportions of those in the social sciences and in business and management science, in contrast, increased.

Table 3.5: First-Year Students in Degree Programs, by Majors, 2000/01 vs. 2010/11

	Total		Universities		Budgeted academic colleges		Non-Budgeted academic colleges	
	2000/01	2010/11	2000/01	2010/11	2000/01	2010/11	2000/01	2010/11
Total	**34,899**	**49,716**	**22,410**	**23,063**	**7,968**	**15,747**	**4,521**	**10,906**
General humanities	3,225	2,889	3,152	2,613	73	244		32
Languages, literature and regional studies	1,422	1,081	1,422	1,081				
Education and teacher training	817	858	791	509	26	211		138
Art, crafts and applied art	1,209	1,965	540	478	669	1,396		91
Social sciences	7,212	13,662	5,284	6,617	865	4,692	1,063	2,353
Business and administration sciences	2,633	7,285	519	968	1,237	2,312	877	4,005
Law	2,586	4,587	769	760		120	1,817	3,707
Medicine	400	556	400	556				
Paramedical studies	1,525	2,621	1,349	1,743	176	737		141
Mathematics, statistics and computer sciences	4,430	2,951	2,412	1,680	1,328	903	690	368
Physical sciences	851	876	816	816	35	46		14
Biological sciences	1,521	1,781	1,436	1,348	85	433		
Agriculture	262	310	262	310				
Engineering and architecture	6,806	8,294	3,258	3,584	3,474	4,653	74	57
Per.	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
General humanities	9.2%	5.8%	14.1%	11.3%	0.9%	1.5%		0.3%
Languages, literature and regional studies	4.1%	2.2%	6.3%	4.7%				0.0%
Education and teacher training	2.3%	1.7%	3.5%	2.2%	0.3%	1.3%		1.3%
Art, crafts and applied art	3.5%	4.0%	2.4%	2.1%	8.4%	8.9%		0.8%
Social sciences	20.7%	27.5%	23.6%	28.7%	10.9%	29.8%	23.5%	21.6%
Business and administration sciences	7.5%	14.7%	2.3%	4.2%	15.5%	14.7%	19.4%	36.7%
Law	7.4%	9.2%	3.4%	3.3%		0.8%	40.2%	34.0%
Medicine	1.1%	1.1%	1.8%	2.4%				
Paramedical studies	4.4%	5.3%	6.0%	7.6%	2.2%	4.7%		1.3%
Mathematics, statistics and computer sciences	12.7%	5.9%	10.8%	7.3%	16.7%	5.7%	15.3%	3.4%
Physical sciences	2.4%	1.8%	3.6%	3.5%	0.4%	0.3%		0.1%
Biological sciences	4.4%	3.6%	6.4%	5.8%	1.1%	2.7%		
Agriculture	0.8%	0.6%	1.2%	1.3%				
Engineering and architecture	19.5%	16.7%	14.5%	15.5%	43.6%	29.5%	1.6%	0.5%

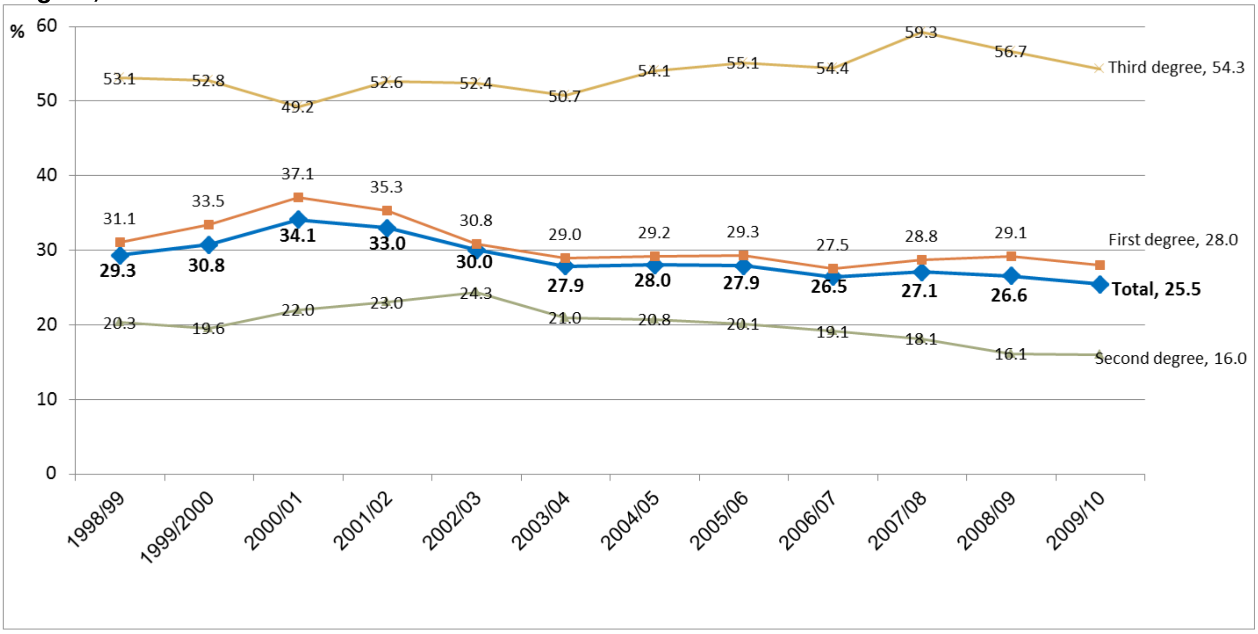
Source: Analysis of CBS data by Samuel Neaman Institute

The next figure presents the share of new students22 who majored in science and technology (S&T)23 at higher-education institutions among all new students. In 2012, 25.5 percent of new students majored in S&T disciplines. The rate has been trending down since 2000, mainly among first-degree candidates. In 2010, among all such students, 28 percent majored in S&T disciplines as against 37 percent in 2001. At the Masters level, the decline was less precipitous: from 22 percent in 2001 to 16 percent in 2010. At the doctoral level, the share of S&T disciplines was the highest of all degree levels, at 54 percent on average with no precipitous changes over the years.

[22] A new student is one who appears for the first time on a list of candidates for a specific degree.

[23] Mathematics, statistics, computer science, physical science, biological science, agriculture, engineering and architecture, medicine (Masters degree and up), and pharmacy (Masters degree and up).

Figure 3.9: Share of New Higher-Education Students Majoring in S&T Disciplines, by Degree, 1999-2009



Source: CBS, Educational indicators for training professionals in science and technology I Israel 1997/98-2009/10

3.3.3 Degree Recipients

This section examines the trend in recipients of university degrees in Israel, focusing on S&T disciplines. The OECD's Canberra Manual, the source of rules for the measurement of human resources devoted to S&T, specifies seven S&T majors: life sciences, engineering, medicine, agriculture, social sciences, humanities, and other. The first five lie at the core S&T of human capital. OECD and European Union publications relate to graduates in two fields only—science and engineering—as the R&D human capital reserve. These disciplines include life sciences, physical sciences, mathematics, statistics, computers, engineering, manufacturing and management, and architecture and building.

CBS sorts the science and engineering disciplines into two categories: mathematics and natural sciences (comprising mathematics, statistics, computer science, physical science, and biological science) and engineering and architecture. Since the CBS definitions resemble those of the OECD, the data permit cross-country comparisons at a reasonable level of confidence.

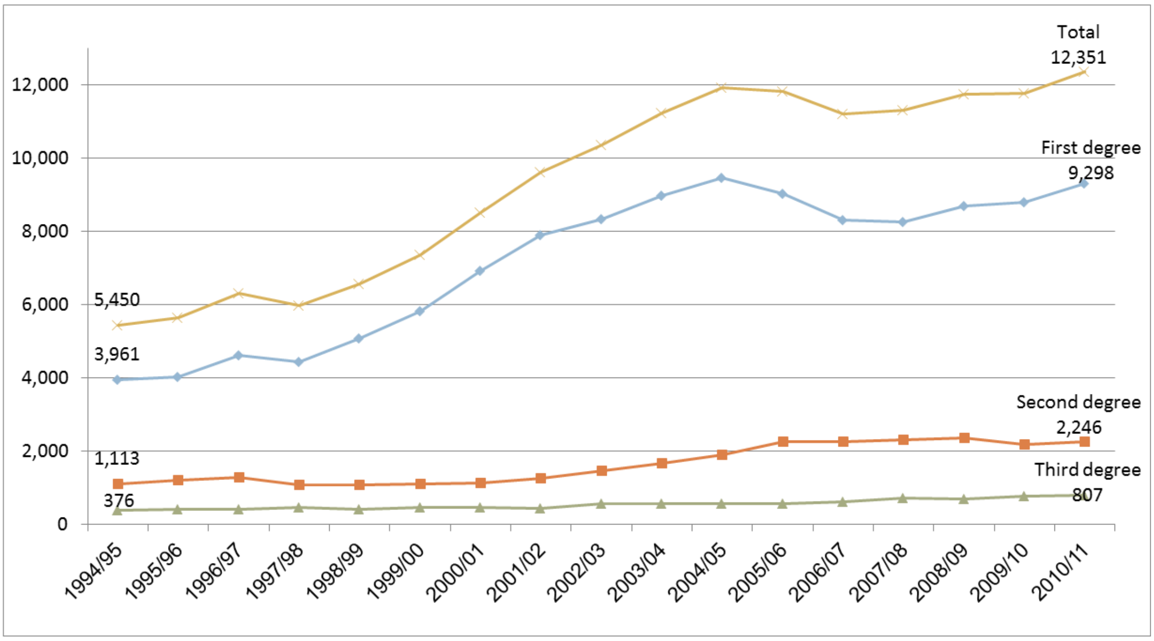
Notably, until 1990, Israel's higher-education system was based almost exclusively on universities. This changed during the 1990s with the establishment of a large number of colleges that allowed new population groups to access higher studies. The data in this chapter pertain to students at both universities and colleges.

Table 3.6: Degree Recipients in Israel in Science and Engineering, by Degree Level, 1994/95–2010/11

Year	Engineering and architecture			,Mathematics Statistics and computer sciences			Biological sciences			Physical sciences			Multi disciplinary sciences		Total			
degree	First	Second	Third	First	Second	Third	First	Second	Third	First	Second	Third	First	Second	First	Second	Third	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
2009/10	5,081	849	132	1,807	382	126	1,300	597	325	614	361	189			8,802	2,189	772	11,763
2010/11	5,536	885	150	1,944	438	87	1,152	588	372	611	335	198	55		9,298	2,246	807	12,351

Source: Analysis of CBS data by Samuel Neaman Institute

Figure 3.10: Degree Recipients in Israel in Science and Engineering, by Degree Level, 1994/95–2010/11



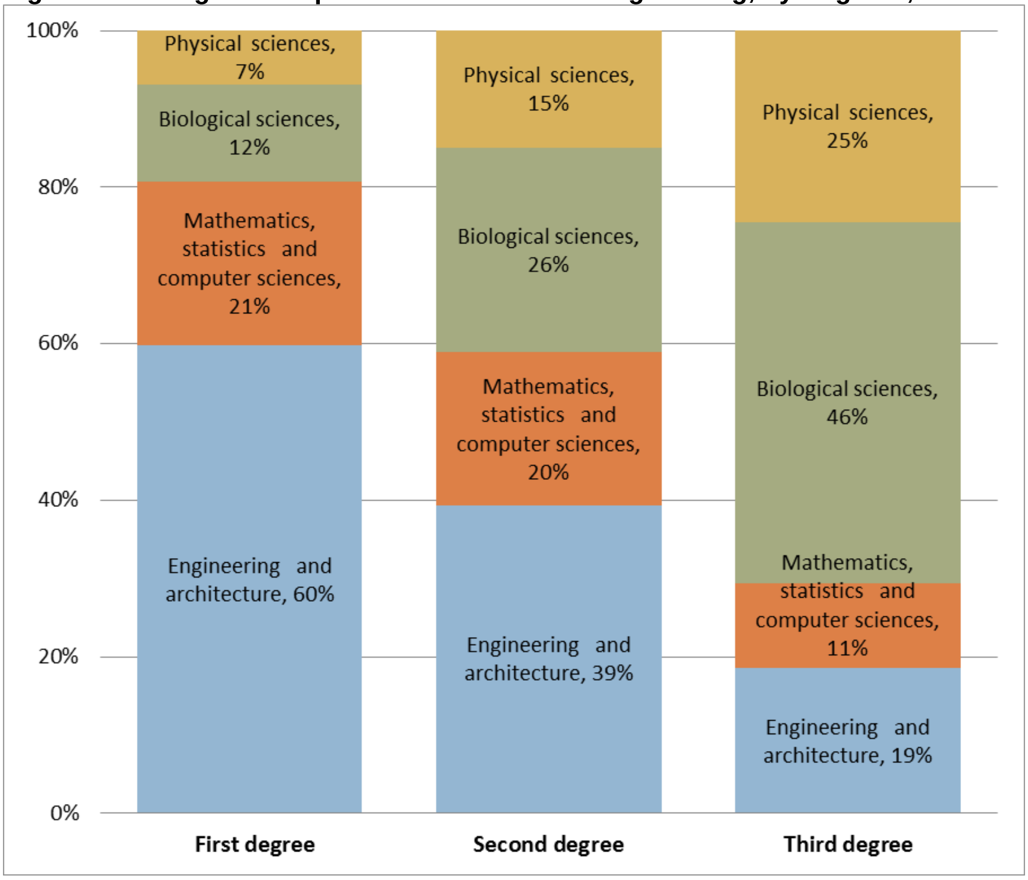
Source: Analysis of CBS data by Samuel Neaman Institute

In 2010/11, 63,983 persons received degrees and 19 percent of them (12,351) did so in science and engineering.

Figure 3.10 plots the trends in the number of recipients of S&E degrees by degree level between 1994/95 and 2010/11. Most of the increase in degree recipients occurred at the first-degree level, but the increase stopped in 2004/05, turned around until 2007/08, and then recovered mildly. The number of recipients of advanced degrees, in contrast, nearly tripled during that time.

The next figure shows the distribution of S&E degrees by specific degree. At the first-degree level, engineering and architecture accounted for 60 percent of degrees awarded; this rate fell to 39 percent at the Masters level and only 19 percent at the Ph.D. level. In biological sciences, the opposite was observed: their share was only 12 percent of S&E degree recipients at the first-degree level and rose to 46 percent at the doctoral level.

Figure 3.11: Degree Recipients in Science and Engineering, by Degrees, 2010/11



Source: Analysis of CBS data by Samuel Neaman Institute

3.4 Academic Staff

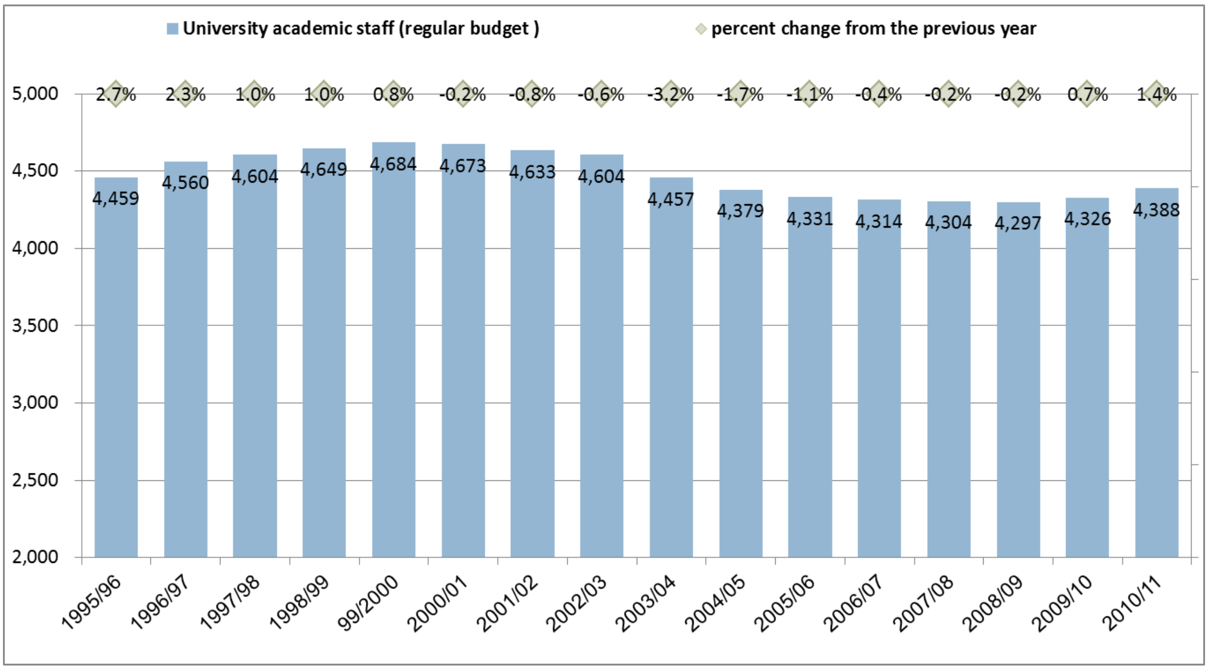
University staff is an important if not a definitive factor in the advancement of university research in Israel. It is also responsible for the quality of curricula and teaching and, in this sense, for the quality of graduates of higher-education institutions—who, as stated, constitute the national reserve of human capital. 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 instructors (doctoral students), assistants, and teaching and research aides;
- **other academic staff,** mainly external teachers.

Senior academic staff directs the research that it performs and also has the highest level of knowledge and experience in teaching. The next figure tracks total university academic staff funded via the universities' regular budget in 1995/96–2010/11 in terms of full-time-post equivalent (monthly average).

In 2010/11, there were 4,388 senior academic staff posts—basically unchanged since 1995/96 even though enrollment increased by 50 percent.[24]

Figure 3.12: Total University Teaching and Research Staff, Full-Time-Post Equivalent, 1995/96–2010/11

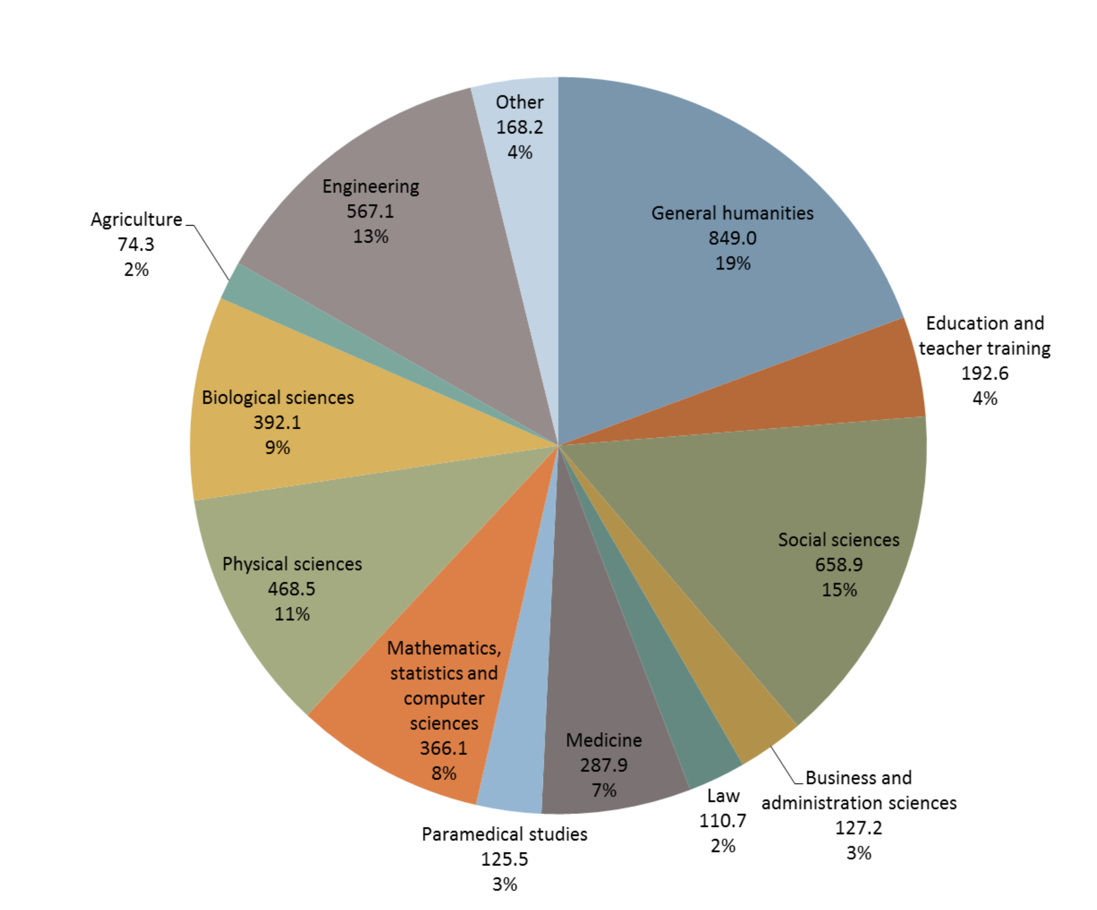


Source: Analysis of PGC data by Samuel Neaman Institute

Discipline: the next figure shows the distribution of staff members by academic disciplines: 13 percent in engineering and architecture, 9 percent in biological science, 11 percent in physical science, and 8 percent in mathematics, statistics, and computer science.

[24] Source for calculation of the proportions of students: CBS, *Statistical Abstract of Israel, 2012*—http://www.cbs.gov.il/reader/shnaton/templ_shnaton.html?num_tab=st08_54&CYear=2012

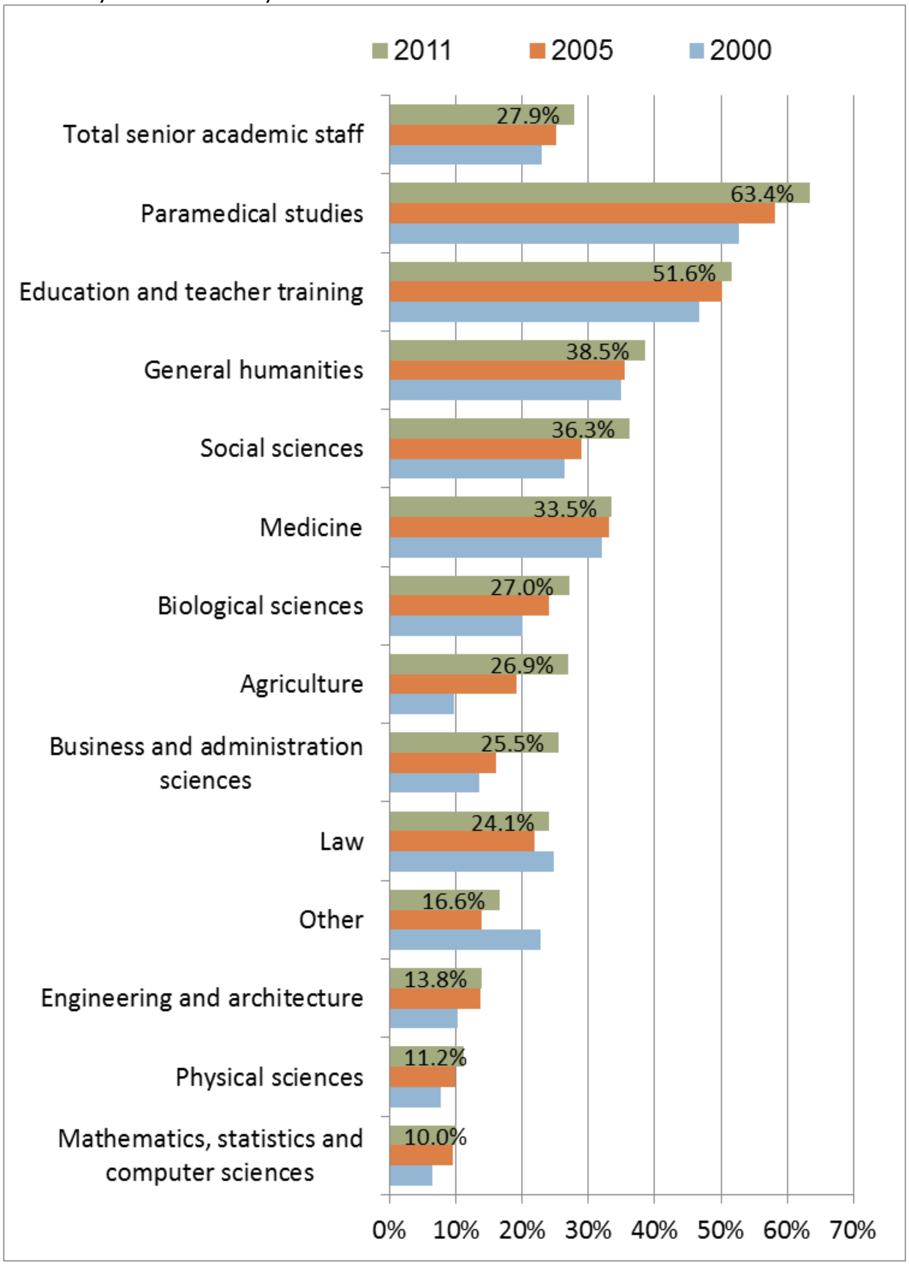
Figure 3.13: University Senior Academic Staff by Scientific Discipline, 2010/11



Source: Analysis of CBS data by Samuel Neaman Institute

Women: 27.9 percent the senior academic staff was composed of women in 2010/11, up 5 percentage points in the past decade. Women's representation increased in most disciplines but remained very low in engineering (13.8 percent), physical sciences (11.2 percent), and mathematics and computer sciences (10 percent) relative to education (51.6 percent) and paramedical occupations (63.4 percent).

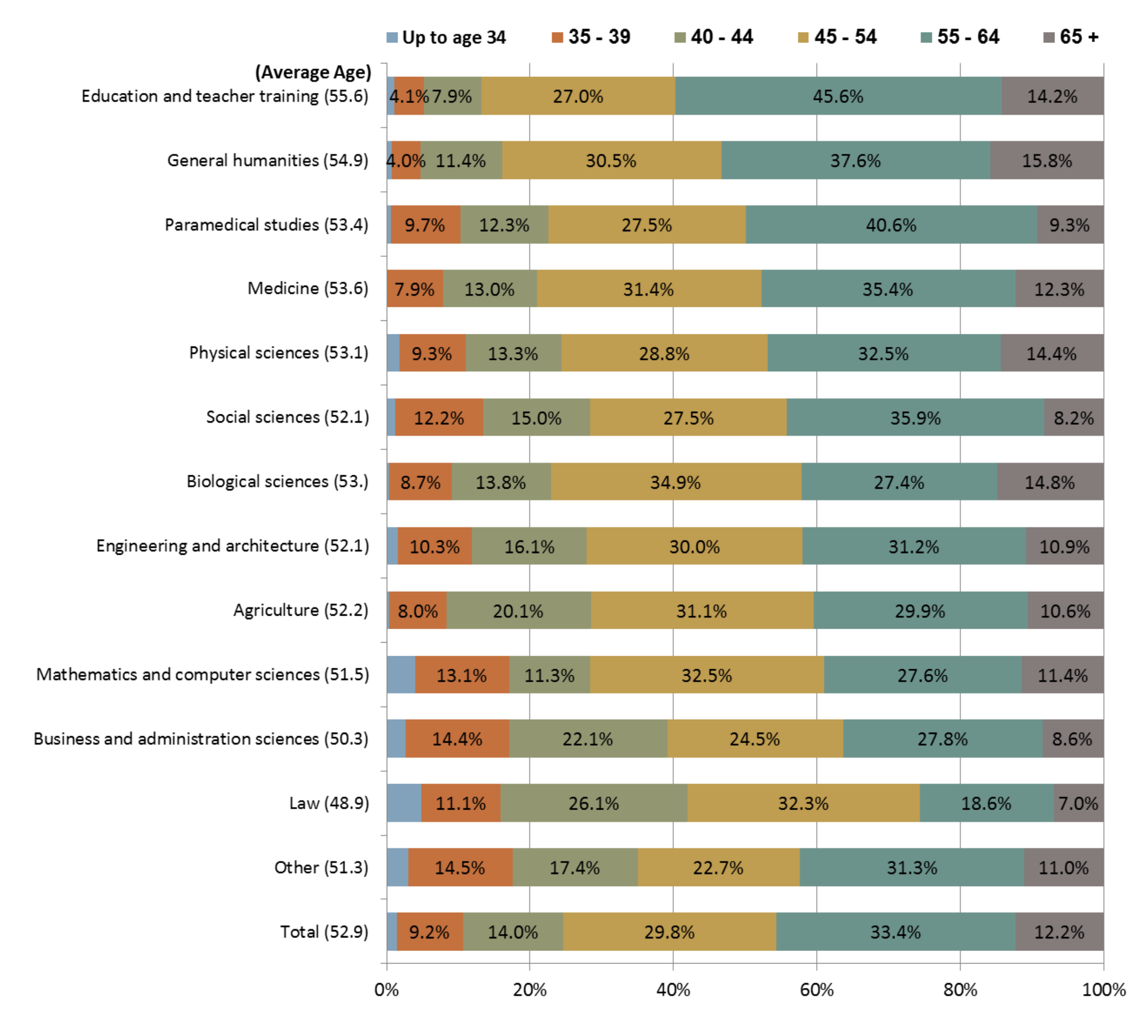
Figure 3.14: Women in University Senior Academic Staff by Disciplines, 1999/2000, 2004/05, and 2010/11, Pct.



Source: Analysis of CBS data by Samuel Neaman Institute

Age: the average age of university senior academic staff in 2010/11 was 52.9 and 45.6 percent of staff were over age 55. Notably, since the retirement age of academic staff is 68, about half of the staff will be retiring within a decade or so. The proportion of staff members in physical and biological sciences over age 65 was 14 percent.

Figure 3.15: Distribution* of University Senior Academic Staff by Age, 2010/11 (in Parentheses—Average Age in Discipline)



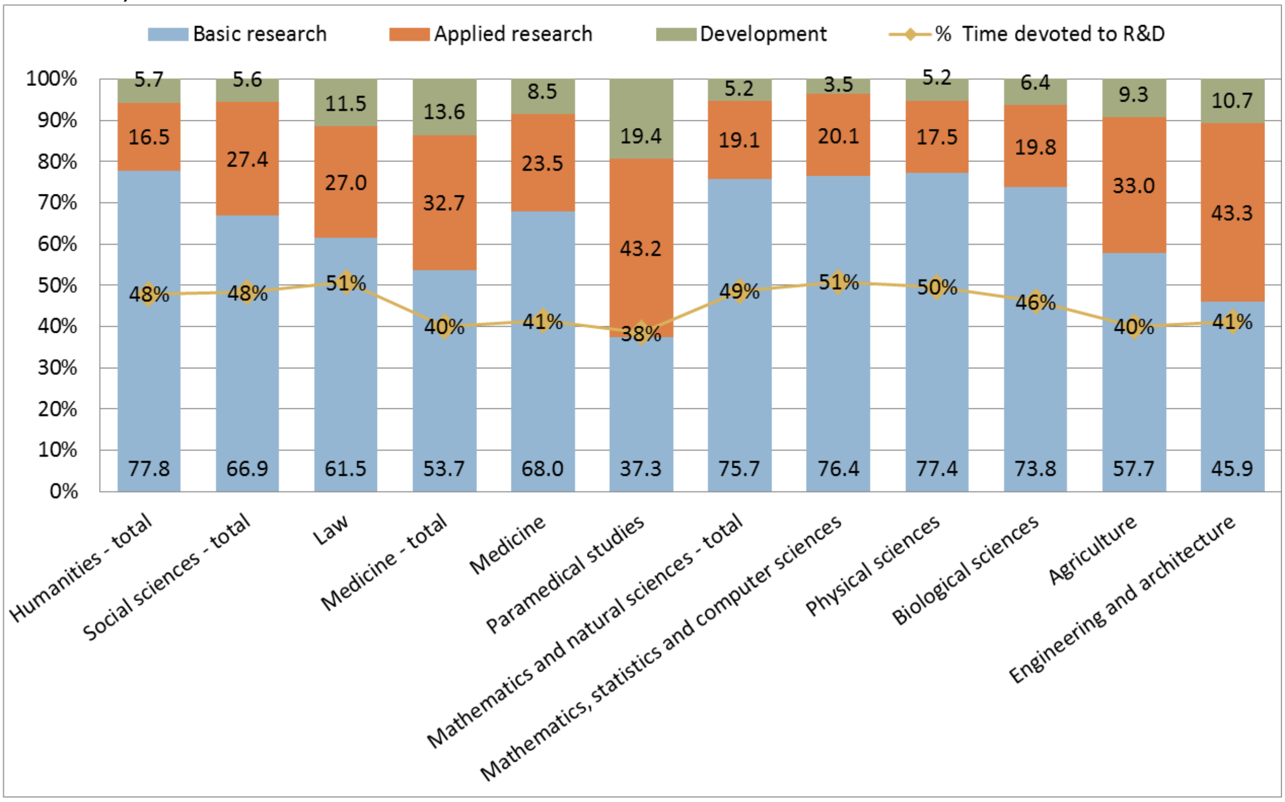
Notes: * The table is sorted by the percentage of staff over age 55 (except, Total and Other at the that listed in the bottom of the table)
Source: Analysis of CBS data by Samuel Neaman Institute

Time Devoted to R&D by Type of Research: In 2009, CBS performed a survey on the teaching and research activities of university senior academic staff[25] (results published in January 2011). The purpose of the survey was to update the coefficient of wage expenditure on research in the general budget allocated to universities for teaching and research.

[25] http://www.cbs.gov.il/webpub/pub/text_page.html?publ=76&CYear=2009&CMonth=1

The figure below shows the amount of time invested by academic staff in R&D and the distribution of this time by types of research.[26] In engineering and architecture, 41 percent of time is devoted to R&D, as against 49 percent in mathematics and the natural sciences. The share of time invested in basic research is lower in engineering and architecture than in other fields, whereas that invested in applied research in engineering and architecture is higher.

Figure 3.16: University Senior Academic Staff—Time Devoted to Research and Type of Research, 2009/10



Source: Analysis of CBS data by Samuel Neaman Institute

[26] Research is parsed into three distinct types:

a. Basic research—experimental or academic research performed without application or preplanned use meant to yield basic knowledge about a phenomenon or an existing work.
b. Applied research—original research geared to a specific objective or a specific useful purpose, and for the purpose of acquiring new knowledge.
c. Development—systematic work based on existing knowledge and aided by practical studies and experiments for the purpose of producing new materials, products, or instruments, e.g., new processes, services, and systems, or to improve existing ones perceptibly.

3.5 R&D Human Resources in the Business-Enterprise Sector

Above we observed the higher-education sector in a way that allowed us to gauge the human resources that this sector, in its various settings, is training for R&D and innovation activities, and those that perform academic research. Here we present data on human resources employed in the business-enterprise sector, where most R&D takes place.

According to the definitions in *Frascati Manual*,[27] on which the data in this chapter are predicated, R&D human resources include all persons employed directly in R&D and who provide direct services for R&D, such as R&D managers and administrative workers. The *Manual* distinguishes among three main categories:

- **researchers:** personnel 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:** personnel 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 personnel directly connected with R&D projects.

R&D personnel are enumerated in two ways: by headcount and by number of full-time posts. The cross-country comparison that follows uses the latter method and not the former in order to neutralize the effect of part-time R&D personnel.

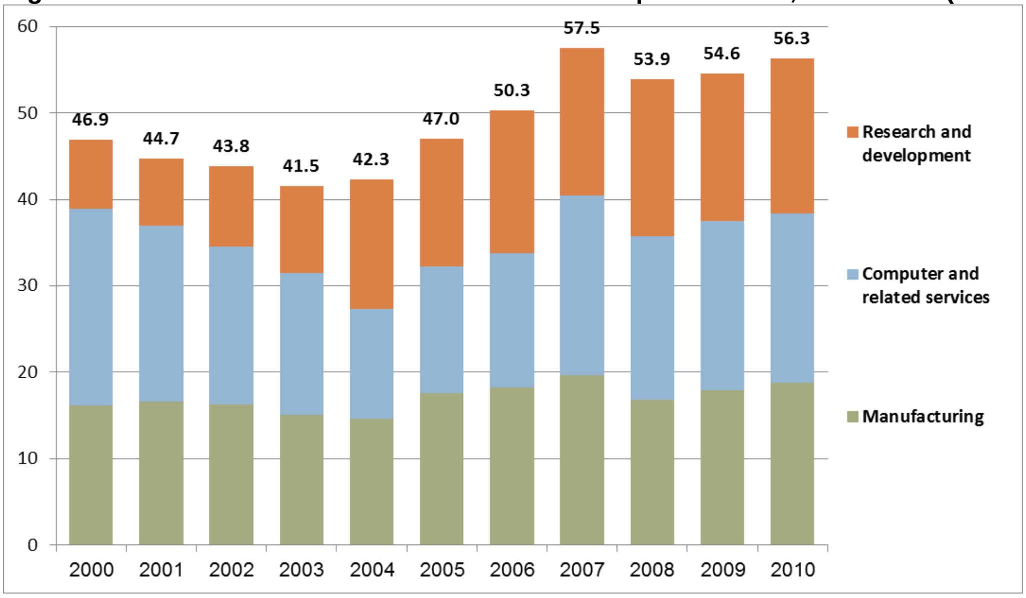
In Israel, R&D personnel in the business-enterprise sector include those in manufacturing industries (10–39), computer and related services (72), and research and development (73).28 The table below presents total R&D employee posts in Israel's business-enterprise sector in 2000–2010. During this decade, the number of employee posts increased by 20 percent (from 47,000 in 2000 to 56,000 in 2010); more than 60 percent of the posts were in research and development and computer and related services.

---

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

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

Figure 3.17: R&D Personnel in the Business-Enterprise Sector, 2000–2010 (Thousands)



Source: CBS

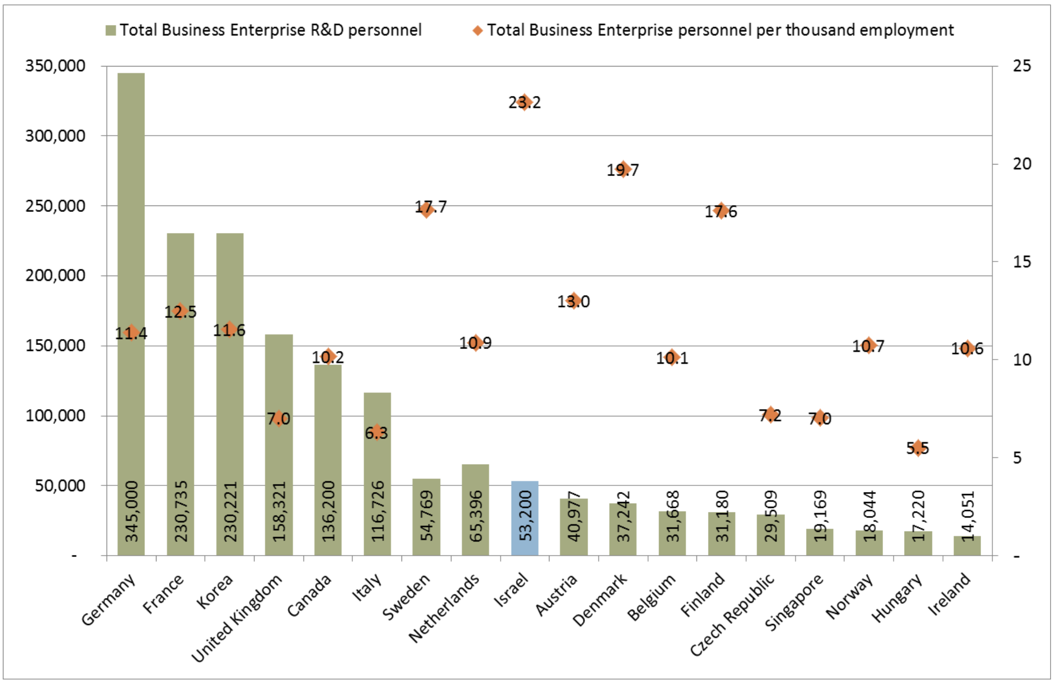
The table and figure below account for R&D personnel in the business-enterprise sector. The table presents the data in thousands of posts and does not permit cross-country comparison. Therefore, the last column shows the number of persons employed in R&D in the business-enterprise sector relative to thousands of personnel in this sector. Israel's ratio by this reckoning is very high by international standards.

Table 3.7: R&D Personnel (Full-Time Posts) in Business Enterprises Engaging in R&D, Headcount and Per Thousand Employed in Business-Enterprise Sector, 2000–2011

	R&D Employees (Full-Time Equivalents) in Companies Practicing R&D in the Business Sector 2011-2000												per Thous Emp.
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2011**
EU27	1,049,343	1,069,959	1,080,849	1,083,408	1,100,062	1,126,254	1,184,022	1,232,164	1,276,846	1,273,335	1,303,963	1,348,478	8.02
Japan	581,721	561,735	555,772	580,628	587,414	609,808	619,184	620,004	625,264	616,965	614,772	..	11.91
Germany	312,490	307,257	302,600	298,072	298,549	304,502	312,145	321,853	332,909	332,491	337,211	345,000	11.4
France	177,688	185,468	191,217	193,256	200,512	194,991	207,875	215,891	220,016	225,891	230,735	..	12.5
Korea	87,113	117,018	120,717	128,441	132,523	153,400	171,643	184,607	208,428	212,349	230,221	..	11.56
UK	145,499	154,047	158,161	156,361	149,685	145,401	149,473	157,323	152,173	151,494	154,870	158,321	7.02
Canada	104,707	115,723	118,461	127,230	138,213	142,025	151,726	167,690	172,740	153,740	136,200	..	10.16
Italy	63,998	65,271	70,228	67,958	67,519	70,725	80,082	93,760	..	109,768	112,212	116,726	6.29
Sweden	..	49,433	..	48,113	47,123	56,106	57,641	53,558	58,782	54,285	54,797	54,769	17.67
Netherlands	47,509	48,366	47,034	44,485	50,028	48,588	52,841	49,246	48,019	42,336	54,139	65,396	10.88
Israel	41,144	41,123	40,228	38,862	39,267	43,049	46,530	53,085	51,620	50,674	53,200	..	23.16
Austria	..	..	26,728	..	29,143	32,780	34,126	36,989	40,296	38,303	40,037	40,977	13.01
Denmark	23,725	25,849	28,481	27,230	28,040	28,359	29,238	31,168	41,041	37,366	37,055	37,242	19.74
Belgium	33,493	35,490	31,686	31,375	30,741	31,613	32,750	34,011	32,905	32,969	31,151	31,668	10.13
Finland	29,384	30,090	30,321	31,861	32,612	32,109	32,993	31,940	33,111	32,237	30,559	31,180	17.61
Czech Rep.	11,527	12,040	12,658	13,711	14,829	21,782	23,713	25,217	26,069	25,884	26,998	29,509	7.2
Singapore	10,246	9,930	11,459	12,517	14,844	17,076	17,616	18,948	19,703	19,309	19,169	..	7.03
Norway	..	14,459	14,184	15,615	15,668	15,399	16,031	16,941	18,491	18,166	17,821	18,044	10.74
Hungary	6,471	6,779	7,196	7,180	6,704	7,393	9,279	10,342	11,373	13,189	14,999	17,220	5.51
Ireland	8,724	9,126	9,204	9,280	9,650	10,338	10,647	10,956	11,755	11,959	12,194	14,051	10.59

Notes: The data in the last column is for 2011 or latest year for which data is available
Source: Analysis of CBS data by Samuel Neaman Institute

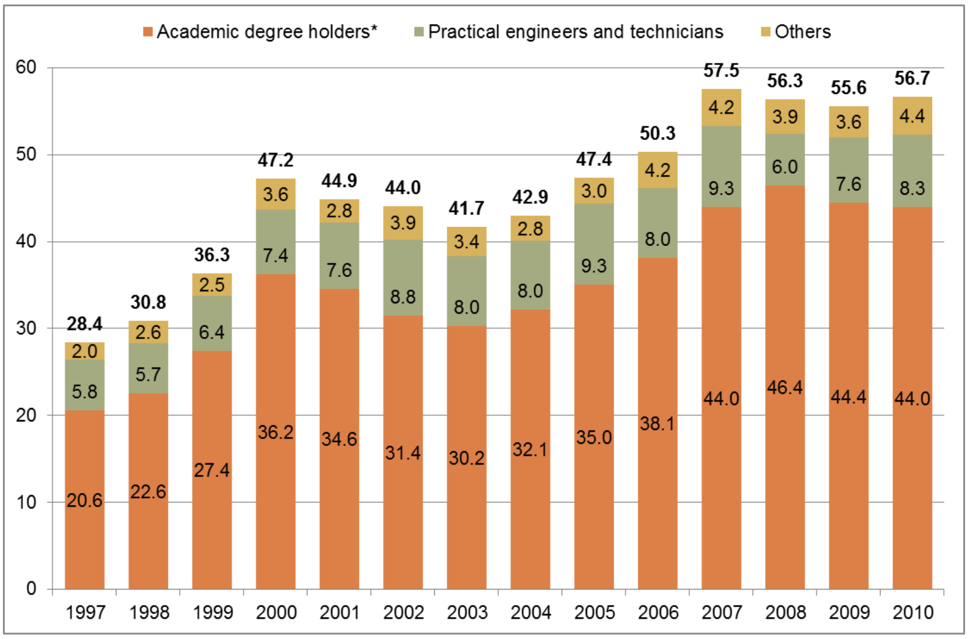
Figure 3.18: R&D Personnel (Full-Time Posts) in Business Enterprises Engaging in R&D, Headcount and Per Thousand Employed in Business-Enterprise Sector, 2000–2011



Notes: The data is for 2011 or latest year for which data is available
Source: Analysis of CBS data by Samuel Neaman Institute

Figure 3.19 segments the headcount of R&D personnel in Israel in 1997–2010 by the three categories specified at the beginning of this section. On multiannual average, 75 percent of total R&D personnel in the business-enterprise sector are academic researchers. The ratio among the categories has remained more or less constant over the years. Headcount, however, grew from 28,000 in 1997 to 56,000 in 2010—a 100 percent increase.

Figure 3.19: Business-Enterprise Sector R&D Headcount by Education (Thousands), 1997–2010



Source: Analysis of CBS data by Samuel Neaman Institute

3.6 Careers of Doctorate Holders

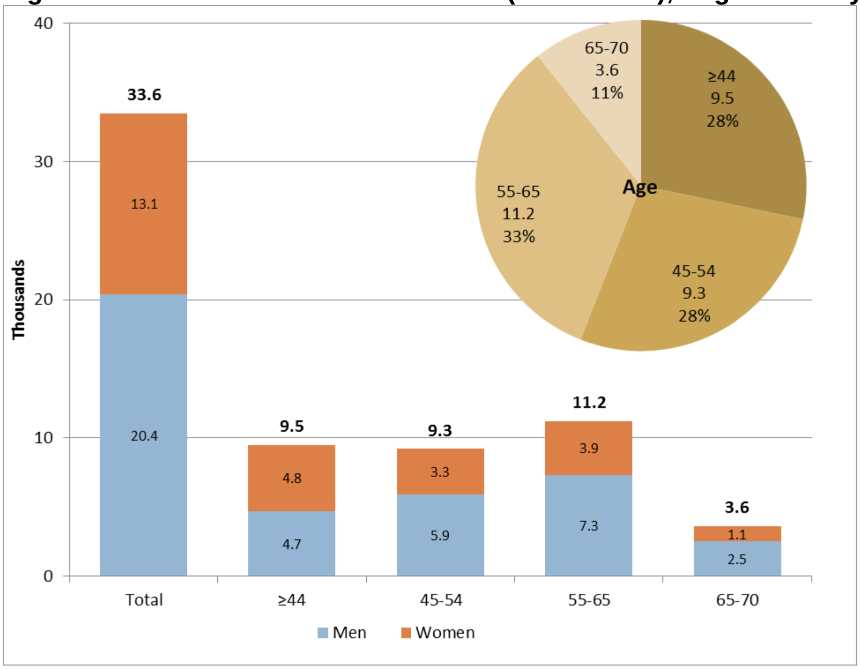
Holders of doctoral degrees play a special role in the S&T labor market as leaders of research and development and promoters of new technologies. As providers of leadership and enterprise, they are the segment of the labor force on which scientific and technological R&D is based. The proportion of Ph.D.'s in a country is considered an accepted indicator of the country's economic and technological strength.

In 2009, CBS joined the CDH (Careers of Doctorate Holders) project[29] and conducted a survey on the careers of doctorate holders in Israel. Israel's participation in the survey makes it possible to compare its data with those of other participating countries.

This subsection segments the data on the population of doctorate holders by criteria such as sex, age, area of specialization, employment, and cross-country comparisons.

In 2009, there were 33,600 doctorate holders in Israel—60 percent men and 40 percent women. Some 44 percent were over age 55. About one-third were up to age 44; in this age group, men and women were almost equally represented.

Figure 3.20: Doctorate Holders in Israel (Thousands), Segmented by Sex and Age, 2009



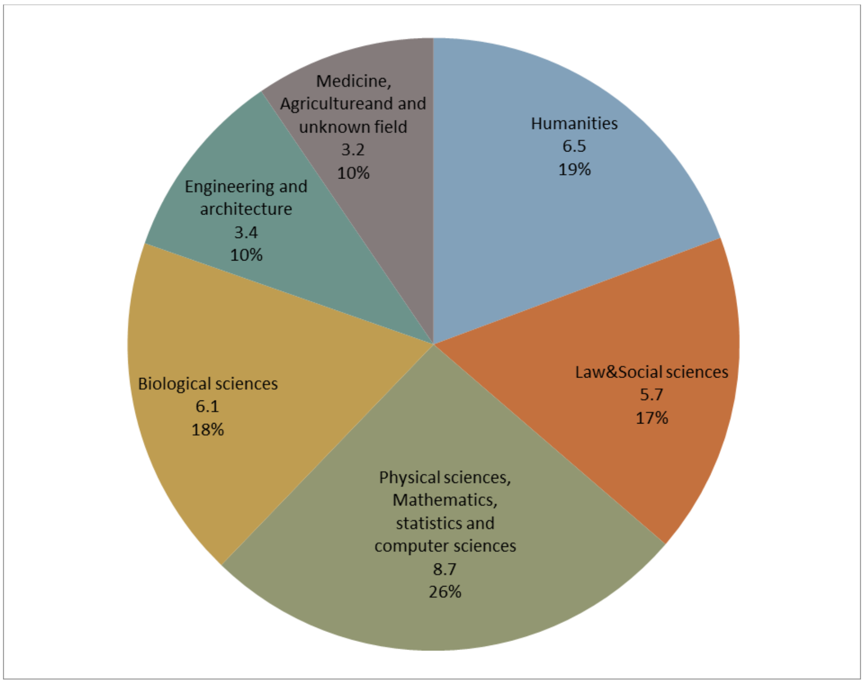
Source: Analysis of CBS data by Samuel Neaman Institute

The next figure distributes doctorate holders in Israel by discipline in 2009. Twenty-six percent are affiliated with the physical sciences, mathematics, statistics,

29 Careers of Doctorate Holders (CDH)—launched in 2004 as a joint project of UNESCO, the European Union, and the OECD to develop comparative indicators of doctorate holders' careers and mobility. The following indicators relating to doctorate holders have been gathered: age, sex, unemployment, wages, and job mobility, among others.

and computer science field; 18 percent with biological science, and 10 percent with engineering.

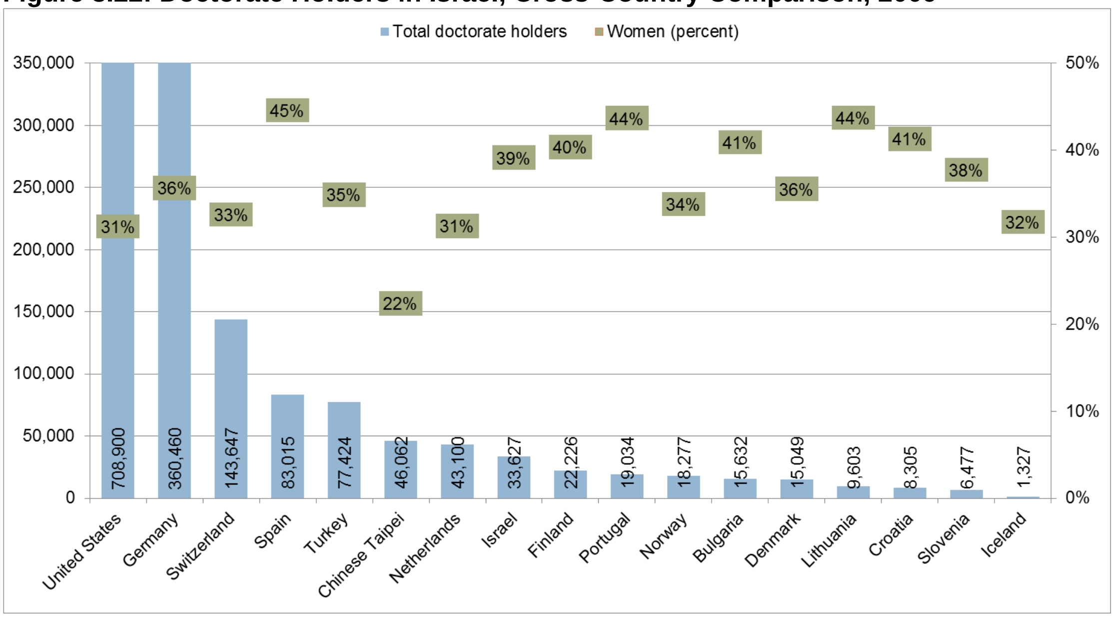
Figure 3.21: Doctorate Holders in Israel (Thousands and Pct.), by Academic Discipline, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

By cross-country comparison, Israel (33,627) trails countries such as the Netherlands (43,100) but surpasses Finland (22,226), Norway (18,277), and Denmark (15,049). Some 39 percent of doctorate holders in Israel are women; this proportion ranges from 30 percent to 45 percent in most countries.

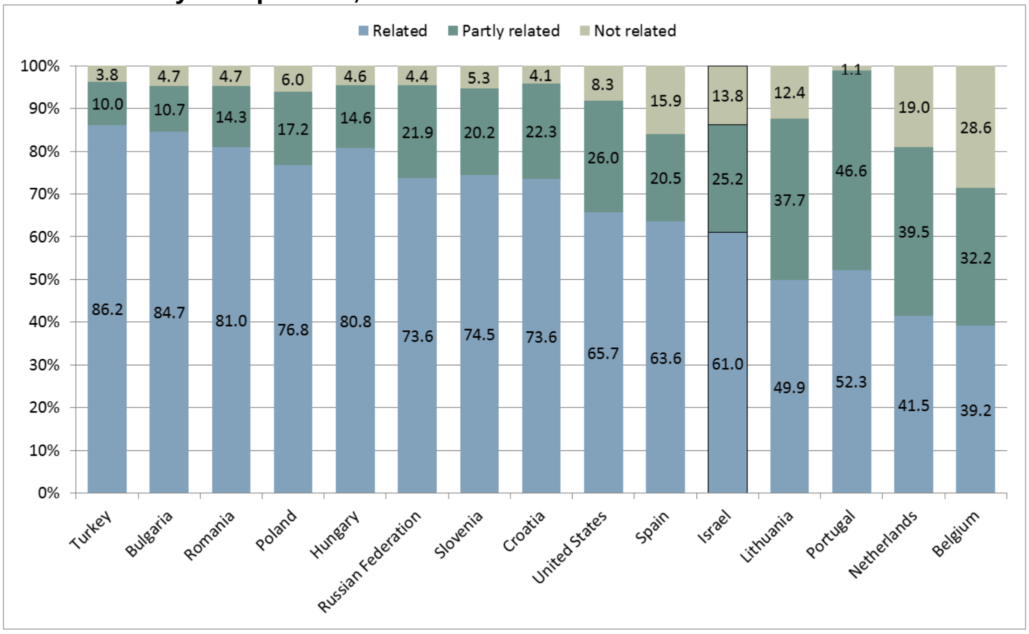
Figure 3.22: Doctorate Holders in Israel, Cross-Country Comparison, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

In Israel, 61 percent of doctorate holders are employed in a profession close to the discipline that they studied, 25 percent somewhat close, and 16 percent not close at all. This may be indicative of the non-fulfillment of this population's potential or a mismatch between its credentials and the labor market's requirements. Some of the explanation for the phenomenon in Israel is that many immigrants, particularly those from the former Soviet Union, reached Israel with doctorate degrees in disciplines and in numbers that ruled out smooth integration into posts suited to their schooling.

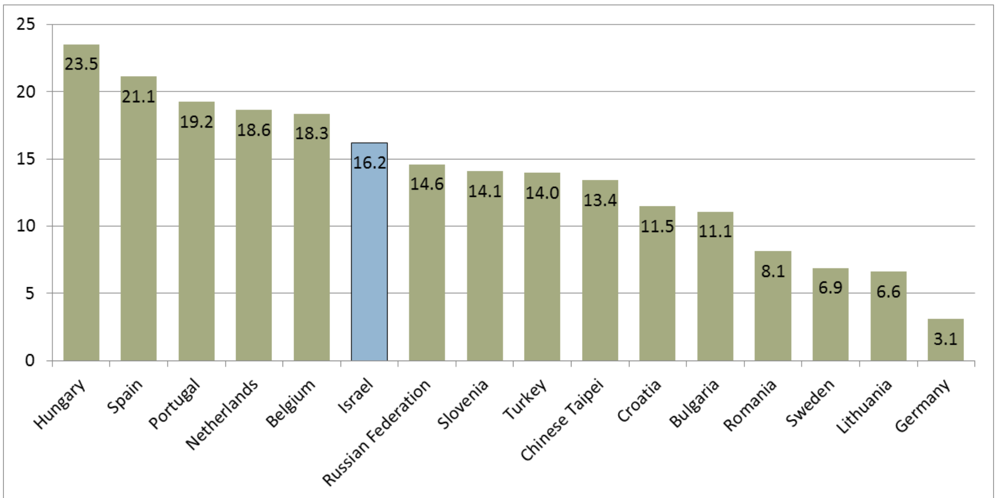
Figure 3.23: Employed Doctorate Holders by Proximity of Post to Discipline Studied, Cross-Country Comparison, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

Sixteen percent of those who earned doctorates have left Israel in the past decade. This may be indicative of the rate of "brain drain" among members of this population. By cross-country comparison, Israel ranks in the middle, under Belgium and the Netherlands (18 percent) but far above Sweden (7 percent) and Germany (3 percent).

Figure 3.24: Pct. of Doctorate Holders Who Left the Country in the Past Decade



Source: Analysis of CBS data by Samuel Neaman Institute

4. Economic Indicators

- High-tech manufacturing generated 5.1 percent of Israel's GDP in 2010; the rate has been trending downward since 2007. Medium-high technology manufacturing contributed 2.2 percent, the same as in 2008 and up from 1.9 percent in 2009.
- In 2010, per-employee output was 1.2 times the national average in high-tech manufacturing and nearly twice the national average in medium-high technology manufacturing (the highest ratio in the world). Per-employee output in R&D and computer services in 2009 was 1.9 times the per-worker average in business services (also the world's highest ratio).
- In 2010, the average monthly wage in high-tech manufacturing and in service industries identified with high-tech was NIS 16,300—1.9 times the national average.
- In 2010, 110,700 persons were employed in high-tech manufacturing, 3.8 percent of all employees countrywide, and 163,200 in technological service industries (5.6 percent of all employees), down from 3.9 percent and 5.7 percent of all employees in 2008 and 2009, respectively.

This chapter examines several economic aspects of technological innovation: the contribution of technology-intensive industries to macroeconomic indicators such as Gross Domestic Product and business output, the relation between innovation and economic growth, and analysis of the high-tech employment market.

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

- **high-tech manufacturing**—electronic and optical equipment (including medical equipment), control and supervision equipment, office machinery and computers, aircraft, and pharmaceuticals;
- **medium-high technology manufacturing**—oil refining, petrochemicals excluding pharmaceuticals, machinery, electrical equipment and motors, and transport equipment excluding aircraft;
- **medium-low technology manufacturing**—mining and quarrying, rubber and plastic, basic metals, metal products, ferrous and nonferrous minerals, and jewelry;
- **low-tech manufacturing**—food, beverages, and tobacco; textiles; clothing; leather products; paper; printing; wood and its products; and furniture.

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

4.1 Product

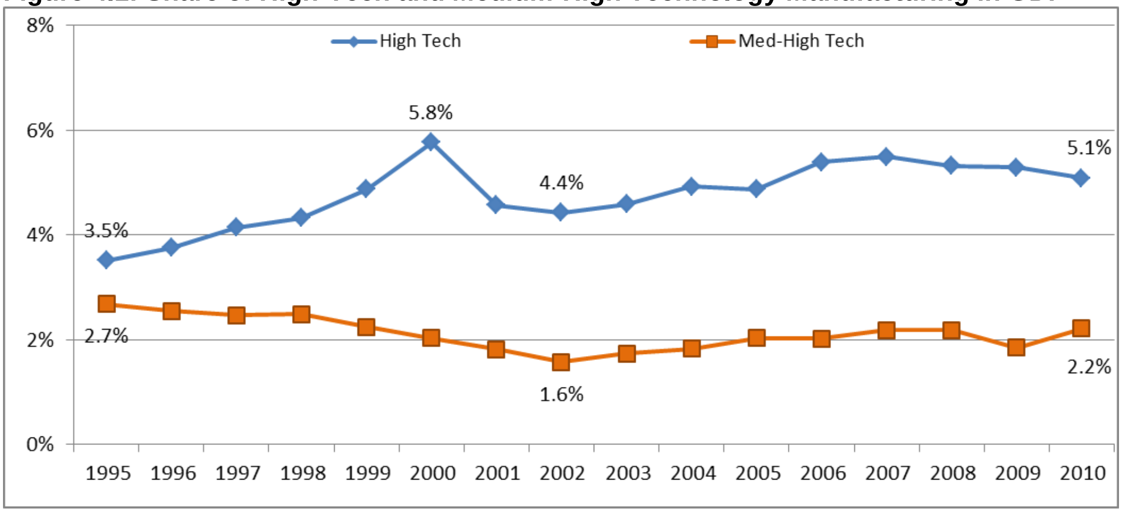
This section examines the contribution of high-tech manufacturing and knowledge- and technology-intensive service industries to various product-based indicators.

4.1.1 Gross Domestic Product

Gross Domestic Product (GDP) is crucial indicator in examining a country's macroeconomic activity. Figure 4.1 shows the share of high-tech and medium-high-technology manufacturing in Israel's GDP.

Since 2006, the proportion of high-tech manufacturing in GDP has been shrinking slowly but steadily (from 5.5 percent in 2006 to 5.1 percent in 2010). Conversely, the share of medium-high technology manufacturing has been rising, from 1.6 percent in 2002 to 2.2 percent in 2010, stopping only in 2009 due to the global economic crisis. That year, gross output of medium-high technology manufacturing slipped from 2.2 percent of GDP to 1.9 percent but, as stated, rebounded to the previous level in 2010.

Figure 4.1: Share of High-Tech and Medium-High Technology Manufacturing in GDP



Source: Analysis of CBS data by Samuel Neaman Institute

4.1.2 Business Output

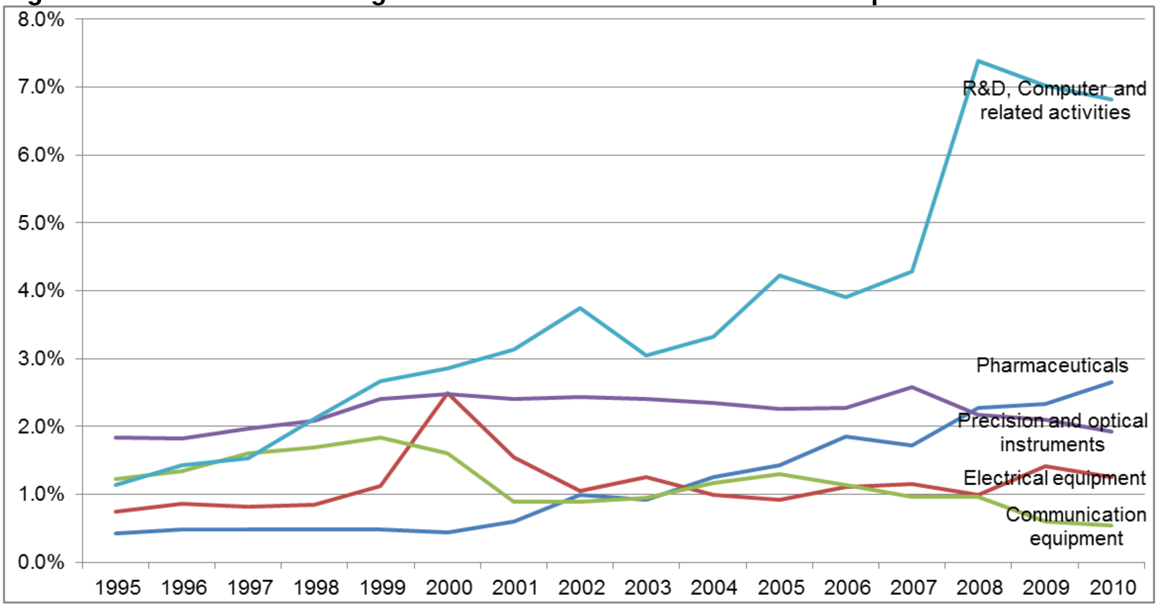
Gross Domestic Product of the business sector (business output) is total GDP net of product of the government sector, municipal authorities, the National Institutions, and nonprofit organizations, as well as housing services.

Figure 4.2 presents the share of selected industries in business output. The most conspicuous trend, of course, is a steep increase in the contribution of knowledge- and technology-intensive service industries—from 1.1 percent in 1995 to 7.4 percent in 2008. In 2009–2010, however, a slight retreat to 6.8 percent occurred. At the present writing, it is hard to stay whether this is a temporary effect of the late-2008 crisis or a change in trend.

Unlike knowledge- and technology-intensive service industries, most high-tech manufacturing industries are on the retreat. Thus, electronic components declined from 2.5 percent in 2000 to 1.3 percent in 2010. Control and optical equipment slumped from 2.5 percent to 1.9 percent in the respective years. The share of electronic communications equipment in business output also decreased, to only 0.5 percent in 2010—the lowest reading at any point of time in the measurement period.

Only pharmaceuticals countered the trend in the rest of high-tech. Its share in business output has been rising steadily since 2000—from 0.4 percent to 2.6 percent (a 550 percent increase within a decade). Even the 2008 crisis had no serious effect on the pharmaceuticals industry; its share grew from 2.2 percent to 2.3 percent between 2008 and 2009 and from 2.3 percent to 2.6 percent between 2009 and 2010.

Figure 4.2: Share of Knowledge-Intensive Industries in Business Output



Source: Analysis of CBS data by Samuel Neaman Institute

4.2 Indicators of Economic Growth

Economic growth is defined as the increase in product (usually, Gross Domestic Product—GDP) over time. In OECD countries, it is conventional to calculate economic growth by using the Solow 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, growth is the change in Y over time. The formula also shows that such a change may occur if capital and labor (K and L) increase and if improvements take place in technology, human resource quality, and the quality of equipment included in capital, thereby allowing a given quantity of capital and labor to produce more output (= more A).

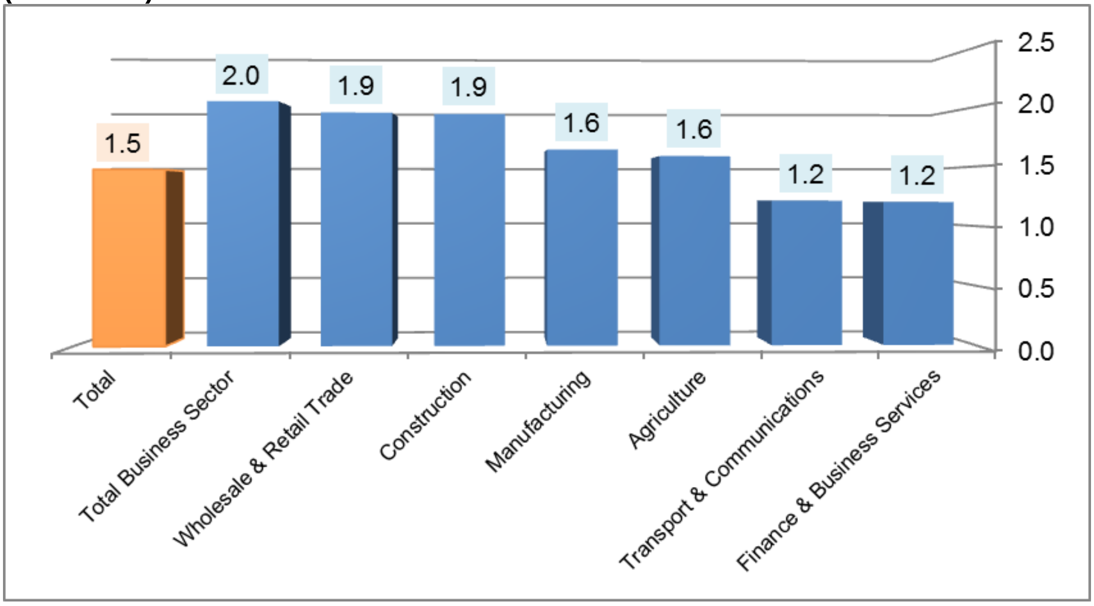
This section focuses on indicators that are strongly associated with innovation: increases in total factor productivity (TFP), labor productivity, and ICT capital.

4.2.1 Increase in Total Factor Productivity

Since any number that expresses total factor productivity (or technological level) is meaningless, an increase in TFP is generally used for economic comparisons purposes.

The growth calculation formula shows that an increase in TFP denotes an increase in growth that is not explained by growth in capital and/or labor. It is customary to connect the pace of TFP growth with technological innovation and the strength of R&D in the country/industry at issue. Since this indicator is also affected by non recurrent factors, it is best to use an average over several years, as is done in Figure 4.3.

Figure 4.3: Average Increase in Total Factor Productivity, Selected Industries, Percent (2004–2011)



Source: Analysis of CBS data by Samuel Neaman Institute

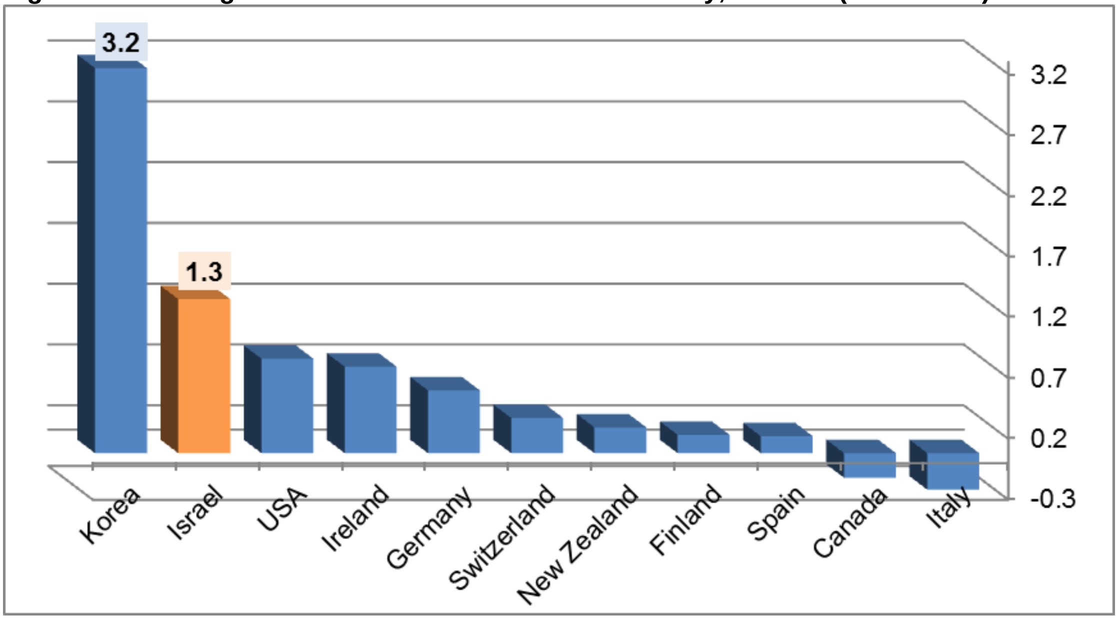
Figure 4.3 invites several conclusions. First, a multiyear average does make it possible to neutralize much of the seasonal effects. The agriculture indicator demonstrates this: the increase in agricultural TFP is not significantly different from the average in the economy as large, even though it is typified by extreme year-on-year volatility due to variances in weather. (For example, agricultural TFP rose by 20.5 percent in 2009 and decreased by April 7 percent in 2010.)

Second, building and trade, hotels, and food had higher rates of TFP increase than communications. This may have had something to do with the escalating use of advanced technologies in these industries. (See data on ICT capital stock by industries.)

It is also evident that the TCP grew more rapidly in the business-enterprise sector than in the economy at large—during the period all told and in most annual observations as well. This is probably an additional manifestation of the private sector's ability to utilize existing sources more efficiently than the government sector can.

Figure 4.4 shows Israel's TCP growth rate relative to other OECD countries. It is quite rapid, bested only by South Korea, another country that exhibits strong technological innovation.

Figure 4.4: Average Increase in Total Factor Productivity, Percent (2005–2010)



Source: Analysis of OECD.Stat & CBS data by Samuel Neaman Institute

4.2.2 <u>Labor Productivity</u>

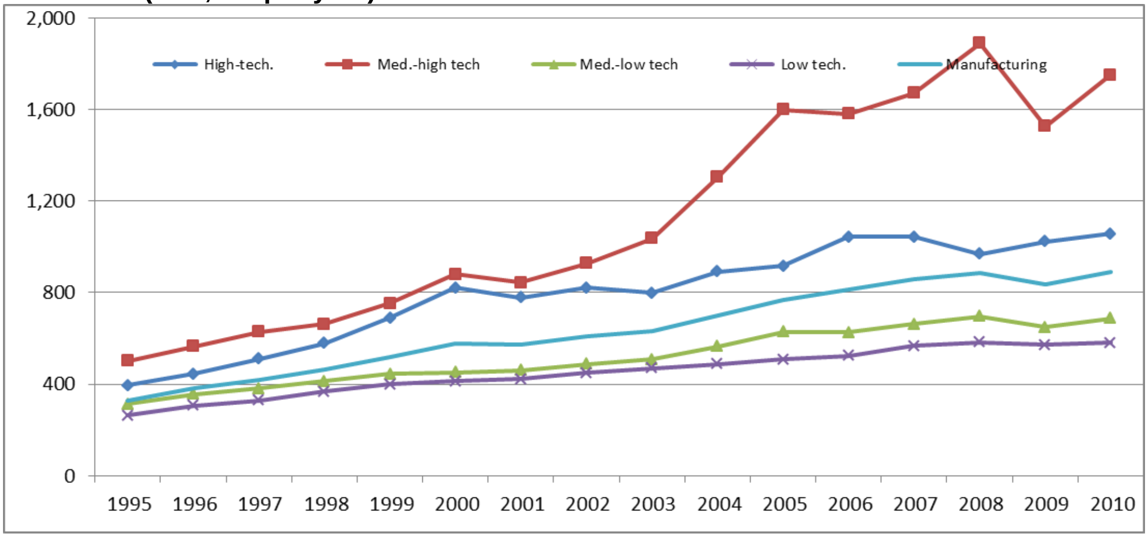
Output per employed person in an economic unit is defined as the value of goods and services produced by the unit, divided by the number of persons employed in it.

Figure 4.5 presents per-employee output in industries of varying levels of technological intensity. The data show that output in high-tech and medium-high technology manufacturing exceeded the national average in at NIS 1,057,000 and NIS 1,753,000, respectively, in 2010, as against NIS 890,000 in the economy at large.

The 2008 crisis had varying effects on these industries. Per-worker output countrywide contracted from NIS 887,000 in 2008 to NIS 836,000 in 2009 but returned to the previous level in 2010. In middle-high technology manufacturing, the decrease was steeper at 19 percent—from NIS 1,891,000 and 2008 to NIS 1,528,000 in 2009—the lowest output since 2004. An increase in 2010 did not offset the entire decline.

In high-tech manufacturing, in contrast, the crisis was not followed by any decrease. On the contrary: in 2009, per-worker output stopped falling for the first time since 2006 and advanced by 5.5 percent—from NIS 968,000 in 2008 to NIS 1,023,000. Per-worker output continued to rise in 2010, as stated.

Figure 4.5: Per-Worker Output in Manufacturing Industries by Technology Intensity, 1995–2010 (NIS ,000 per year)



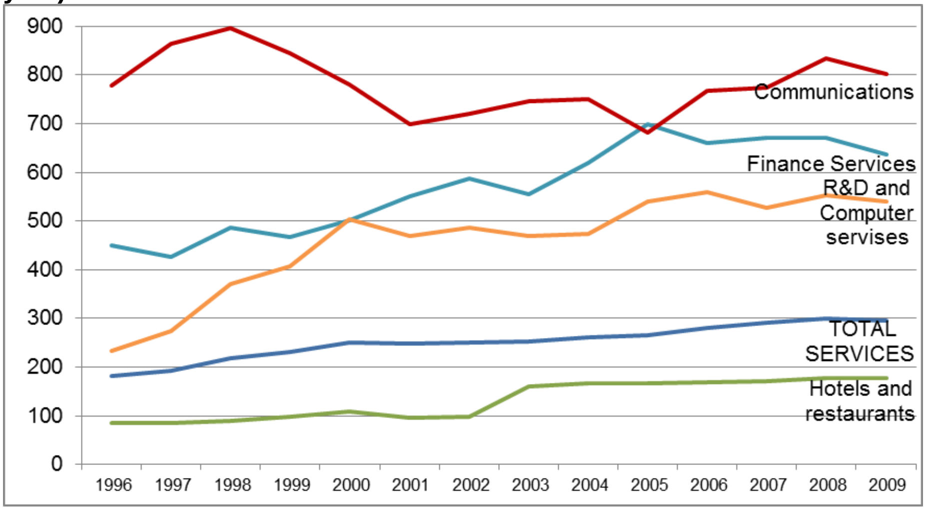
Source: Analysis of CBS data by Samuel Neaman Institute

It is also worth noting that the ratio of per-worker output in high-tech and middle-high technology manufacturing to average per-worker output in manufacturing has varied over the years. In 2000, it stood at 1.4 in high-tech and 1.5 in middle-high technology and, in 2007, at 1.2 and 2.0, respectively. The latter ratio recurred in 2010.

Figure 4.6 presents per-worker output in selected service industries. In 2009, the average was NIS 295,300 in the service sector all told, as against NIS 540,200 in computer and R&D services (1.8 times the average) and NIS 802,700 in communication services (2.7 times the average).

The figure also shows that even though per-worker output in communication services is especially high, it has hardly increased since 1996. Consequently, the ratio in average per-worker output between communication services and the total services sector has been narrowing: from 4.3 in 1996 to 3.1 in 2000 to only 2.7, as stated, in 2009.

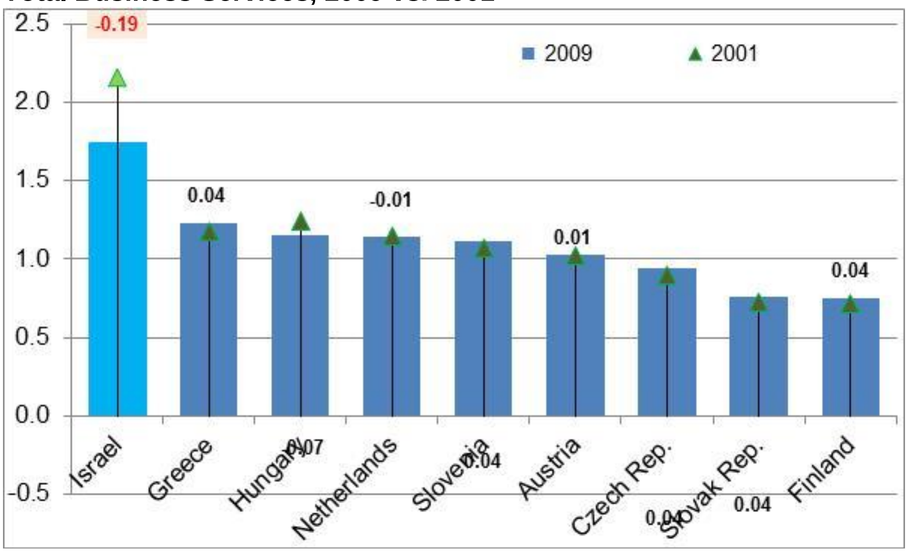
Figure 4.6: Per-Worker Output in Selected Service Industries, 1996–2009 (NIS ,000 per year)



Source: Analysis of CBS data by Samuel Neaman Institute

The ratio of per-worker output in knowledge- and technology-intensive service industries (computer and R&D services) to average per-worker output in business services is significantly higher in Israel than in other OECD countries (Figure 4.7): 1.74 in 2009, as against 1.4 in Hungary and 1.1 in the Czech Republic (the two OECD countries that had the highest output ratios). In 2001, however, Israel's output ratio was to 2.2. By 2009, the gap had narrowed by 20 percent—the steepest contraction among all OECD countries examined (Figure 4.7, numbers over arrows). Just the same, Israel's ratio of output in R&D computer services to total output per worker in this sector remains very large relative to other OECD countries (Figure 7.6).

Figure 4.7: Per-Worker Output in Computer and R&D Service Industries Relative to Total Business Services, 2009 vs. 2001



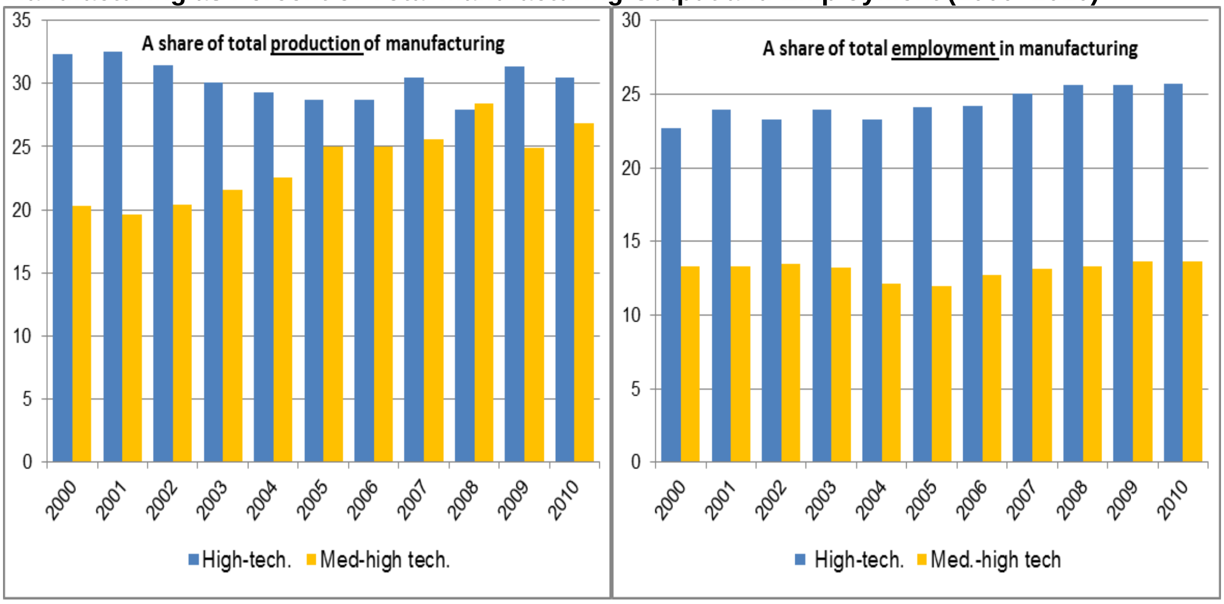
Source: Analysis of OECD.Stat & CBS data by Samuel Neaman Institute

Figure 4.8 summarizes the output and employment data in high-tech and middle-high-technology manufacturing. The share of persons employed in high-tech industries has been rising slowly but steadily—from 22.7 percent of all persons employed in manufacturing to 25.7 percent in 2010. The rate of employment in middle-high-technology manufacturing appears to be stable—13.3 percent in 2000 and 13.7 percent in 2010—but there was a decrease in between, bottoming out in 2004 (12.1 percent of all manufacturing workers) and bouncing back since then.

Conversely, the share of high-tech manufacturing output in total manufacturing output declined until 2008 (from 32.5 percent in 2001 to 28.0 percent in 2008). Conversely, middle-high-technology output increased steadily—from 19.6 percent in 2001 to 28.4 percent in 2008—outperforming high-tech.

The main adverse effect of the late-2008 crisis was on the share of middle-high-technology manufacturing output, which sank to 24.9 percent of total output in 2009 and rebounded to 26.9 percent in 2010. Accordingly, the share of high-tech manufacturing in output climbed to 31.4 percent in 2009 and fell back to 30.5 percent in 2010.

Figure 4.8: Output and Employment in High-Tech and Middle-High Technology Manufacturing as Percent of Total Manufacturing Output and Employment (2000–2010)



Source: Analysis of CBS data by Samuel Neaman Institute

In sum, per-worker output in Israel's middle-high-technology manufacturing industries is very high by other countries' standards. However, it was impaired by the 2008 crisis and its recovery from the crisis is not clear, as opposed to high-tech manufacturing, which weathered the crisis almost unscathed.

4.2.3 ICT Capital

Capital is defined as total assets used for the creation of product or income. In recent years, it is customary in statistical analyses to distinguish between ICT capital and other capital. ICT capital comprises three main components:

- stock of electronic instruments that are used for communication and information processing;
- stock of electronic instruments that are used for the identification, measurement, recording, and/or control of various processes;
- software.

ICT capital is a reliable indicator of an economy's level of innovation and use of advanced technology. Studies show that ICT investment is one of the main support factors for increases in productivity and growth.

ICT Capital Stock

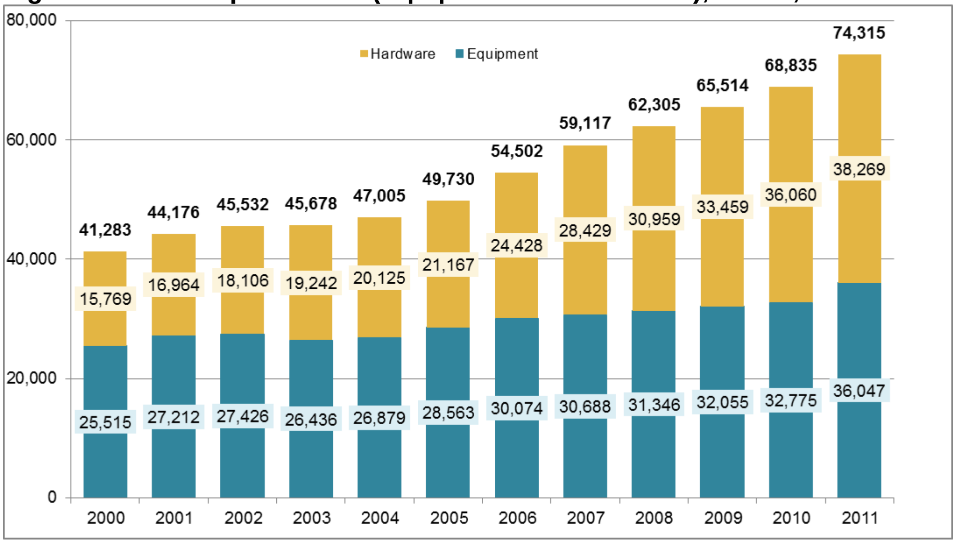
ICT capital stock has been growing rapidly in recent years (Table 4.1 and Figure 4.9), up 80 percent between 2000 and 2011. Software capital stock burgeoned by 142 percent during that time; therefore, its share in ICT capital stock has been rising steadily—to 51.5 percent in 2011, 35 percent more than in 2000.

Table 4.1: ICT Capital Stock (incl. Software)

ICT net capital stock, NIS mil. 2005 prices			**Hardware as a % of ICT Capital stock**
Year	**ICT**	Hardware	
2000	41,283	15,769	38.2%
2001	44,176	16,964	38.4%
2002	45,532	18,106	39.8%
2003	45,678	19,242	42.1%
2004	47,005	20,125	42.8%
2005	49,730	21,167	42.6%
2006	54,502	24,428	44.8%
2007	59,117	28,429	48.1%
2008	62,305	30,959	49.7%
2009	65,514	33,459	51.1%
2010	68,835	36,060	52.4%
2011	74,315	38,269	51.5%

Source: Analysis of CBS data by Samuel Neaman Institute

Figure 4.9: ICT Capital Stock (Equipment and Software), mNIS , 2005 Prices

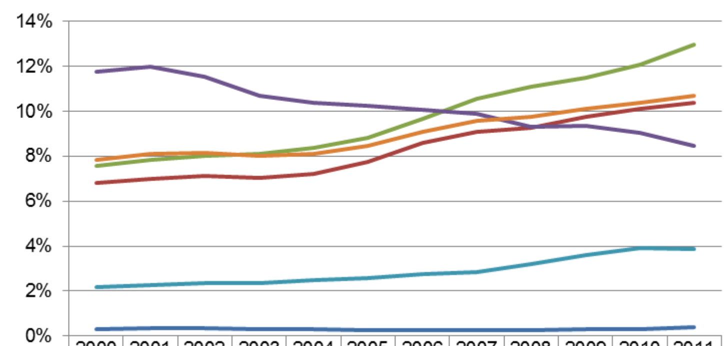


Source: Analysis of CBS data by Samuel Neaman Institute

Not only has the value of ICT capital stock increased; so has its share in net capital stock (total stock less depreciation) (Figure 4.10). The rate of increase has been accelerating since 2005. The share of ICT capital stock in total net capital stock was stable between 2000 and 2004 (average annual increase of 0.1 percent) but slanted upward between 2005 and 2011 (by 4 percent on annual average). In 2011, ICT was 10.7 percent of total net capital stock.

Figure 4.10 segments the share of ICT capital in total capital stock by industries. Thus, in transport and communication (in which most ICT industries are included), the share of ICT capital was higher than in other industries but has been diminishing as the trendy and other industries has been the opposite. In other words, this indicator shows that most industries (with the exception of agriculture) has been improving their technological level at a steadily increasing pace.

Figure 4.10: Share of ICT Capital Stock in Total Net Capital Stock, 2000–2011, by Main Industry Groups

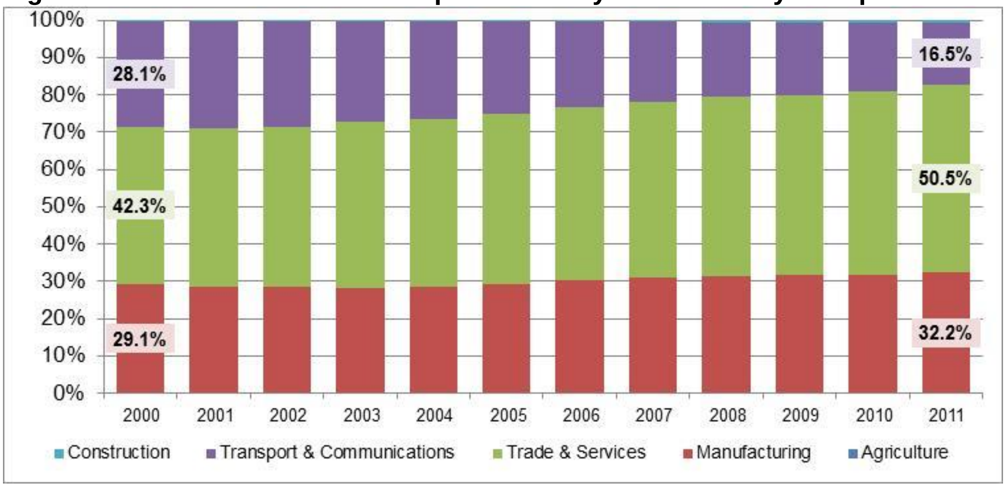


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agriculture	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.3%	0.3%	0.4%
Manufacturing	6.8%	7.0%	7.1%	7.0%	7.2%	7.8%	8.6%	9.1%	9.3%	9.8%	10.1%	10.4%
Trade & Services	7.6%	7.9%	8.0%	8.1%	8.4%	8.8%	9.7%	10.6%	11.1%	11.5%	12.1%	12.9%
Transport & Communications	11.8%	12.0%	11.5%	10.7%	10.4%	10.2%	10.1%	9.9%	9.3%	9.4%	9.0%	8.5%
Construction	2.2%	2.3%	2.3%	2.4%	2.5%	2.6%	2.8%	2.8%	3.2%	3.6%	3.9%	3.9%
Total	7.8%	8.1%	8.1%	8.0%	8.1%	8.5%	9.1%	9.6%	9.8%	10.1%	10.4%	10.7%

Source: Analysis of CBS data by Samuel Neaman Institute

The value of ICT capital stock in trade and services industries and in manufacturing has also been rising steadily. In 2011, ICT capital in trade and services was 50.5 percent of total ICT capital countrywide, at NIS 37,529 million (2005 prices) as against NIS 17,473 million (42.3 percent) in 2000 (Figure 4.11). The picture in manufacturing is similar (NIS 23,940 million, 32.2 percent of total ICT capital stock in 2011, as against NIS 12,016 million, 29.1 percent, in 2000). Conversely capital stock in transport and communication, while increasing in absolute terms (NIS 12,284 million in 2011 as against NIS 11,586 million in 2000), decreased in proportional terms, from 28.1 percent to 16.5 percent in the respective years.

Figure 4.11: Distribution of ICT Capital Stock by Main Industry Groups



Source: Analysis of CBS data by Samuel Neaman Institute

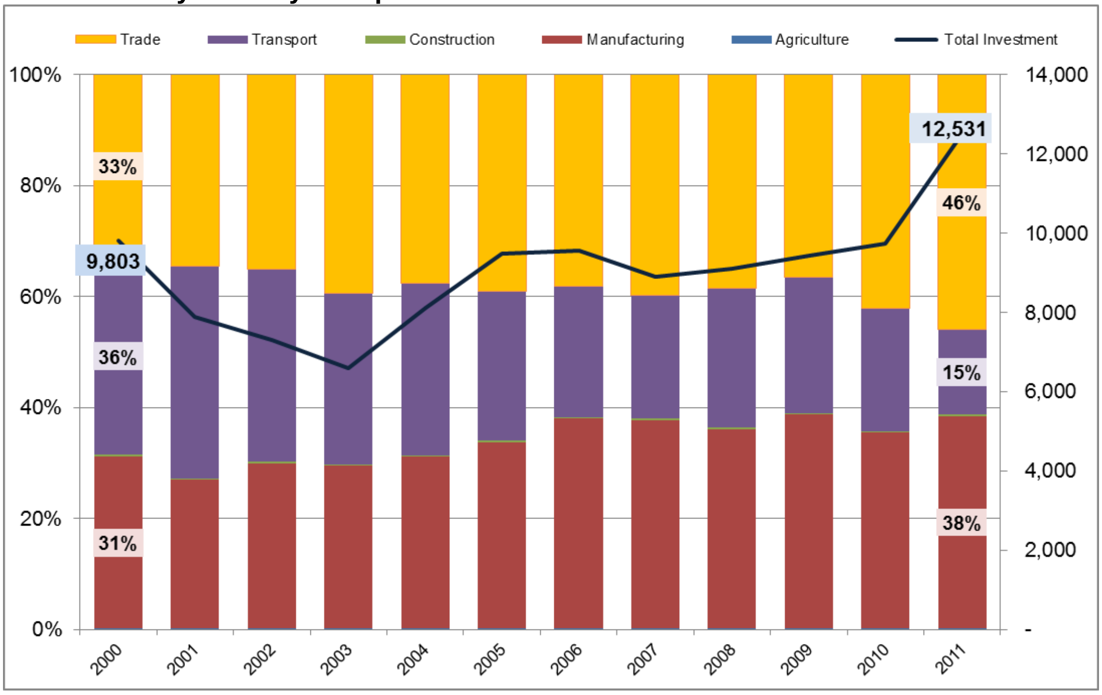
ICT Capital Investment

Since capital stock value is cumulatively defined, it is not highly sensitive and may mask short-term changes. Therefore, it is conventional to investigate not only the value of stock but also that of ICT capital investment.

Indeed, by tracking ICT capital investment one can detect an effect of the 2000 crisis and even that of the mini-crisis in 2006–2007, which other indicators failed to identify (Figure 4.12). The rate of increase in ICT capital investments slowed to less than 1 percent in 2006 (from NIS 9,489 million to NIS 9,570 million) and declined by 7 percent in 2007 (to NIS 8,899 million). After the 2008 crisis, ICT capital investment—like ICT capital stock—showed no decrease.

Similarly, the segmenting trends in ICT capital, noted in the “ICT Capital Stock” section of this report, recur in ICT capital investment. The share of ICT capital investment has been rising steadily in manufacturing and trade and services and falling steadily in transport and communication. In 2000, transport and communication were the favorite destinations of ICT capital investment (36 percent of total investment). Transport and communication was passed by investment in trade and services in 2002 (35.0 percent vs. 34.8 percent) and has been in third place since 2005.

Figure 4.12: ICT Capital Investments (excl. Software, mNIS , 2005 prices) and Distribution by Industry Groups



Source: Analysis of CBS data by Samuel Neaman Institute

The share of ICT in total fixed investment has been rising steadily (Table 4.2). Interestingly, the two recent crises—in 2003 and starting in late 2008—induced a decrease in fixed investment (e.g., buildings) but hardly affected ICT capital investment.

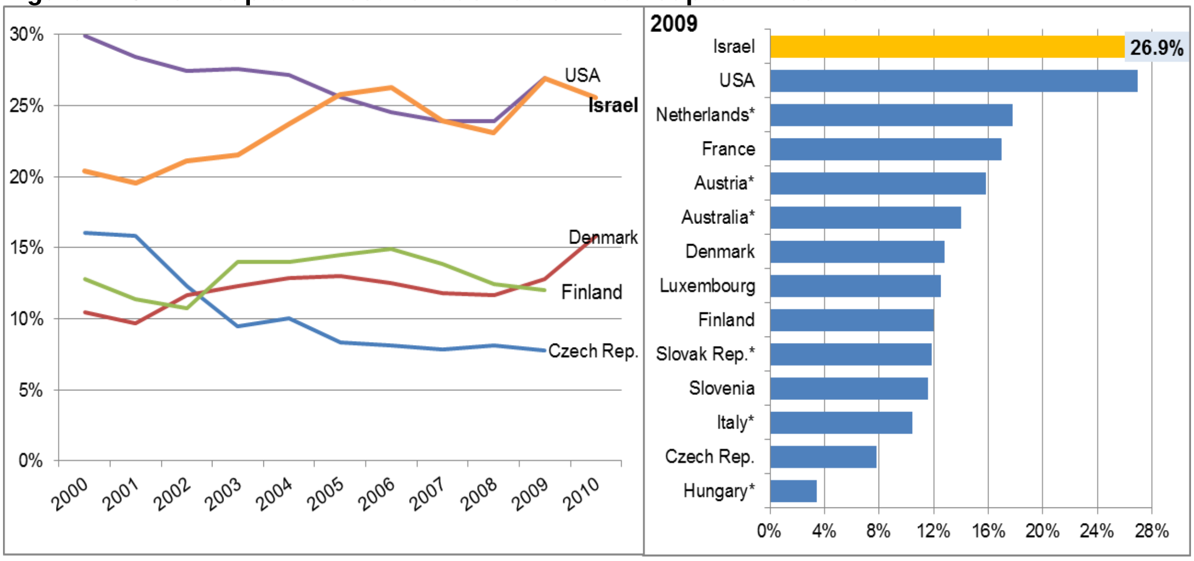
Table 4.2: ICT Capital Investment, incl. Software, mNIS and Pct. of Total Capital Investment

	ICT	Hardware	Total ICT Capital Investment	Total Investment	%
2000	9,803	6,061	15,865	77,845	20.4%
2001	7,897	7,088	14,985	76,694	19.5%
2002	7,309	7,345	14,655	69,502	21.1%
2003	6,581	7,785	14,365	66,703	21.5%
2004	8,101	7,935	16,036	67,510	23.8%
2005	9,489	8,571	18,060	70,036	25.8%
2006	9,570	11,492	21,061	80,121	26.3%
2007	8,899	13,450	22,349	93,497	23.9%
2008	9,110	13,038	22,148	96,019	23.1%
2009	9,430	14,464	23,894	88,893	26.9%
2010	9,737	15,686	25,423	99,516	25.5%
2011	12,531	16,280	28,810	117,067	24.6%

Source: Analysis of CBS data by Samuel Neaman Institute

Notably, Israel's rate of ICT capital investment in total fixed investment is high by most countries' standards. In 2009, as Figure 4.13 shows, Israel was the leader in this indicator among all OECD countries except the U.S. (which matched Israel's rate). Since 2006, however, the share of ICT capital investment in total investment has been flat with a slight downturn, as has been typical of most other OECD countries as well. Slight changes began only in 2009. That year, in several countries including Israel, the rate of ICT capital investment increased, evidently reflecting the significant decline in total investment that followed the 2008 crisis. For the time being, however, it is difficult to draw unequivocal conclusions.

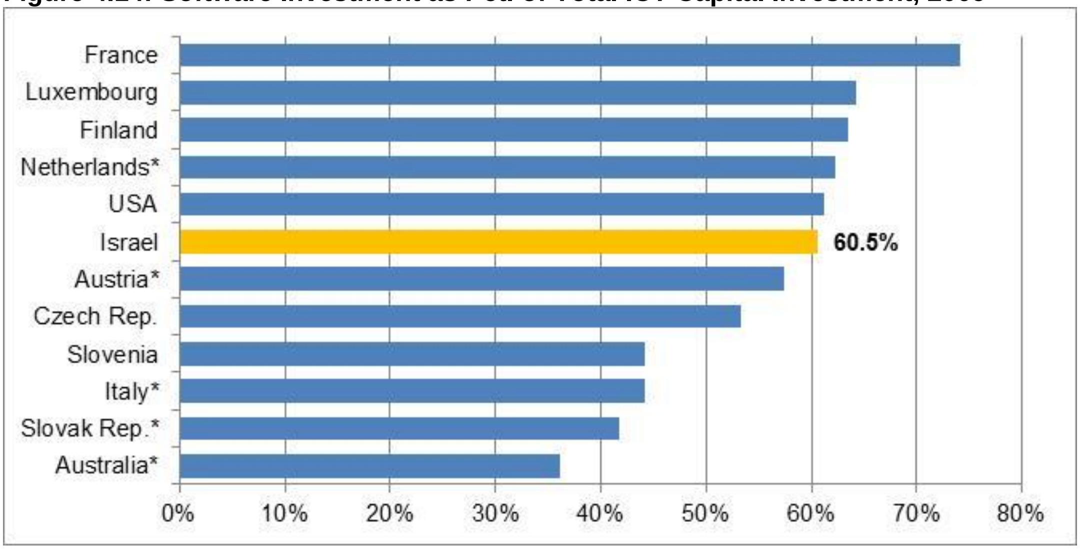
Figure 4.13: ICT Capital Investment as Pct. of Total Capital Investment



Source: Analysis of OECD. Stat & CBS data by Samuel Neaman Institute

In 2009, 60.5 percent of total ICT capital investment in Israel was made in software (Figure 4.14), approximating the OECD norm and demonstrating that Israel's ICT capital investment is not intensively concentrated in any particular field.

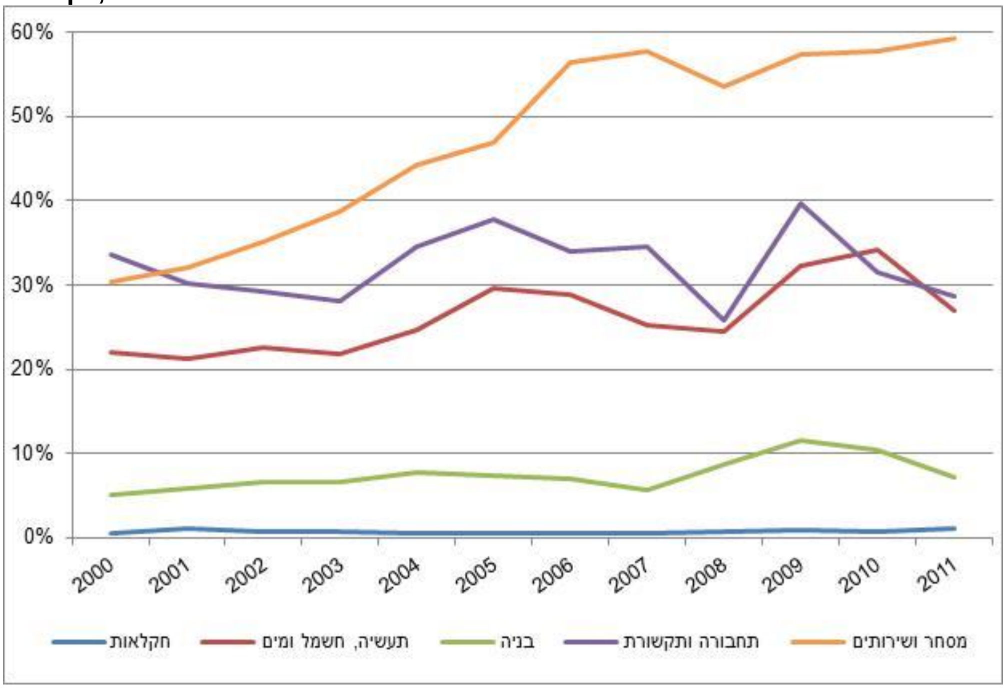
Figure 4.14: Software Investment as Pct. of Total ICT Capital Investment, 2009



Source: Analysis of OECD. Stat & CBS data by Samuel Neaman Institute

To complete the ICT investment picture, the share of this investment in various industry groups should be addressed. Figure 4.15 shows that the share of ICT investment has been rising in most industry groups (except transport and communication) but is growing fastest in trade and services—from 30.3 percent in 2000 to 59.2 percent in 2001.

Figure 4.15: ICT Capital Investment as Pct. of Total Capital Investment, by Industry Groups, 2009



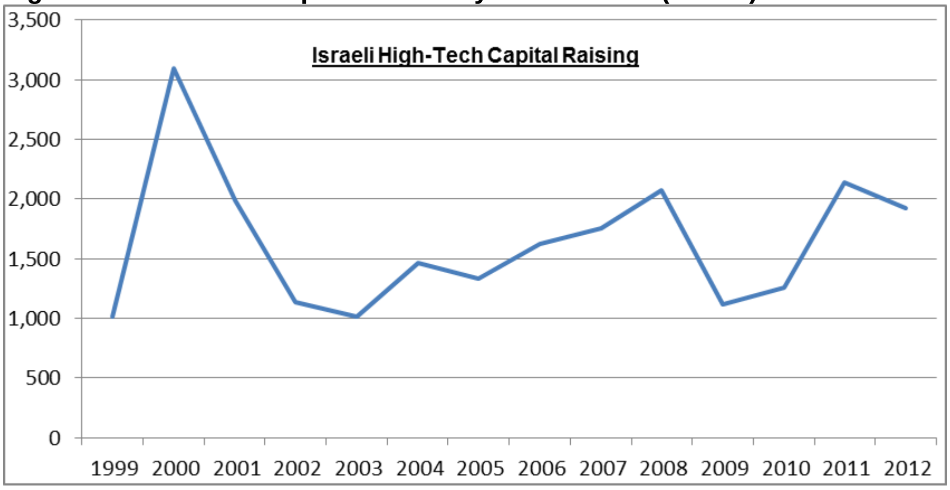
Source: Analysis of CBS data by Samuel Neaman Institute

4.3 <u>Venture Capital</u>

Venture capital (VC) funds are funds that raise money for investment in startup enterprises. Since such enterprises invest in the cutting edge of scientific research, the extent of venture capital raised is considered a good indicator of the strength of a country's R&D activity.

The 2008 crisis dealt Israel's VC market a serious blow. Between 2008 and 2009, VC raised by Israeli firms plummeted by 46 percent—from USD 2,096 million to USD 1,122 million. This was followed by a relatively mild upturn in 2009—13 percent, bringing the total to USD 1,262 million—and an additional steep 70 percent increase in 2010 and 2011 (to USD 2,136 million). In 2012, Israeli firms raised USD 1,924 million in VC (10 percent down from 2011).

Figure 4.16: Venture Capital Raised by Israeli Firms (mUSD)



Source: Analysis of IVC Research Center data by Samuel Neaman Institute

The composition of investments made by VC funds has also been varying in recent years. Table 4.3 shows that in 2009–10 the share of investment performed by firms in their final stage of project development (late revenue growth) declined and investment in mid-stage firms rose. The picture was different in 2011: a steep increase in investment at the late revenue growth stage, a decline in the early stage, and a slight contraction in mid-stage as well. The 2008 crisis appears to have abetted this volatility; this, however, is hard to determine with certainty.

Table 4.3: Venture Capital Fund Investments, by Stage (Pct.)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Seed	10%	5%	2%	6%	7%	8%	9%	9%	5%	6%	3%	5%
Early R&D	38%	41%	35%	32%	25%	28%	31%	32%	36%	30%	35%	26%
Mid	30%	32%	54%	49%	56%	53%	42%	38%	38%	49%	46%	42%
Late revenue growth	22%	22%	9%	13%	12%	11%	19%	22%	21%	16%	16%	27%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Analysis of IVC Research Center data by Samuel Neaman Institute

In contrast, changes in the research performed by firms sourced from VC funds were hardly affected by the crisis. The main trend—contraction of investment in ICT research and growing support for firms that develop life-science products—has been persisting for more than a decade. Thus, the proportions shifted from 69 percent of total investment in ICT and only 8 percent in life sciences in 2000 to 34 percent and 26 percent, respectively, in 2012.

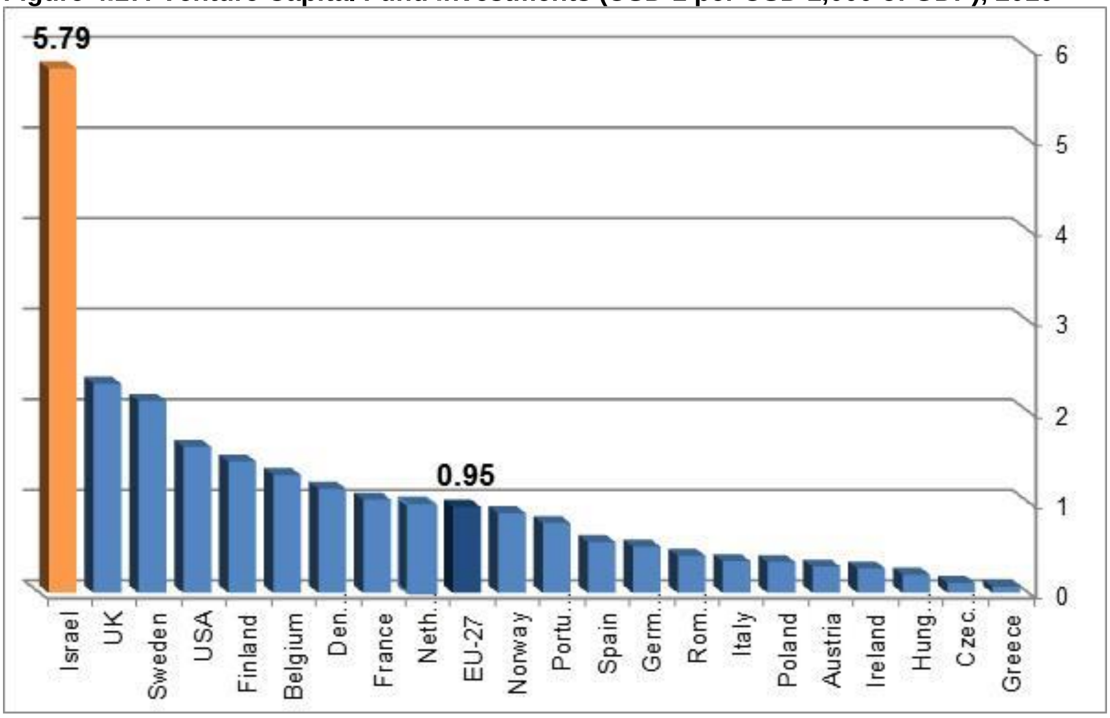
Table 4.4: Israeli Venture Capital Fund Investments, by Area of Activity (Pct.)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Communications	29%	39%	42%	37%	35%	29%	35%	24%	21%	25%	20%	19%	20%	17%
Internet	33%	30%	9%	4%	4%	4%	3%	5%	15%	14%	13%	18%	23%	17%
Software	14%	16%	20%	18%	18%	22%	17%	22%	13%	20%	23%	12%	19%	21%
Life Sciences	13%	8%	16%	15%	19%	22%	21%	23%	20%	15%	24%	28%	18%	26%
Other	11%	6%	13%	26%	24%	23%	24%	26%	31%	27%	20%	23%	19%	19%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Analysis of IVC Research Center data by Samuel Neaman Institute

In conclusion (Figure 4.17), Israel is still a VC power. In 2010, the value of VC invested in the Israeli economy was 0.58 percent of GDP—the highest rate in the world. The UK, the runner-up, generated 0.23 percent of its GDP in this manner, and the average among European Union countries was 0.1 percent.

Figure 4.17: Venture Capital Fund Investments (USD 1 per USD 1,000 of GDP), 2010



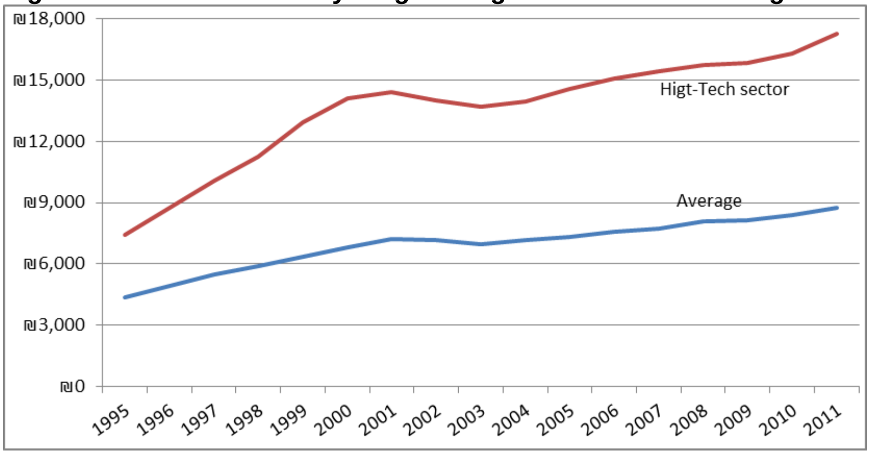
Source: Analysis of European Innovation Scoreboard 2011 ,NVCA 2012 & IVC Research Center data by Samuel Neaman Institute

4.4 Employment and Wages in Technology-Intensive Industries

This section discusses employment and wages in technology-intensive industries.

4.4.1 Wages

Figure 4.18: Gross Monthly Wage in High-Tech Manufacturing vs. National Average



Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

High-tech wages and the national average wage usually move in the same direction (Figure 4.18) and at similar rates (Table 4.3). Since 1999, however, high-tech manufacturing and high-tech-service wages have been 1.9–2.0 times above the national average. In several individual years, wages in ICT manufacturing industries were slightly higher—up to 2.1 times. Analysis of the data in the table also shows that the gap between high-tech-service wages and the national average narrowed slightly in 2010 but widened again in 2011.

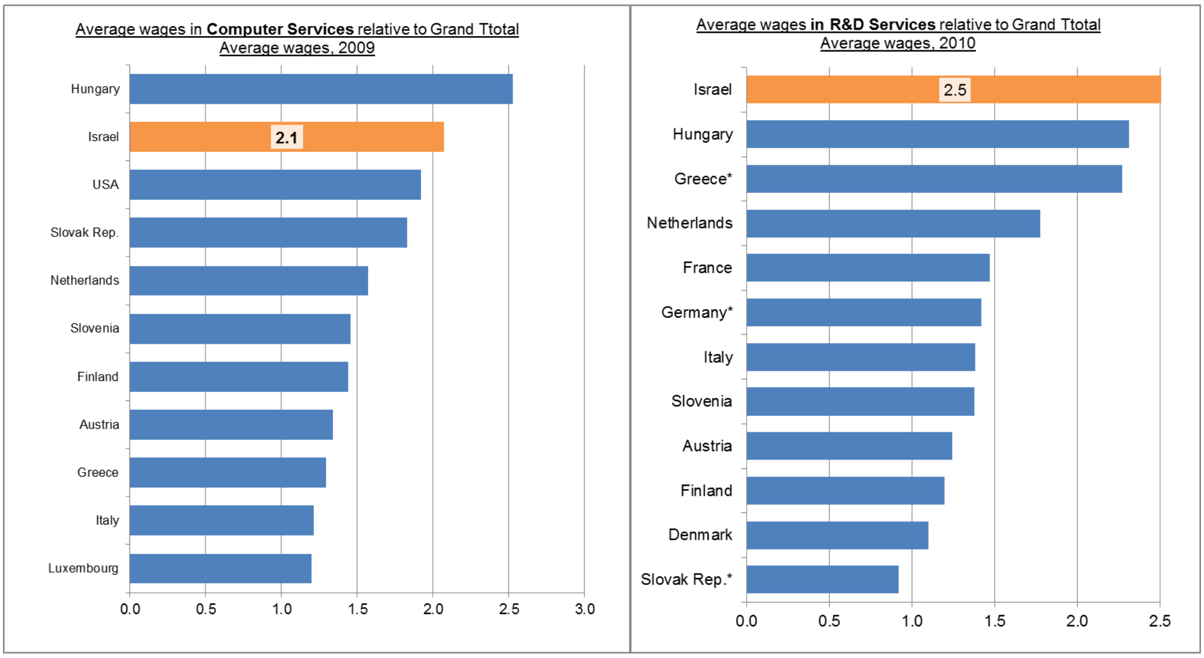
Table 4.5: Average Monthly Gross Wage in High-Tech vs. National Average

	GRAND TOTAL	High-tech Manuf.	Knowledge Intensive Services	ICT Manuf.	ICT Services	High-tech Manuf.	High-tech Services	ICT Manuf.	ICT Services
	(NIS)	NIS				Relative to average wages			
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
2010	8,414	16,304	16,326	16,871	16,326	1.9	1.9	2.0	1.9
2011	8,741	16,787	17,058	17,510	17,058	1.9	2.0	2.0	2.0

Source: Analysis of CBS data by Samuel Neaman Institute

Before the change described in Table 4.5, in 2009–10 wages per worker in some service industries (Divisions 72 and 73) were very high even by world standards. In 2010, as Figure 4.19 shows, R&D wages in Israel were 2.5 times greater than the national average—the highest among OECD countries. In computer services, too, the average wage is around 2.1 times the national average—high by other countries' standards although not the highest; in Hungary, wages in computer services in 2009 were 2.5 times the national average.

Figure 4.19: Gross Wage in R&D and Computer Services vs. National Average—Cross-Country Comparison



Source: Analysis of OECD. Stat & CBS data by Samuel Neaman Institute

4.4.2 Jobs

In previous reports, we cited the steady increase in high-tech employment as one of the signs of the development of this sector. Indeed, between 1995 and 2008, employment in technological manufacturing and service industries increased by 6.1 percent per year in an almost linear fashion (in contrast to 1999–2003, which included a spurt and a decline) and came to 269,700 in 2008 (9.6 percent of employees countrywide). Notably, an important factor in this increase was the growth of the service industries,[30] which have accounted for the majority of jobs in Israeli high-tech since 2000. In 2008, 158,900 people were working in service industries—5.7 percent of employees countrywide and 59 percent of high-tech employees.

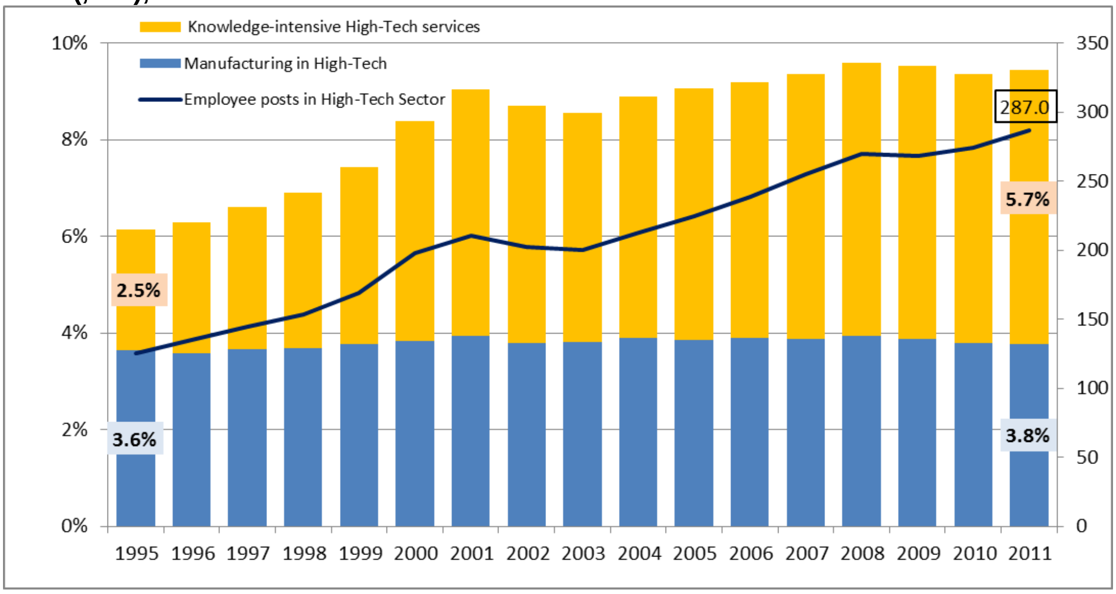
The crisis that began in late 2008 apparently had a substantial effect on employment in this sector. In 2009, the number of jobs in Israel high-tech actually contracted by 0.5 percent, to 268,300. The shares of technological services and high-

[30] Communication services, R&D services, and computer services.

tech manufacturing hardly changed, remaining at 5.7 and 3.9 percent of total employee posts, respectively.

In 2010, high-tech headcount increased by 2 percent but the proportion of high-tech employees among employees countrywide declined in both services and manufacturing (25.6 percent and 3.8 percent—Figure 4.20) because the number of employee posts countrywide grew more vigorously: by 3.29 percent (from 2,815,900 in 2009 to 2,924,600 in 2010, up 109,000).

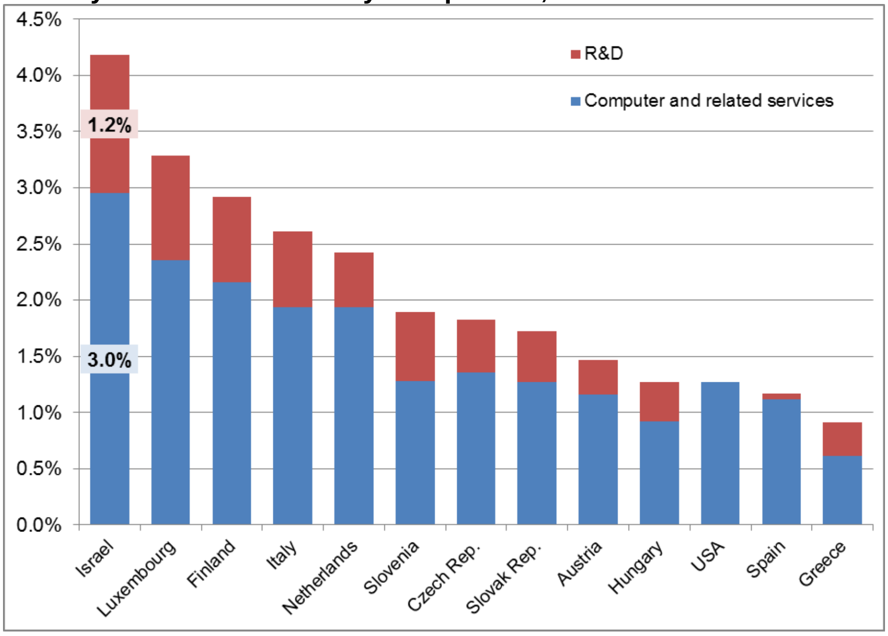
Figure 4.20: Share of High-Tech Employment in National Employment and High-Tech Jobs (,000), 1995–2011



Source: Analysis of CBS data by Samuel Neaman Institute

The high proportion of jobs in technology-intensive services in Israel also stands out when the country is compared with its peers (Figure 4.19). The shares of employed persons in R&D services and computer services are also among the highest in the OECD class. Thus, in 2009, 3.0 percent of employees in Israel were employed in computer services as against 2.2 percent in Finland and 1.9 percent in Italy and the Netherlands. In the same year, 1.2 percent of Israeli employees worked in the R&D industry —as against 0.8 percent in Finland, 0.7 percent in Italy, 0.6 percent in Slovenia, and 0.5 percent in the Netherlands, the Czech Republic, and Slovakia. If so, Israel appears to have evolved from a “high-tech power” into a “high-tech services power.”

Figure 4.21: Share of Employees in Selected High-Tech Industries among Employees Countrywide—Cross-Country Comparison, 2009



Source: Analysis of OECD. Stat & CBS data by Samuel Neaman Institute

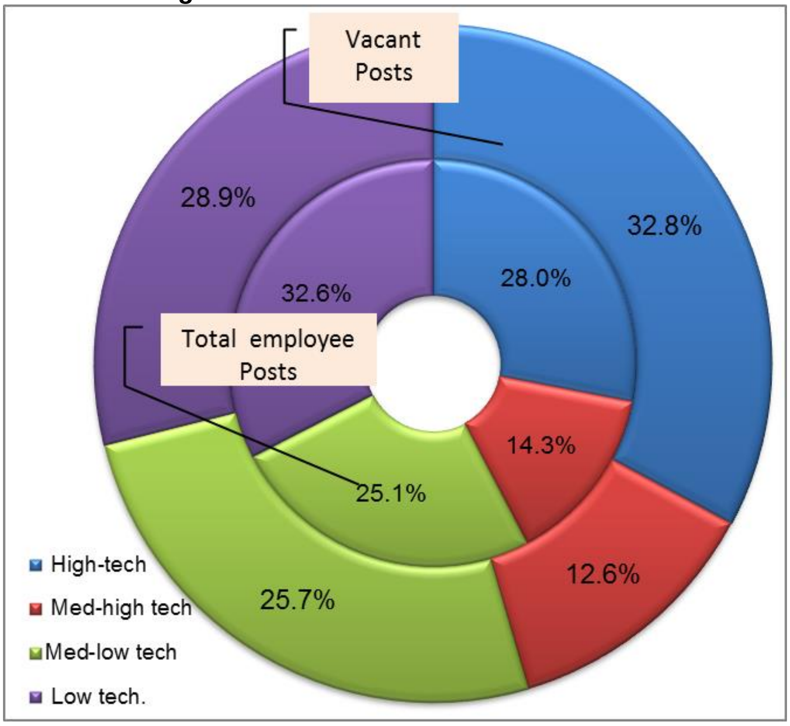
4.4.3 Vacant Posts

CBS defines as a "vacant post" a post that is vacant or about to become vacant, or a newly created post intended for personnel from outside the organization and for which the employer is actively seeking workers. The definition excludes posts intended for people within the system and volunteer posts.

The purpose of this indicator, as CBS defines it, is to examine trends of macroeconomic expansion/contraction. For this purpose, long-term observation analysis is desired because it neutralizes the effects of natural turnover and temporary or seasonal factors. However, the possibility of drawing conclusions from these observations remains limited because (1) CBS began to keep systematic track of vacant posts countrywide only in January 2010 and (2) sampling error in this surveillance is relatively high. Generally speaking, then, the number of vacant posts grew from 40,500 in January 2010 to 69,160 in December 2011. Vacant posts in manufacturing were 11–15 percent of the total; those in miscellaneous service industries were 68–80 percent. The latter class includes all service industries—from trade services (Division E) to community services (Division M). The share of vacant posts in business services (Division I) ranged from 20–26 percent of all posts (28–35 percent of all employee posts in services).

Most vacant posts are in high-tech and low-tech industries (Figure 4.22), in which a large share of workers is employed. However, there is a difference between them. The share of high-tech manufacturing in vacant posts offered in 2010–2011 exceeds its share in total posts (32.8 percent vs. 28.0 percent, respectively). The share of low-tech manufacturing in vacant posts in 2010–2011, in contrast, was below its proportion in total posts (28.9 percent vs. 32.6 percent, respectively).

Figure 4.22: Vacant Posts and Total Posts in Manufacturing, by Technology Intensity, 2010–2011 Avg.

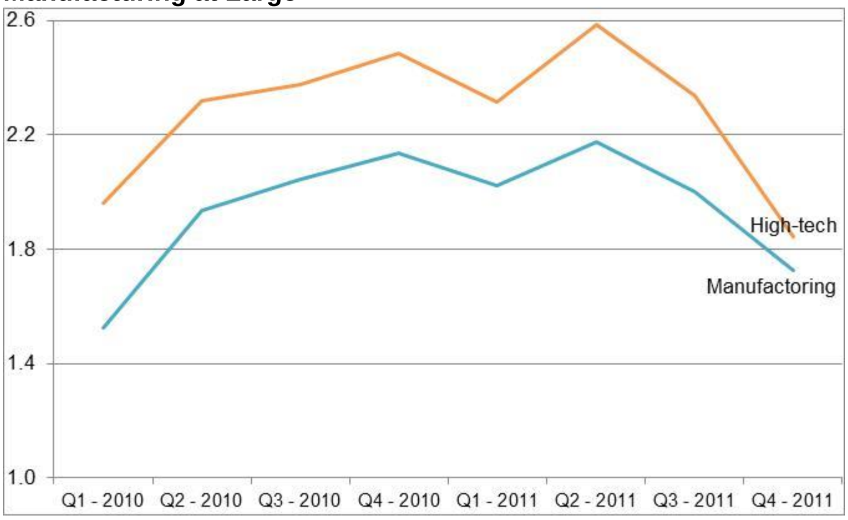


Source: Analysis of CBS data by Samuel Neaman Institute

The monthly data also show that high-tech manufacturing accounted for a larger share of vacant posts than of total posts and that the opposite was the case in low-tech manufacturing. In the other manufacturing classes, the difference fell into the range of statistical error and was consistent throughout the 2010–2011 period.

There are more vacant posts, relative to total posts, in high tech than in manufacturing at large. Also, the share of vacant posts in high-tech manufacturing and manufacturing at large changes in tandem (Figure 4.23).

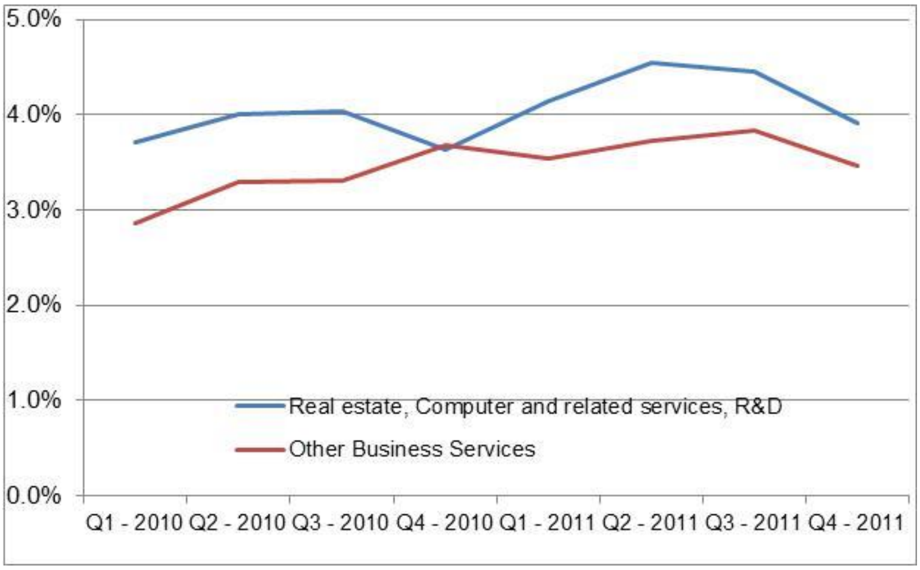
Figure 4.23: Share of Vacant Posts in Total Posts, High-Tech Manufacturing and Manufacturing at Large



Source: Analysis of CBS data by Samuel Neaman Institute

CBS tracks vacant posts in the business service industries by breaking the total into real-estate services, computers, and R&D, and recruitment, personnel, security services, cleaning, other business activities. One may view this as a division into knowledge-intensive services (real estate, computers, and R&D) and other services, but the differentiation is not as clear-cut as the customary sectorization in manufacturing.

Figure 4.24: Vacant Posts in Total Posts, Business Services and Selected Industries



Source: Analysis of CBS data by Samuel Neaman Institute

In 2010–2011, 36 percent of all posts in business services and 42 percent of vacant posts were in knowledge-intensive service industries. The rate of vacant posts in total posts in real-estate, computer, and R&D services during that time was also usually above the average in business services and also in high-tech manufacturing industries.

By and large, the share of vacant posts in knowledge- and technology-intensive industries exceeds the national average. This may identify these industries as more dynamic than the rest and more rapid in their development. As stated, however, the available data do not sustain such an unequivocal statement.

5. Science and Technology Outputs

5.1 Patents[31]

A patent is a legal right to own intellectual property, issued to inventors by authorized entities in each country. A patent is usually valid for twenty years from the day the application is registered, although patents do have to be renewed periodically under the rules of the registering country. The various countries' patent laws grant inventors a monopoly on their inventions to encourage private enterprise so that inventions may be developed and the attendant economic and intellectual investment made. A patent application includes details about the applicants (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 it). The application also includes previously published relevant knowledge. To be patented, an invention must 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 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 are also helpful in disseminating knowledge. Among the few existing measurable indicators of technological output, the patent index is the most common. 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.

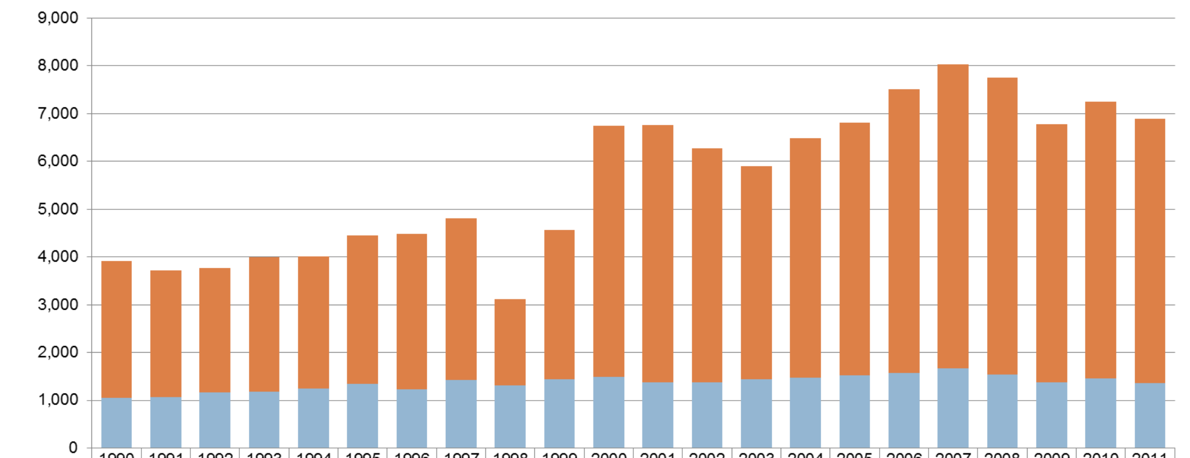
5.1.1 Applications Submitted to the Israel Patent Authority

The Israel Patent Authority (IPA) provides intellectual property in manufacturing with legal protection by registering patents for applicants from Israel and abroad. Figure 5.1 shows the number of patent applications submitted to the IPA by origin (Israel/abroad) in 1990–2011.

[31] For elaboration on R&D outputs, see Getz, D., et al. (2013), *Research and Development Outputs in Israel: Scientific Publications by International Comparison, 1990–2011* (Hebrew).

As Figure 5.1 shows, 2007 was the record year in patent applications, both domestic and foreign. The steep decrease in patent applications in 1998 was evidently technical, tracing to the assimilation of a new automatic counting system for patent applications (replacing the previous manual counting method).[32] Since 2000, the number of patent applications from abroad has been rising significantly; this is associated with the implementation of the PCT[33] in Israel. Seventy-nine percent of patent applications submitted in the past decade (2001–2011) originated in other countries (60,222), leaving the share of Israeli applications at only 21 percent (16,173). In 1990–2000, by comparison, foreign applications were 71 percent of the total.

Figure 5.1: Patent Applications in Israel, by Origin, 1990–2011



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	6,207	5,390	5,800	5,523
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	1,539	1,379	1,449	1,363

Getz, D., Leck, E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

5.1.2 Applications with International Patent Offices

The following tables present total patent applications with the American and European patent offices (USPTO and EPO, respectively), segmented by Israel and other countries. Importantly, USPTO bases its classification of applications on the country that appears in the inventor's address (or, if several investors are listed, on the country shown in the first inventor's address). EPO credits each patent once to each of the applicant investors' countries. Since the comparison that follows includes small countries, large countries, and an aggregate of European countries (EU-27),

[32] Source of information: interview with Ms. Simona Aharonovich of the Israel Patent Authority (see Getz et al., 2011).

[33] 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.

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 5.1: Patent Applications to USPTO, by Inventor's Country, 1998–2011

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	135,483	149,825	164,795	177,511	184,245	188,941	189,536	207,867	221,784	241,347	231,588	224,912	241,977	247,750
Germany	13,885	16,978	17,715	19,900	20,418	18,890	19,824	20,664	22,369	23,608	25,202	25,163	27,702	27,935
Korea	5,452	5,033	5,705	6,719	7,937	10,411	13,646	17,217	21,685	22,976	23,584	23,950	26,040	27,289
Canada	5,689	6,149	6,809	7,221	7,375	7,750	8,202	8,638	9,652	10,421	10,307	10,309	11,685	11,975
UK	6,110	6,948	7,523	8,362	8,391	7,700	7,792	7,962	8,342	9,164	9,771	10,568	11,038	11,279
Israel	1,442	2,009	2,509	2,710	2,645	2,539	2,693	3,157	3,657	4,410	4,550	4,727	5,149	5,436
Sweden	2,359	2,570	2,825	2,827	2,410	2,314	2,270	2,243	2,680	3,164	3,265	3,515	3,840	4,140
Finland	970	1,376	1,530	1,840	1,811	1,935	2,096	2,032	2,383	2,444	2,621	2,610	2,772	2,551
Belgium	1,059	1,204	1,245	1,286	1,293	1,395	1,309	1,460	1,546	1,766	1,609	1,846	2,084	2,115
Singapore	336	460	632	786	807	771	879	919	1,143	1,188	1,266	1,225	1,540	1,564

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

Table 5.2: Patent Applications to EPO, by Inventor's Country, 1997–2010

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU-27	40,964	45,025	49,166	51,799	51,548	51,511	52,922	55,332	56,890	58,075	57,876	56,007	53,811	53,972
U.S.A.	26,265	28,733	31,045	32,046	31,564	32,936	33,687	35,202	36,167	33,768	30,582	28,738	27,719	27,611
Germany	17,568	19,629	21,019	22,179	22,011	21,882	22,218	23,146	23,967	24,015	24,117	22,797	22,017	22,421
UK	4,621	5,218	5,838	6,089	5,685	5,635	5,660	5,589	5,637	5,774	5,553	5,253	5,033	4,876
Korea	660	931	1,050	1,272	1,639	2,349	3,335	4,461	5,117	5,130	4,525	3,884	4,526	4,785
Sweden	2,063	2,086	2,214	2,300	2,153	2,065	2,053	2,229	2,408	2,600	2,754	2,711	2,568	2,625
Canada	1,238	1,418	1,626	1,697	1,750	1,819	1,915	2,264	2,429	2,356	2,232	2,061	2,184	2,202
Belgium	1,159	1,167	1,347	1,320	1,217	1,336	1,365	1,513	1,509	1,534	1,552	1,472	1,414	1,524
Finland	1,022	1,181	1,428	1,434	1,410	1,284	1,287	1,382	1,318	1,337	1,254	1,241	1,225	1,261
Israel	648	797	830	1,065	963	940	1,058	1,208	1,397	1,281	1,195	1,182	1,061	1,036
Singapore	74	112	140	148	195	191	228	267	254	265	252	267	231	247

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

Comparison of the two tables reveals the primacy of USPTO as the location where Israeli invention activity is presented (4.8 times more applications to USPTO than to EPO in 2010). The disparity between USPTO and EPO is smaller among other countries. One explanation for the disparity has to do with the large extent of invention activity by foreign R&D centers in Israel, most of which are owned by American firms (Intel, Microsoft, Applied Materials, Hewlett-Packard, etc.). Since these are applications by *Israeli inventors* (and not by assignees), they are defined as Israeli inventions that belong to foreign assignees (80 percent of whom are American).

Table 5.3 shows the number of patent applications to USPTO per million of population among selected countries in 1998–2011; Table 5.4 compares the same countries in applications to EPO in 1997–2010. In this indicator, Israel ranks higher at USPTO than at EPO among the countries listed, because many more Israeli applications are filed in the U.S. than in Europe. At USPTO, the U.S. (the "home team") is first in per-capita applications (782 applications per million of population in 2010), followed by Israel (675). In 2010, Israeli inventors filed 136 patent applications per million of population with EPO (fifth in the standings). In 2010, Sweden was the leader in applications to EPO (280 per million of population), followed by Germany, Finland, and Belgium.

Table 5.3: Patent Applications to USPTO per Million of Population, by Inventor's Country, 1998–2011

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	491	537	584	623	641	651	647	703	743	801	762	733	782	793
Israel	242	328	399	421	403	380	396	456	518	614	623	631	675	703
Korea	118	108	121	142	167	218	284	358	448	473	482	487	527	549
Finland	188	266	296	355	348	371	401	387	453	462	493	489	517	476
Sweden	267	290	318	318	270	258	252	248	295	346	354	378	409	443
Singapore	106	142	193	236	239	229	258	269	330	337	353	336	406	413
Canada	189	202	222	233	235	245	257	268	296	316	309	306	343	349
Germany	169	207	215	242	248	229	240	251	272	287	307	307	339	340
Belgium	104	118	121	125	125	134	126	139	147	166	150	171	191	195
UK	104	118	128	141	141	129	132	134	140	152	161	173	180	185

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

Table 5.4: Patent Applications to EPO per Million of Population, by Inventor's Country, 1997–2010

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sweden	233	236	250	259	242	231	229	248	267	286	301	294	276	280
Germany	214	239	256	270	267	265	269	281	291	292	293	278	269	274
Finland	199	229	276	277	272	247	247	264	251	254	237	234	230	235
Belgium	114	114	132	129	118	129	132	145	144	145	146	137	131	140
Israel	111	133	136	169	150	143	158	177	202	182	167	162	142	136
EU27	86	94	102	107	107	106	109	113	116	118	117	113	108	108
Korea	14	20	23	27	35	49	70	93	106	106	93	79	92	97
USA	96	104	111	114	111	115	116	120	122	113	102	95	90	89
UK	79	89	99	103	96	95	95	95	95	97	92	87	83	79
Singapore	24	35	43	45	59	57	68	78	74	76	71	75	63	65
Canada	41	47	53	55	56	58	61	71	75	72	68	62	65	65

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute for Advanced Studies in Science and Technology, Technion-Israel Institute of Technology, Haifa (in Hebrew).

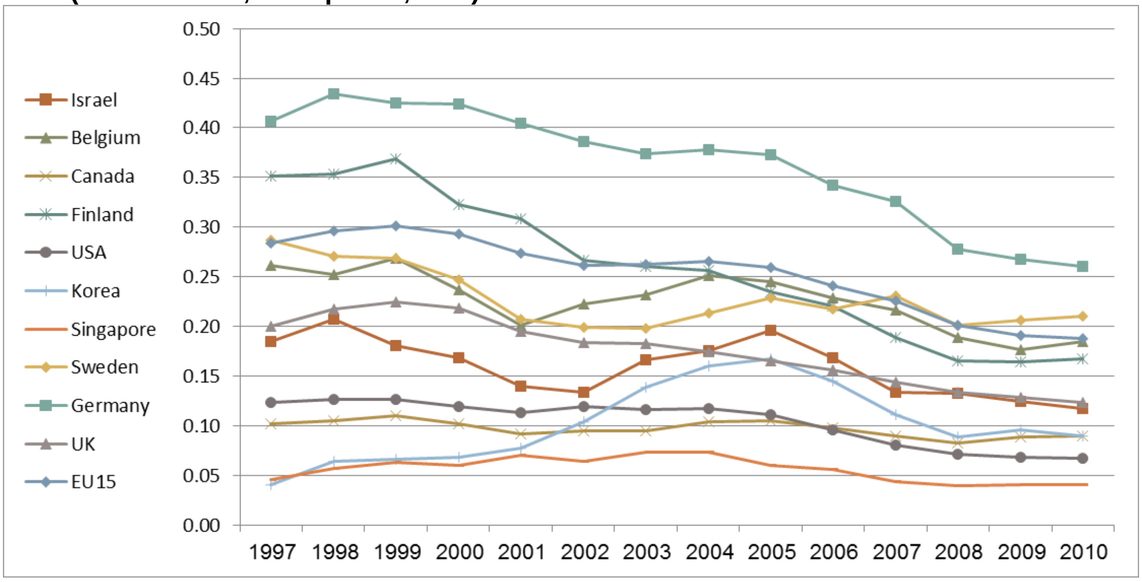
The next indicator presented is the number of patent applications normalized to R&D investment. This indicator, an expression of the ratio of inputs to outputs, may give evidence of the efficiency of a country's R&D system. Table 5.5 and Figure 5.2 show the number of patent applications to EPO by the countries listed above per USD 1 million (in 2000 prices, PPP) of investment R&D in 1997–2010. Table 5.6 and Figure 5.3 do the same for applications to USPTO in 1998–2011. In 2010, Israeli investors EPO presented with 0.12 patent applications per USD 1 million in R&D investment, as against 0.58 applications to USPTO. Comparing the countries examined, the leader in patent applications to EPO is Germany, at 0.26 per USD 1 million of R&D investment (2010); Israel was in the seventh place only. At USPTO, Israel was in second place (2010) among the countries examined, bested only by the U.S. The impressive ascendancy of South Korea is visible in this indicator, too. Importantly, this metric is far from a direct indicator of R&D productivity because it fails to take account of cross-country differences in the costs of these activities. Furthermore, it is affected by inventors' strategic and economic considerations that have nothing whatsoever to do with R&D productivity.

Table 5.5: Patent Applications to EPO Relative to National R&D Expenditure, 1997–2010 (USD millions, 2000 prices, PPP)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Germany	0.41	0.43	0.43	0.42	0.4	0.39	0.37	0.38	0.37	0.34	0.33	0.28	0.27	0.26
Sweden	0.29	0.27	0.27	0.25	0.21	0.2	0.2	0.21	0.23	0.22	0.23	0.2	0.21	0.21
EU15	0.28	0.3	0.3	0.29	0.27	0.26	0.26	0.27	0.26	0.24	0.23	0.2	0.19	0.19
Belgium	0.26	0.25	0.27	0.24	0.2	0.22	0.23	0.25	0.24	0.23	0.22	0.19	0.18	0.18
Finland	0.35	0.35	0.37	0.32	0.31	0.27	0.26	0.26	0.24	0.22	0.19	0.17	0.16	0.17
UK	0.2	0.22	0.23	0.22	0.19	0.18	0.18	0.17	0.17	0.16	0.14	0.13	0.13	0.12
Israel	0.18	0.21	0.18	0.17	0.14	0.13	0.17	0.18	0.2	0.17	0.13	0.13	0.12	0.12
Korea	0.04	0.06	0.07	0.07	0.08	0.1	0.14	0.16	0.17	0.15	0.11	0.09	0.1	0.09
Canada	0.1	0.1	0.11	0.1	0.09	0.1	0.1	0.1	0.11	0.1	0.09	0.08	0.09	0.09
USA	0.12	0.13	0.13	0.12	0.11	0.12	0.12	0.12	0.11	0.1	0.08	0.07	0.07	0.07
Singapore	0.05	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.06	0.06	0.04	0.04	0.04	0.04

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

Figure 5.2: Patent Applications to EPO Relative to National R&D Expenditure, 1997–2010 (USD millions, 2000 prices, PPP)



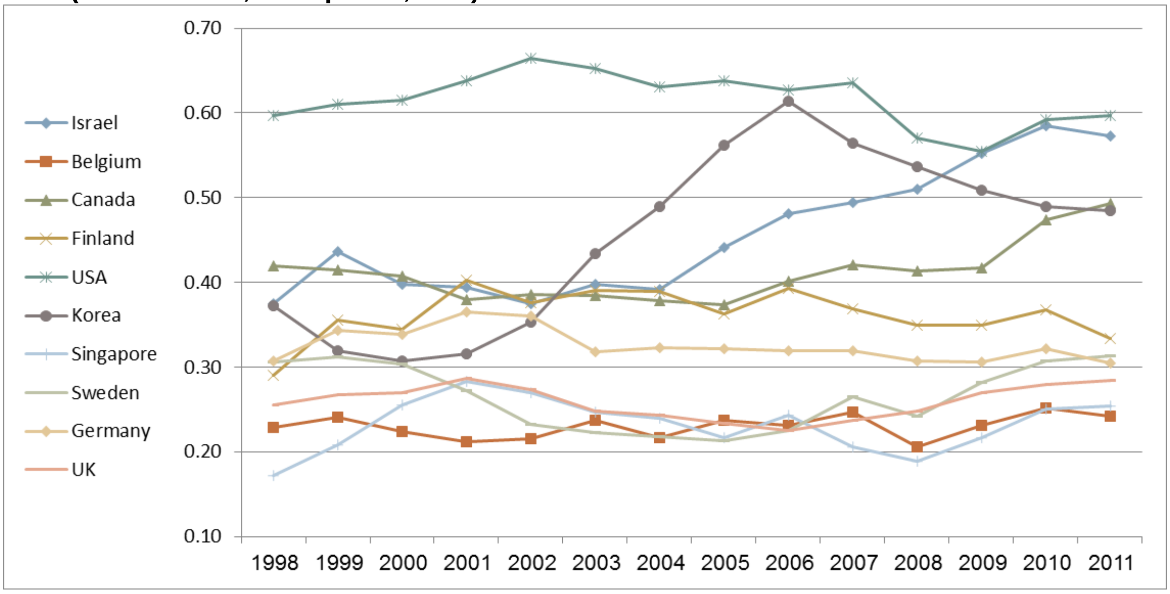
Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

Table 5.6: Patent Applications to USPTO Relative to National R&D Expenditure, 1998–2011 (USD millions, 2000 prices, PPP)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	0.6	0.61	0.61	0.64	0.66	0.65	0.63	0.64	0.63	0.63	0.57	0.56	0.59	0.6
Israel	0.38	0.44	0.4	0.39	0.38	0.4	0.39	0.44	0.48	0.49	0.51	0.55	0.58	0.57
Canada	0.42	0.42	0.41	0.38	0.39	0.38	0.38	0.37	0.4	0.42	0.41	0.42	0.47	0.49
Korea	0.37	0.32	0.31	0.32	0.35	0.43	0.49	0.56	0.61	0.56	0.54	0.51	0.49	0.49
Finland	0.29	0.36	0.34	0.4	0.38	0.39	0.39	0.36	0.39	0.37	0.35	0.35	0.37	0.33
Sweden	0.31	0.31	0.3	0.27	0.23	0.22	0.22	0.21	0.22	0.26	0.24	0.28	0.31	0.31
Germany	0.31	0.34	0.34	0.37	0.36	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.32	0.3
UK	0.26	0.27	0.27	0.29	0.27	0.25	0.24	0.23	0.23	0.24	0.25	0.27	0.28	0.28
Singapore	0.17	0.21	0.26	0.28	0.27	0.25	0.24	0.22	0.24	0.21	0.19	0.22	0.25	0.25
Belgium	0.23	0.24	0.22	0.21	0.22	0.24	0.22	0.24	0.23	0.25	0.21	0.23	0.25	0.24

Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

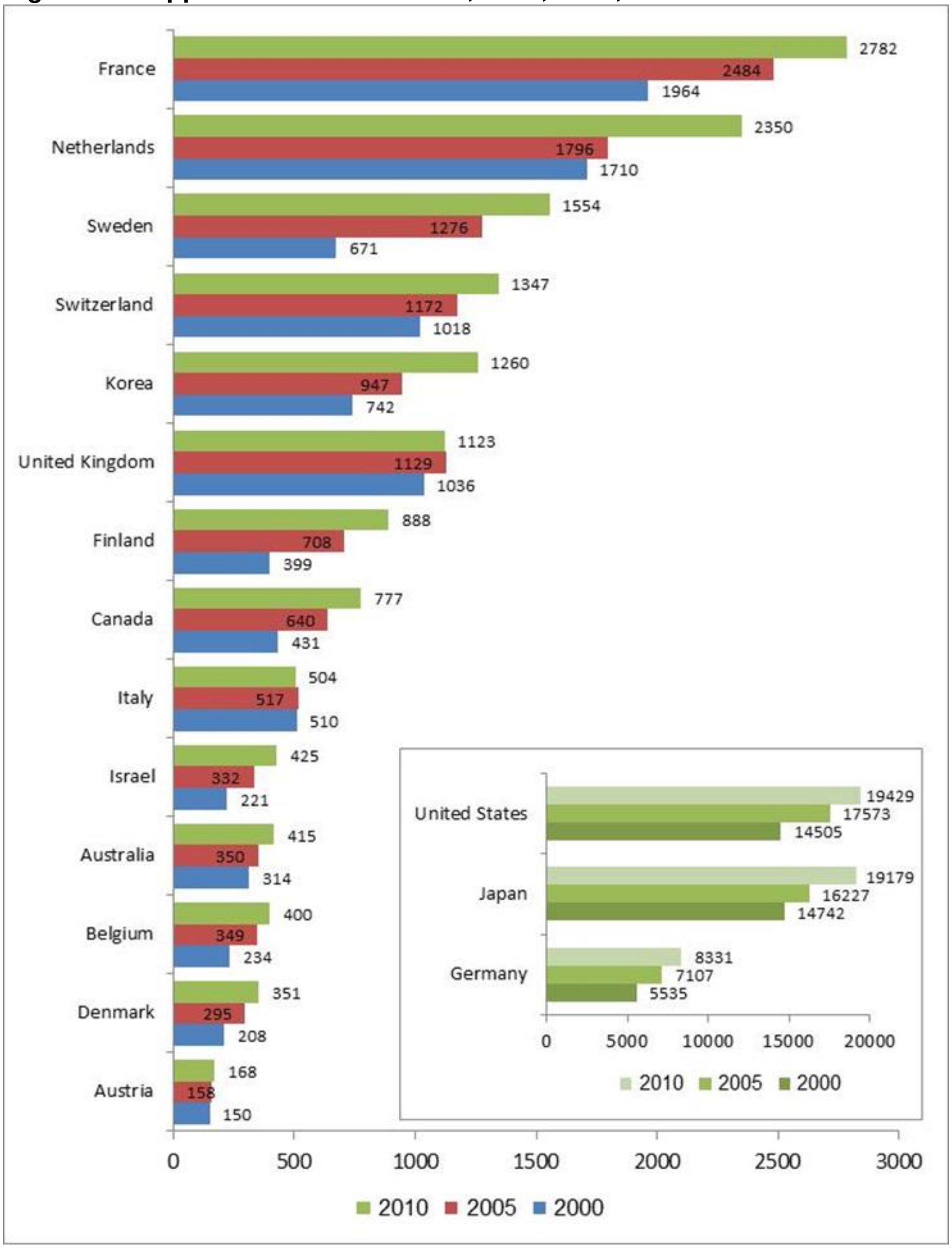
Figure 5.3: Patent Applications to USPTO Relative to National R&D Expenditure, 1998–2011 (USD millions, 2000 prices, PPP)



Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute Triad Patents

Another way to observe and analyze patents is via “triad patents.” The triad-patent indicator represents a cross-section of a set of applications that relate to the same invention irrespective of the applicant office and with no redundancy. A patent is defined as “triad” if it is submitted to the European, Japanese, and American patent offices and is approved (registered) by the last-mentioned. The triad-patent indicator is problematic in describing Israeli invention activity. Since Israeli entities (except large firms such as Teva and Iscar, and the universities) apply for few patents in Japan, the number of Israel’s triad patents is very small.

Figure 5.4: Applicants' Triad Patents, 2000, 2005, 2010[34]



Getz, D., Leck E., & Hefetz, A. (2013). R&D *Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute

[34] Source: special processing by Neaman Institute of OECD.STAT data. Relative tally by first year. Data exist up to 2008. The data for 2010 are standardized (a linear forecast to the near term based on current trends).

5.2 Scientific Publications

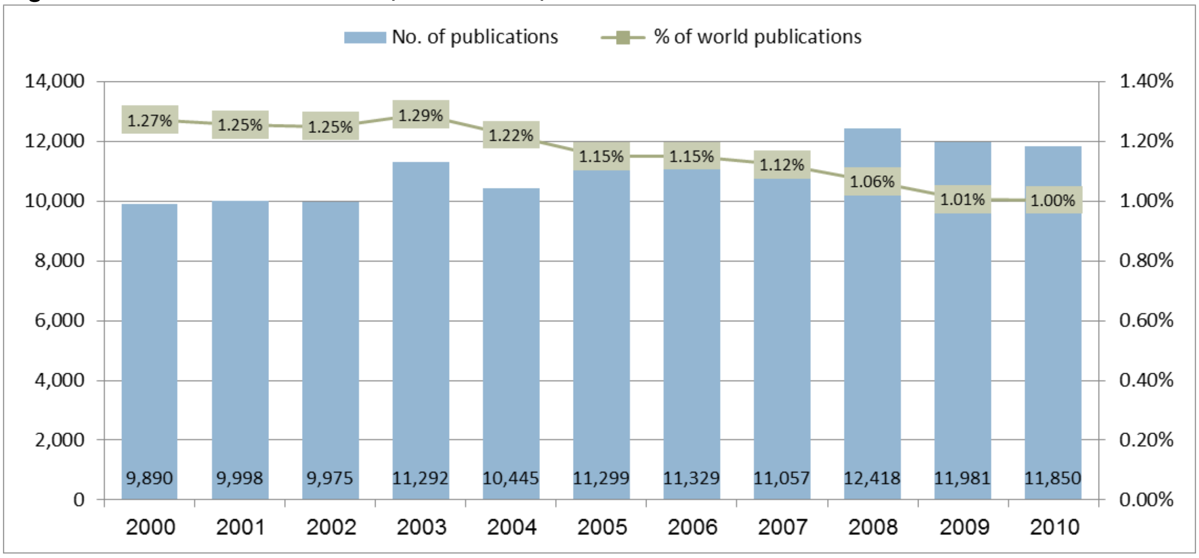
Bibliometric accounting of publications and citations yields quantitative answers to questions about R&D productivity and the quality of scientific publications in various fields and facilitates comparison of researchers, institutions, and countries. The findings of bibliometric research are not immune to bias and generalization; to neutralize these problems, they are used in conjunction with other indicators of output quality.

The data are extracted from several databases. Thomson Reuters Science Citation Index and Science Citation Index Expanded include publications and citations from articles, books, reviews, editorials, and letters that may be found by various fields (author's name, title, topic, institutional affiliation, year of publication) and other parameters. Additional databases that yield data are national citation records and statistical databases. The data are current through the end of 2011.

First we describe the situation in Israel in terms of outputs, priorities, and quality; then we compare Israel with selected countries. A publication is attributed to Israel if at least one author's address is that of an Israeli institution. Figure 5.5 below presents the trends in Israel scientific publications since the beginning of the previous decade.

5.2.1 Indicators of Research Productivity

Figure 5.5: Israeli Publications, 2000–2010, Normalized to All Publications Worldwide



Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011. Samuel Neaman Institute

Figure 5.5 shows that 2008 was the record year in scientific publications produced in Israel. The number of such publications declined gently in 2009 and 2010 and rebounded in 2011. In the share of Israeli publications among all publications worldwide, there was a downward trend in 2000–2003 followed by an increase of about 2 percent, and a steady downward slant afterwards. By 2011, only 0.96 percent of all publications worldwide, in all fields, were Israeli, as against 1.27 percent in 2000, 1.15 percent in 2005, and 1.00 percent in 2010. However, it should be borne in mind that Israel's population is only 0.1 percent of the world's population. The question that these data raise is whether the quantity decrease in publications indicates a real decline in scientific output or traces to the entrance of additional countries to the circle of scientific publications. (The data show that Israel produces ten times as many publications as its share in the world's population.)

The number of publications that each country produces depends, among other things, on the size of its population. Therefore, when comparing different countries, one customarily normalizes the number of publications to population. The next table shows the number of publications in 2011 per 100,000 inhabitants. (The countries listed are those that accounted for more than 0.5 percent of publications worldwide.)

Table 5.7: Leading Countries in Publications per 100,000 Inhabitants, 2011

	Country	Publications	Population ('000)	per Publications 100,000 Inhabitants
1	Switzerland	24,152	7,907	**305.5**
2	Denmark	13,261	5,574	**237.9**
3	Sweden	20,700	9,453	**219**
4	Norway	10,360	4,952	**209.2**
5	Netherlands	32,975	16,696	**197.5**
6	Finland	10,414	5,387	**193.3**
7	Australia	43,441	22,621	**192**
8	Singapore	9,770	5,184	**188.5**
9	New Zealand	7,791	4,405	**176.9**
10	Belgium	18,371	11,008	**166.9**
11	Canada	57,263	34,483	**166.1**
12	Ireland	7,184	4,487	**160.1**
13	Israel	12,154	7,766	**156.5**
14	UK	97,834	62,641	**156.2**
15	Hong Kong	10,668	7,072	**150.9**
16	Austria	12,496	8,419	**148.4**
17	Taiwan	26,648	23,225	**114.7**
18	Germany	93,541	81,726	**114.5**
19	USA	354,486	311,592	**113.8**
20	Spain	49,095	46,235	**106.2**

Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011. Samuel Neaman Institute

Israel ranked thirteenth in this indicator in 2011 after having been one of the leaders in this respect: first in 1990, third in 1999–2003, and fifth in 2004–2008.

The ratio of publications in each area of research to all publications countrywide reflects the priority that the area of research is given. Priority is manifested, among other things, in the amount of resources that the country pledges to the advancement of research in this field. The assumption is that the number of publications correlates with the quantity of research, the number of researchers, and the size of the research budgets. The priority metric speaks neither about the quality of research in a given field nor about the level of research in the country; it addresses only the priority that research in a given field commands in the country at issue.

Table 5.8: Percent of S&T Publications in Total Publications in Country, Cross-Country Comparison, 2007–2011

	Israel	Finland	Denmark	Switzerland	EU-27	Singapore	USA	World
Clinical Medicine	23.07	22.65	27.43	24.78	22.47	16	24.38	20.85
Physics	11.44	8.61	6.79	10.61	8.73	14.07	6.63	8.76
Chemistry	7.19	7.39	6.8	9.31	10.03	12.84	6.89	11.39
Engineering	6.38	7.07	5.15	5.99	7.66	16.67	6.34	8.42
Social Sciences, general	5.75	5.01	4.32	2.95	4.39	3.71	7.11	4.86
Biology & Biochemistry	5.35	5.52	7.38	4.98	5.12	4.35	5.72	5.12
Mathematics	4.71	2.28	1.33	1.73	3.12	1.95	2.38	2.79
Psychiatry/Psychology	4.26	2.82	1.86	2.54	2.57	1.6	4.12	2.48
Neuroscience & Behavior	3.89	3.16	3.3	3.69	3.04	1.44	3.94	2.8
Plant & Animal Science	3.85	6	6.61	4.74	5.18	1.71	4.6	5.35
Molecular Biology & Genetics	3.66	3.25	3.62	3.66	2.87	3.54	3.92	2.7
Computer Science	3.35	2.42	1.52	1.64	2.01	4.74	1.95	2.03
Materials Science	2.29	2.99	1.88	2.78	3.65	7.69	2.37	4.6
Environment/Ecology	1.99	5.07	4.43	3.62	3	1.28	2.9	2.84
Geosciences	1.82	3.39	3.46	4.54	3.18	0.69	3	2.82
Economics & Business	1.77	2.35	2.26	1.83	2.04	2.74	2.47	1.76
Space Science	1.54	1.84	1.68	2.01	1.63	0.05	1.77	1.1
Immunology	1.39	1.32	1.81	1.81	1.23	0.83	1.66	1.13
Microbiology	1.38	1.59	1.94	1.81	1.71	1.31	1.75	1.66
Pharmacology & Toxicology	1.15	1.67	1.9	1.79	1.69	1.45	1.79	1.93
Agricultural Sciences	1	2.18	2.91	1.75	2.15	0.47	1.36	2.27

Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011*.* Samuel Neaman Institute

Table 5.8 shows that in Israel and in its peer developed countries, clinical medicine commands the strongest priority (with the exception of Singapore, where engineering ranks first). In all countries in the table, physics and chemistry rank in second and third place. Different countries assign different levels of priority to the other scientific disciplines.

The quality of Israeli publications in various domains, compared with selected countries, is shown in Table 7.5, which gives mean citations of Israeli publications in each major field, normalized to average citations in the field worldwide, in 2007–2011.

5.2.2 Indicators of Research Quality

Table 5.9: Ratio of Average Citations in S&T Disciplines in Israel to Average Citations per Discipline, Cross-Country Comparison—Normalized to Discipline (Global), 2007–2011

	Israel	Finland	Denmark	Switzerland	EU-27	Singapore	USA
Science Materials	1.59	1.01	2.03	1.77	1.11	1.85	1.74
Science Space	1.53	1.04	1.61	1.77	1.17	0.52	1.38
Animal Science & Plant	1.46	1.22	1.55	1.65	1.22	1.11	1.33
Physics	1.42	1.52	1.49	1.89	1.2	1.08	1.56
Geosciences	1.32	1.66	1.64	1.77	1.16	0.65	1.48
Genetics & Biology Molecular	1.3	1.64	1.55	1.57	1.1	1.26	1.36
Sciences Agricultural	1.3	1.63	1.53	1.35	1.23	1.21	1.36
Chemistry	1.29	1.06	1.41	1.55	1.16	1.42	1.59
Microbiology	1.25	0.94	1.34	1.41	1.13	1.37	1.49
Biochemistry & Biology	1.24	1.16	1.37	1.6	1.08	1.12	1.42
Toxicology & Pharmacology	1.15	1.33	1.22	1.38	1.17	1.32	1.35
Medicine Clinical	1.13	1.51	1.67	1.57	1.1	1.15	1.42
Business & Economics	1.11	0.89	0.93	1.25	0.92	1.14	1.37
Behavior & Neuroscience	1.06	1.14	1.14	1.26	1.06	0.97	1.31
Immunology	1.06	1.01	0.97	1.4	1	1.13	1.3
Engineering	1.01	1.13	1.49	1.39	1.04	1.29	1.17
Psychiatry/Psychology	1	1.14	1.15	1.31	1.01	0.82	1.19
Environment/Ecology	0.98	1.43	1.52	1.73	1.12	1.44	1.3
Science Computer	0.96	1.11	1.3	2.45	1.06	1.05	1.25
Mathematics	0.96	1.32	1.13	1.38	1.06	1.3	1.3
Sciences, general Social	0.94	1	1.19	1.31	1	0.8	1.21

Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011. Samuel Neaman Institute

The table shows greater cross-country variance in research quality (reflected in citations) than in the priority that different countries give to different research disciplines. Materials science, earth science, computer science, and physics usually surpass the global average level of quality. Even in these disciplines, however, this outcome does not apply to all countries compared. In Israel, citations are most common in materials science, followed by space science, life and plant sciences, and physics (contrasting with the priority that Israel assigns to clinical medicine, physics, and chemistry).

The next table compares Israel with selected countries in number of publications in various S&T disciplines.

Table 5.10: S&T Publications as Percent of All Publications in Discipline, Cross-Country Comparison, 2007–2011

	Israel	Finland	Denmark	Switzerland	Singapore	USA	EU-27
Psychiatry/Psychology	1.76	0.96	0.74	1.91	0.46	48.36	37.61
Mathematics	1.74	0.69	0.47	1.16	0.5	24.85	40.66
Science Computer	1.7	1.01	0.74	1.5	1.68	28.04	36.05
Science Space	1.44	1.41	1.5	3.39	0.03	46.83	53.62
Behavior & Neuroscience	1.43	0.95	1.16	2.45	0.37	40.95	39.34
Genetics & Biology Molecular	1.39	1.01	1.32	2.52	0.94	42.25	38.53
Physics	1.34	0.83	0.76	2.26	1.16	22.07	36.18
Immunology	1.26	0.98	1.57	2.98	0.52	42.74	39.57
Sciences, general Social	1.22	0.87	0.88	1.13	0.55	42.66	32.86
Medicine Clinical	1.14	0.92	1.29	2.21	0.55	34.09	39.13
Biochemistry & Biology	1.07	0.91	1.42	1.81	0.61	32.62	36.34
Business & Economics	1.03	1.13	1.26	1.93	1.12	40.88	42.06
Microbiology	0.86	0.81	1.15	2.03	0.57	30.75	37.45
Engineering	0.78	0.71	0.6	1.32	1.42	21.94	33.04
Animal Science & Plant	0.74	0.95	1.22	1.65	0.23	25.07	35.18
Environment/Ecology	0.72	1.51	1.54	2.37	0.33	29.79	38.42
Geosciences	0.66	1.01	1.21	2.99	0.18	30.99	40.87
Chemistry	0.65	0.55	0.59	1.52	0.81	17.64	31.97
Toxicology & Pharmacology	0.61	0.73	0.97	1.73	0.54	27.1	31.86
Science Materials	0.51	0.55	0.4	1.13	1.2	15.01	28.85
Sciences Agricultural	0.46	0.81	1.26	1.44	0.15	17.51	34.44

Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011. Samuel Neaman Institute

Table 5.11 compares the number of S&T publications in Israel with that in other countries, normalized to the global average. In Israel, psychology/psychiatry is the percent leader of publications, followed by mathematics and computer science. In comparison between the United States and the Eurozone, each bloc appears to be stronger in some disciplines and weaker in others. The U.S. is particularly strong in psychology/psychiatry; Europe is first in space science publications.

The next Table shows Israel's ranking in number of citations per publications normalized to the world, as an indicator of publication quality.

Table 5.11: Leading Countries in Quality Ranking (Average Citations per Publication, Normalized to World), 2007–2011

Impact Relative To World	Country
Switzerland	1.71
Denmark	1.6
Netherlands	1.56
Sweden	1.46
USA	1.45
UK	1.43
Belgium	1.42
Germany	1.37
Finland	1.36
Austria	1.32
Canada	1.29
France	1.26
Italy	1.24
Israel	1.22
Australia	1.21
Spain	1.1
Hong Kong	1.04
Japan	1.02

Getz, D, et al. (2013). Outputs in Israel: International Comparison of Scientific Publications, 1990-2011. Samuel Neaman Institute

Of the eighteen countries shown in the table, Israel ranks fourteenth in average citations per publication, normalized to the world.

5.2.3 <u>Conclusion</u>

The indicators in this chapter show that Israel has retreated rather severely in number of publications normalized to population: from first in this respect in 1990 to third in 1999–2003, fifth in 2004–2008, and thirteenth in 2011.

In publication quality, mirrored in citations, Israel was in fourteenth place and the most-cited discipline was materials science.

The indicator of priorities in Israel's S&P publications reserved first place for clinical medicine, followed far behind by physics and chemistry.

Overall, there has been a decrease in Israel's S&T publishing. Nevertheless, the country still turns out ten times as many scientific publications as its share in the world's population.

6. R&D and Innovation by Selected Industries and Research Institutions

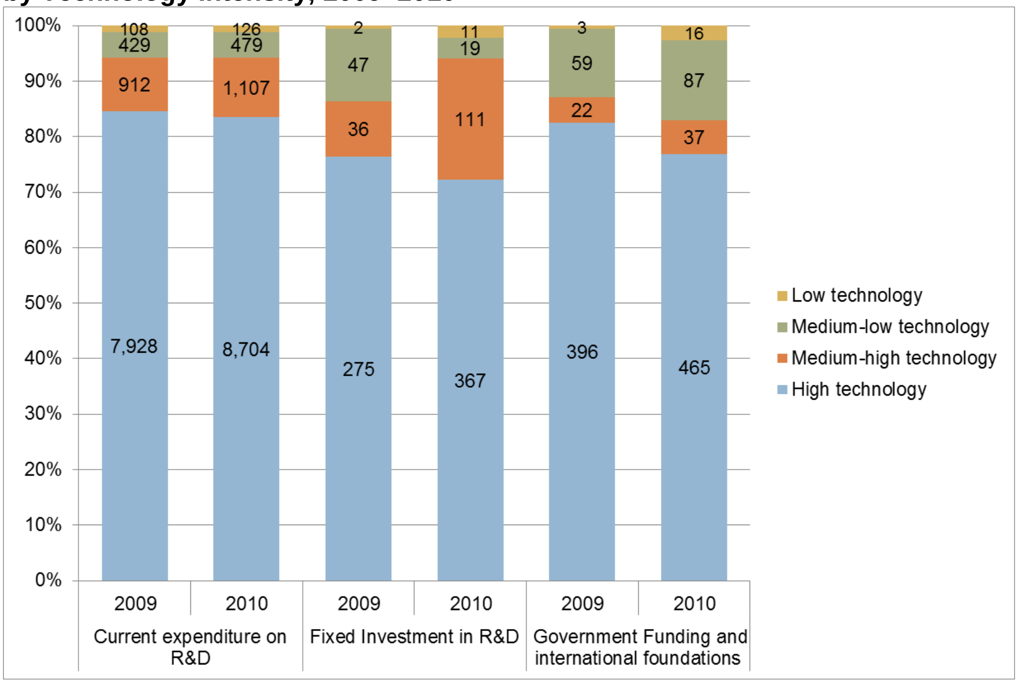
6.1 MANUFACTURING INDUSTRIES

According to a CBS survey in 2010, current R&D expenditure in manufacturing was NIS 10.9 billion (current prices). In establishments that engaged in R&D, 7 percent of turnover was expended on R&D. Ten establishments performed 45 percent of total manufacturing R&D. High-tech manufacturing industries spent NIS 9.1 billion on R&D in 2010—by far the greater portion (83 percent) of such expenditure in manufacturing.

Governmental funding of R&D in high-tech manufacturing is 76 percent of total funding for all manufacturing industries, lower than the share of high-tech in total R&D expenditure. In contrast, the share of low (traditional) and medium-high technology industries in total R&D expenditure is 5.8 percent (NIS 635 million) and their share in governmental funding is 17 percent. (For a breakdown of government funding for low-technology manufacturing, see Section 2.3, "The Government Sector.")

Government and international funding for manufacturing R&D was NIS 605 million in 2010 as against NIS 479 million in 2009 (current prices), up 26 percent. Establishments that received government funding performed 52 percent of total manufacturing R&D expenditure in 2010, much as in 2009.[35]

Figure 6.1: Current Expenditure, Fixed Investment in R&D, and Government Funding, by Technology Intensity, 2009–2010



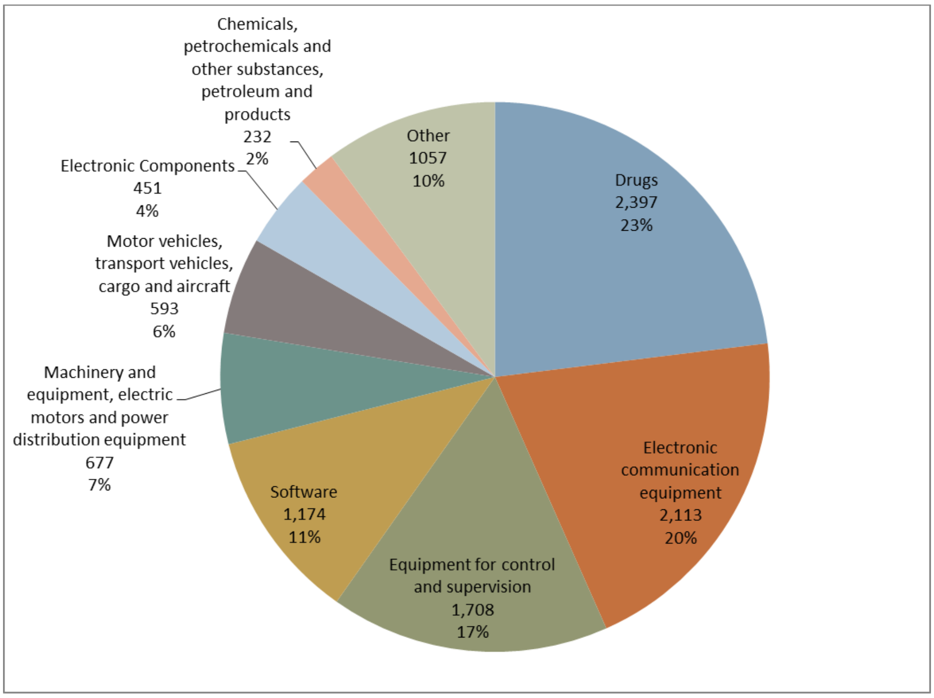
Source: Analysis of CBS data by Samuel Neaman Institute

[35] Source: Central Bureau of Statistics press release, "Research and Development (R&D) Expenditure in the Business-Enterprise Sector in 2010," August 2012 (in Hebrew).

The next figure shows the distribution of current R&D expenditure by **areas of activity** in the manufacturing industries. Often, the area of the R&D activity is different from the economic classification of the firm that performs it. Much R&D performed by manufacturing establishments is also related to research activity in other industries. Several areas of manufacturing are latitudinal; firms invest in them irrespective of their economic classification. An example is **software;** it accounts for 11 percent of R&D expenditure by manufacturing industries even though it is not a manufacturing industrial activity.

Seventy percent of manufacturing R&D expenditure is concentrated in four areas of activity: pharmaceuticals (23 percent), electronic communication equipment (20 percent), medical and scientific control and supervision equipment (17 percent), and software (11 percent).

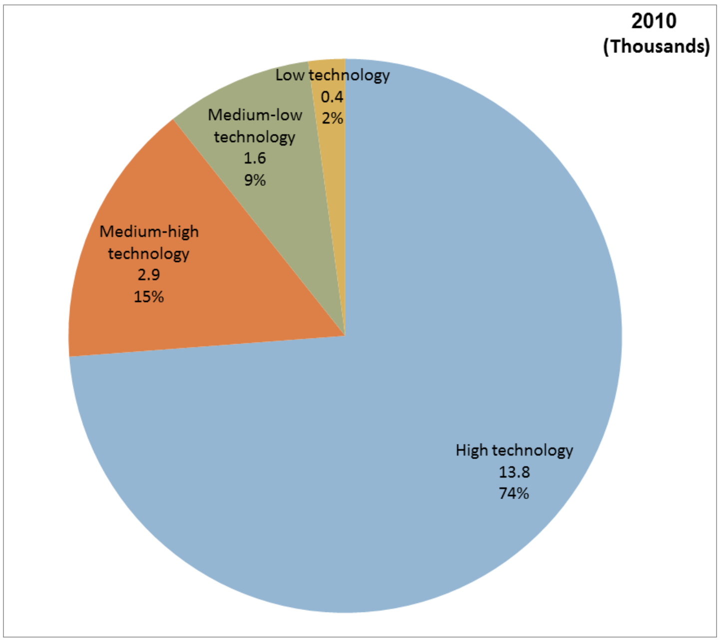
Figure 6.2: Current R&D Expenditure in Manufacturing Industries, by *Type of Activity*, 2010



Source: Analysis of CBS data by Samuel Neaman Institute

The number of R&D employee posts in manufacturing industries increased from 18,000 in 2009 to 18,700 in 2010. Approximately 13,800 of those who hold these posts (75 percent) have academic degrees, including around 1,000 who have doctorates.

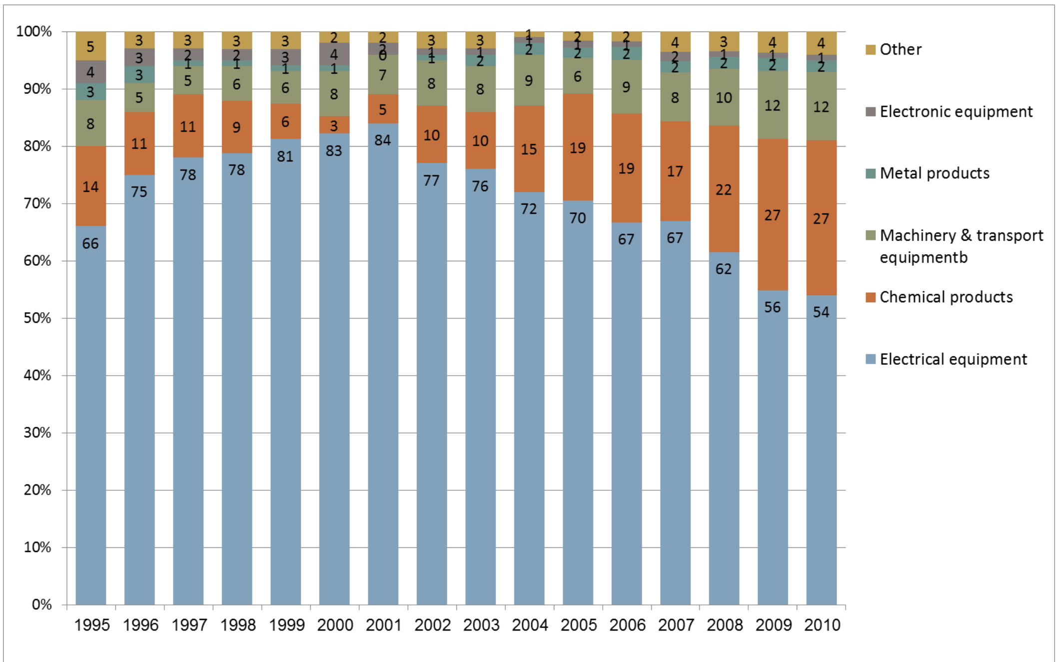
Figure 6.3: R&D Employee Posts in Manufacturing Industries, by Technology Intensity, 2010



Source: Analysis of CBS data by Samuel Neaman Institute

The data in Figure 6.4 underscore the trend of R&D concentration in communication and electronics industries as far back as 1995, at 66 percent, and the increase in this concentration to 84 percent in 2001. From 2001 to 2010, a steep decrease lowered the rate of R&D expenditure in the electronic equipment industry to 54 percent of total manufacturing R&D. The share of the chemical products industry in manufacturing R&D, in contrast, has been rising and came to 27 percent in 2010. (In Israel, chemical products include pharmaceuticals.)

Figure 6.4: Current R&D expenditure in Selected Manufacturing Industries in Israel, 1995–2010



Source: Analysis of CBS data by Samuel Neaman Institute

Table 6.1 compares various countries in the share of selected manufacturing industries in manufacturing R&D in 2009. The acute concentration of Israel's manufacturing R&D in the electronic equipment industry stands out; it resembles that in Finland and South Korea and is much higher than that in the other countries, where 56 percent of manufacturing R&D in the business-enterprise sector is performed by the electronic communication industry. In large countries that have heavy industry, such as Germany, the UK, and the U.S., high expenditure in industries such as machinery and transport vehicles is observed; Israel's transport-vehicle industry performs no civilian R&D expenditure whatsoever. Although Israel does have an aviation and space industry, it is largely defense-related and is not represented in these data. Another one-third of manufacturing R&D in Israel is concentrated in the chemical products industry, which has grown in recent years and resembles that in countries such as Ireland, France, Spain, and the U.S.

Table 6.1: R&D Expenditure by Manufacturing Industries, Cross-Country Comparison, 2009

	Electronic equipment	Chemical products	Machinery & transport equipment[b]	Other	Metal products	Electronic equipment	transport vehicles	Food, beverages and tobacco	
Finland	68%	6%	9%	5%	3%	5%	2%	2%	**100%**
Israel[2]	**56%**	**27%**	**12%**	**4%**	**2%**	**1%**	**[1]0%**	**0%**	**100%**
Korea	55%	9%	8%	3%	3%	3%	17%	2%	**100%**
Netherlands	32%	32%	17%	2%	3%	2%	5%	7%	**100%**
Ireland	31%	34%	6%	15%	0%	4%	0%	10%	**100%**
Canada	26%	17%	8%	15%	8%	9%	15%	2%	**100%**
Japan	25%	19%	15%	7%	4%	9%	19%	2%	**100%**
Denmark	20%	52%	10%	5%	1%	4%	0%	8%	**100%**
Norway	20%	17%	23%	7%	7%	6%	10%	10%	**100%**
France	20%	24%	6%	8%	3%	5%	31%	3%	**100%**
Switzeland	20%	57%	0%	0%	17%	0%	0%	6%	**100%**
Austria	19%	13%	17%	8%	7%	19%	16%	1%	**100%**
USA	19%	28%	10%	15%	2%	2%	22%	2%	**100%**
Italy	18%	13%	18%	11%	4%	3%	31%	2%	**100%**
Germany	16%	16%	14%	4%	3%	4%	42%	1%	**100%**
Australia	15%	18%	8%	12%	18%	2%	17%	10%	**100%**
Belgium	15%	47%	9%	8%	6%	6%	6%	3%	**100%**
UK	11%	44%	8%	1%	1%	5%	27%	3%	**100%**
Spain	8%	27%	10%	12%	7%	6%	24%	6%	**100%**
Sweden	0%	25%	14%	35%	3%	0%	22%	1%	**100%**

Note: 1. For Israel the machinery and transport equipment industry includes transport vehicles.
2. The data for Israel do not include defense R&D.
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

6.2 Information and Communication Technology (ICT) Industries

A phenomenon unique to the Israeli economy is that 80 percent of business-enterprise R&D takes place in information and communication technology (ICT) industries, foremost ICT services. In the past decade, these industries have developed vigorously around the world and specifically in Israel. Given the major impact of the ICT industries on output and exports, we devote a special section of this chapter to these industries. Many studies show that these industries make an especially important contribution to national labor productivity and total factor productivity and may serve as foundations for long-term growth. For elaboration on the topic, see Subsection 4.2.3—"ICT Capital Investment."

In a departure from previous years, when these industries typically grew more quickly than total business product, in the past three years they have been basically flat as against a 5 percent increase in business-sector product. Since ICT accounts for much of Israel's total civilian R&D, as noted in previous reports, the reasons for the slowdown deserve thorough investigation.

The definition of ICT industries, laid down by the OECD in 1998 on the basis of the ISIC (International Standard Industrial Classification), pertains to "activities in manufacturing and service industries, which use electronic means to facilitate processing, preparation, transmission, and display of information. The classification of information technologies does not include 'content' industries, i.e., the industries that create information."

The industries covered by the definition are grouped as follows:

* ICT manufacturing industries—industries that produce ICT equipment such as office machinery, accounting machinery, and computers; electronic components, electronic communication equipment, and industrial control and supervision equipment (excluding medical equipment).

* ICT service industries—communication services, computerization and software services, research and development services, and start-ups.

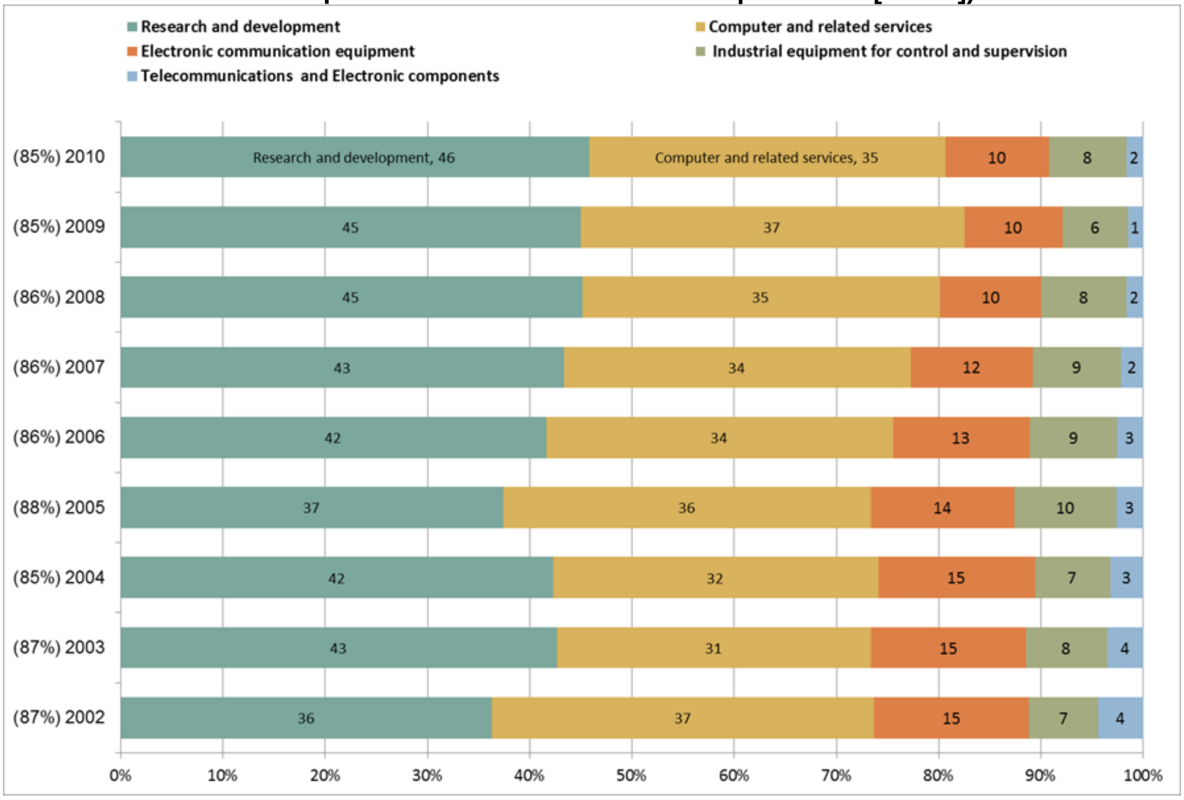
CBS calculates data on ICT industries in accordance with the OECD definition and segments it into manufacturing and services. In addition to the OECD definition, however, the data in Israel add the R&D industry to the ICT services group. Notably, the R&D industry is an outlier among the industries in the national statistics; it differs in the types of organizations that are active in it and the nature and areas of their activity. Unlike the other industries, in which the area of establishments' economic activity (electronic components, banking, communication, etc.) and types of activity (manufacturing and services of various kinds) are defined, in the R&D industry the commonality is the nature of the activity—research and development. All organizations classified in this industry engage in creating knowledge and technology by performing or supporting research and development. However, they differ in type (e.g., consulting firms alongside research institutes and start-ups) and operate in a wide range of areas of economic activity.[36]

It is also noteworthy that the definition of ICT industries is different from that of high-tech, which parallels the term "high-technology" at the Central Bureau of Statistics. The definition of high-tech is based on two main criteria: a large share of R&D expenditure in total business-enterprise R&D expenditure, and a large share of academically trained professionals in total headcount.

6.2.1 R&D expenditure in the ICT industries

R&D expenditure in the ICT industries claims a hefty share of business-enterprise R&D expenditure (BERD) at large: NIS 25 billion in 2010, 85 percent of BERD, representing a steady decline from 88 percent in 2005. The next figure shows the apportionment of R&D expenditure among ICT industries in 2010: 46 percent in the R&D industry, 35 percent in computerization services, and 19 percent in ICT manufacturing. Notably, given that the R&D industry accounts for nearly half of these industries' expenditure including non-ICT activity, the ICT statistics are skewed upward, especially in R&D expenditure. We elaborate on this industry in the next section.

Figure 6.5: Distribution of ICT Expenditure on R&D (in parentheses next to year: share of ICT industries' R&D expenditure in total business-enterprise R&D [BERD])



Source: Analysis of CBS data by Samuel Neaman Institute

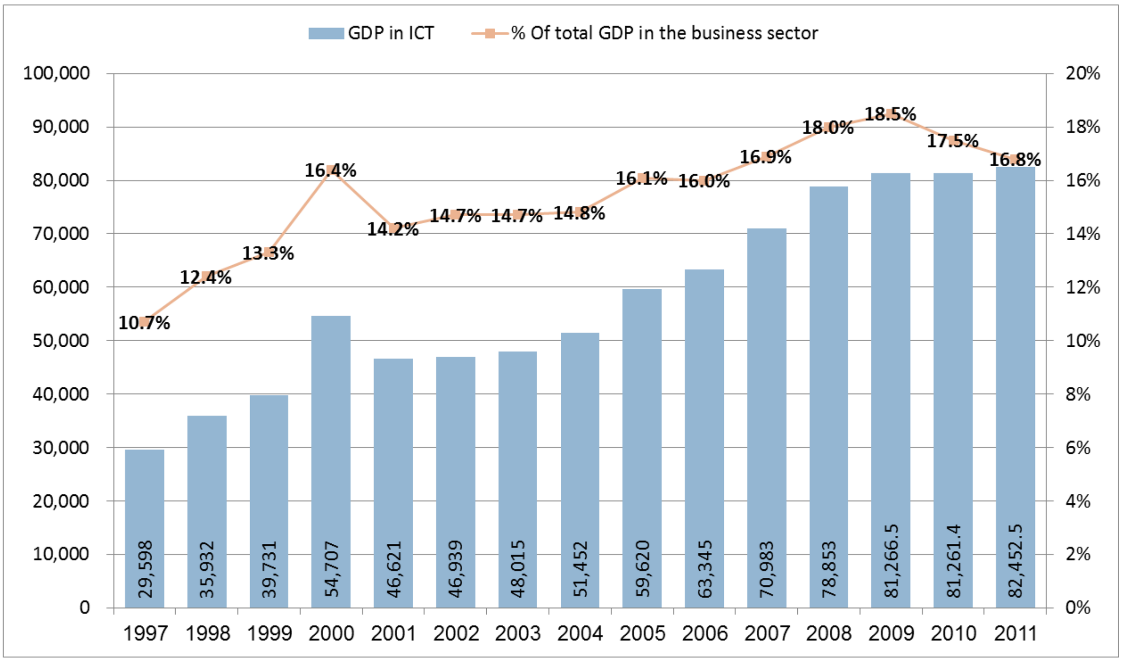
[36] From the CBS web site, Evyatar Kirschberg, "Business Demography and Labour Mobility in the Research and Development Industry," Working Paper 72, September 2012 (in Hebrew, abstract in English at http://www.cbs.gov.il/www/publications/tak72_e.pdf).

6.2.2 Output

In 2011, the ICT industries generated NIS 82,452 million in gross output, 16.8 percent of gross business output and 12.1 percent of GDP.

In 2009–2011, ICT gross product was basically flat as against 10 percent average annual growth in previous years, and its share in the total business-enterprise sector has been trending downward since 2009.

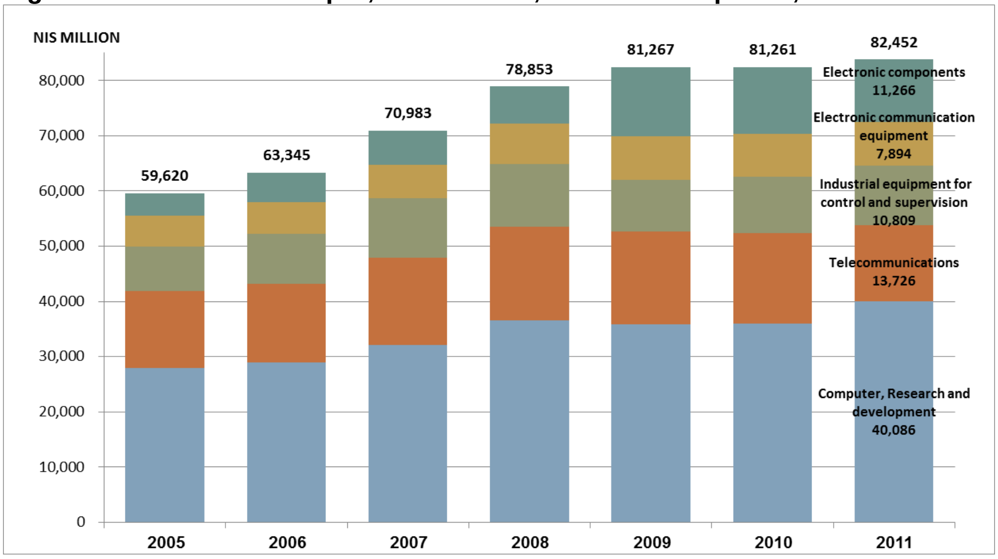
Figure 6.6: ICT Gross Output, NIS Millions, 2005 Prices, 1997–2011



Source: Analysis of CBS data by Samuel Neaman Institute

The next figure shows the distribution of ICT gross output. About half of ICT output is generated by the computerization and R&D services industries and 17 percent by communications. Overall, 65 percent of ICT gross product traces to service industries and 35 percent originate in manufacturing industries.

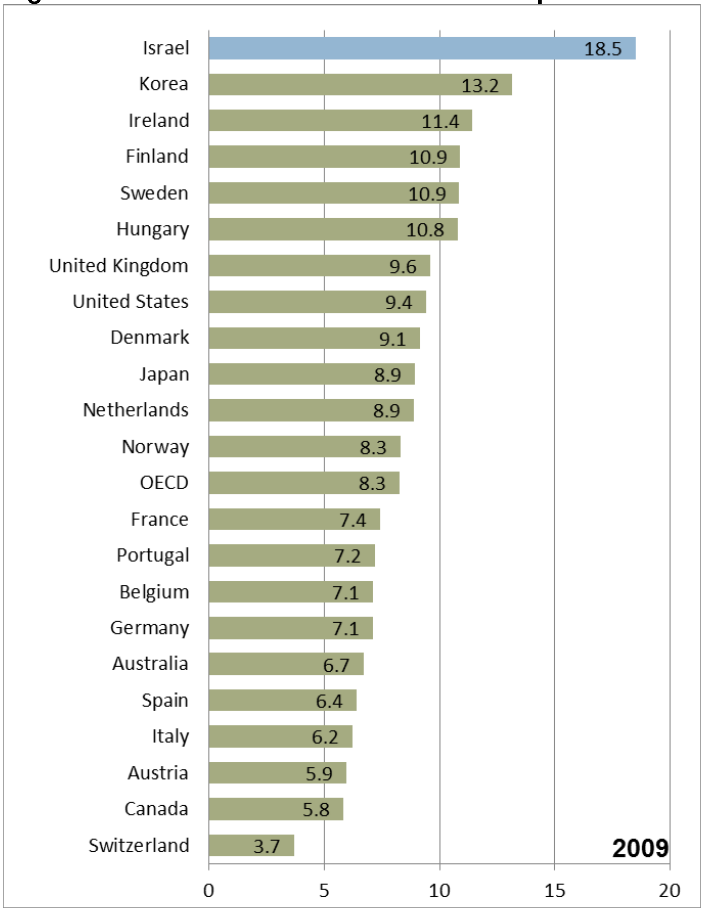
Figure 6.7: ICT Gross Output, NIS Millions, current 2005 prices, 2005–2011



Source: Analysis of CBS data by Samuel Neaman Institute

The next figure compares the shares of ICT in business-enterprise-sector gross product in various countries in 2009. In Israel, the ICT industries accounted for 18.5 percent of total business-enterprise-sector output that year, a very large proportion by international standards, ranking Israel above South Korea (13.2 percent), Ireland (11.4 percent), Finland (10.9 percent), and Sweden (10.9 percent).

Figure 6.8: Share of ICT in Business-Enterprise-Sector Gross Output

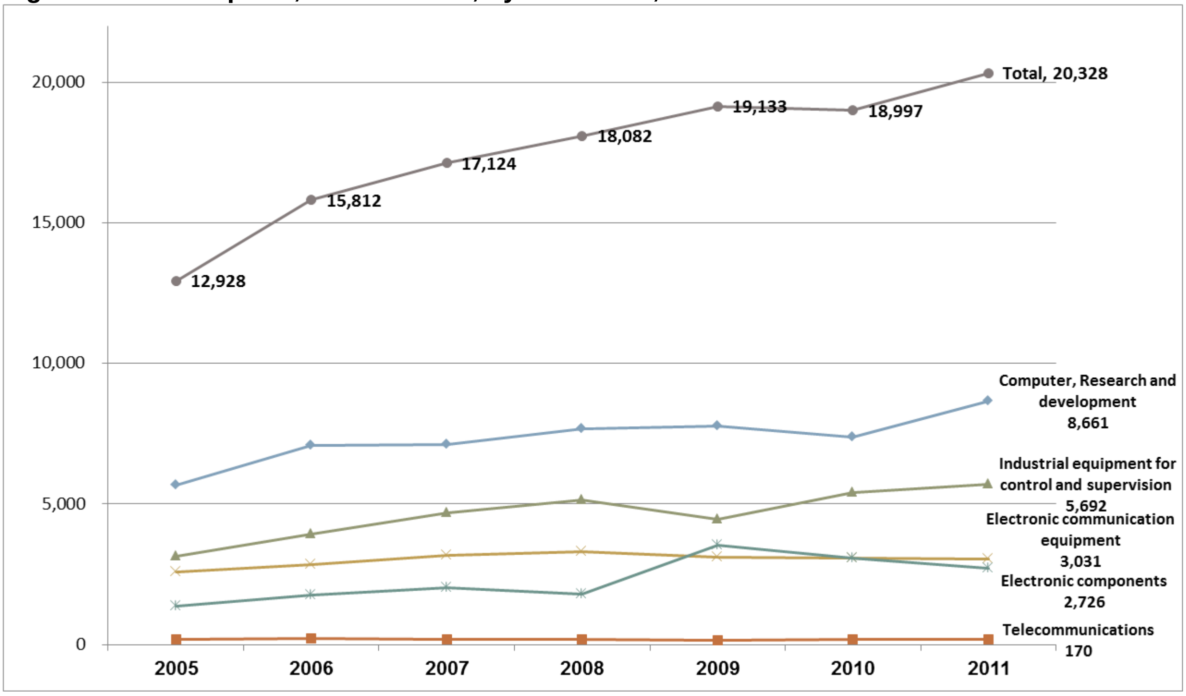


Source: Analysis of CBS data by Samuel Neaman Institute

6.2.3 Exports

Another indicator of the enormous contribution of ICT industries to the economy is exports. In 2011, ICT industries exported $20,328 million in goods and services, 27 percent of Israel's total exports. In 2005–2011, ICT exports increased by 97 percent (from $12,928 million to $20,328 million). The next figure shows total ICT exports and its segmentation among industries. The computerization and R&D services industries made the largest contribution to ICT exports, at 43 percent of the total. Industrial control and inspection equipment and medical and information equipment accounted for 28 percent, electronic communication equipment 15 percent, electronic components 13 percent, and communication services only 2%.

Figure 6.9: ICT Exports, USD Millions, by Industries, 2005–2011



Source: Analysis of CBS data by Samuel Neaman Institute

The Israel Export Institute also publishes export estimates segmented by industries. In January 2013,[37] the Institute reported an 11 percent increase in high-tech exports in 2012, to $38 billion.[38] Exports of communication, control, and medical and scientific equipment contracted by 3.5 percent in 2012 after growing by 4.5 percent in 2011 and were projected at $8 billion. Exports of electronic components and computers increased by 9 percent after a 4 percent upturn the previous year and were estimated at $5 billion in 2012.

[37] Summary of 2012 Export Data and 2013 Forecast, Israel Export Institute, Economics Division, January 2013, http://www.export.gov.il/uploadfiles/01_2013/developmentstrendsisraelexportsq4-2012.pdf

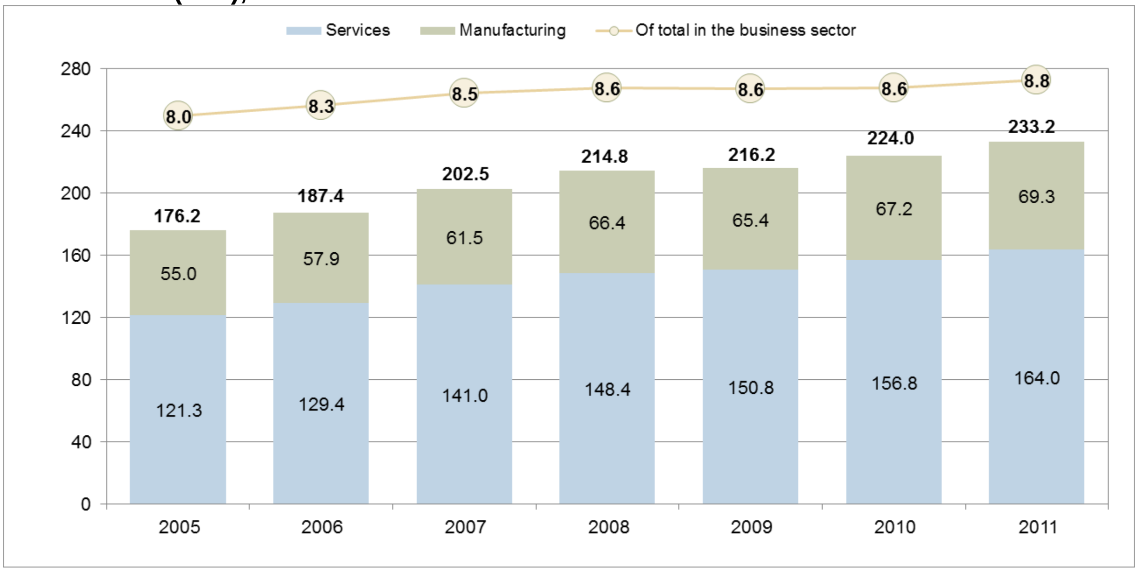
[38] The high-tech export data include adjustments based, among other things, on reportage in the financial statements of several large Israeli high-tech firms and data on exports of R&D and computer services.

As noted above, the computer and R&D services industry accounts for a large share of ICT exports. The industries that comprise this class are classified among the business services. Exports of business services (excluding tourism and transport) were $20 billion in 2012. Exports of R&D services increased by 47 percent, to $4.5 billion, and of software and computerization services by 12 percent, to $7.7 billion. Exports of software and computerization services account for more than 25 percent of Israel's total exports of services; their growth has catapulted these industries into the class of important exporters, as the Chair of the Israel Export Institute confirms. The increase in exports in 2012 followed an impressive 28 percent upturn in 2011. The Export Institute makes a special effort to steer services toward international markets. Recently, it even introduced a mobile applications team to provide Israeli developers and firms with services in promoting exports and liaising with leading communication establishments enterprises abroad.[39]

6.2.4 Employment

The ICT industries are important creators of jobs. The next figure, showing total employee posts in ICT industries and the share of these posts in total business-enterprise sector posts in 2005–2011, illuminates the job creation that took place in ICT during these years, the number of posts rising by 32 percent, from 176,000 to 233,000. In 2011, 8.8 percent of all employee posts in the business-enterprise sector were in ICT, as against 8 percent in 2005.

Figure 6.10: ICT Employee Posts (,000) and Their Share in Total Business-Enterprise Sector Posts (Pct.), 2005–2011

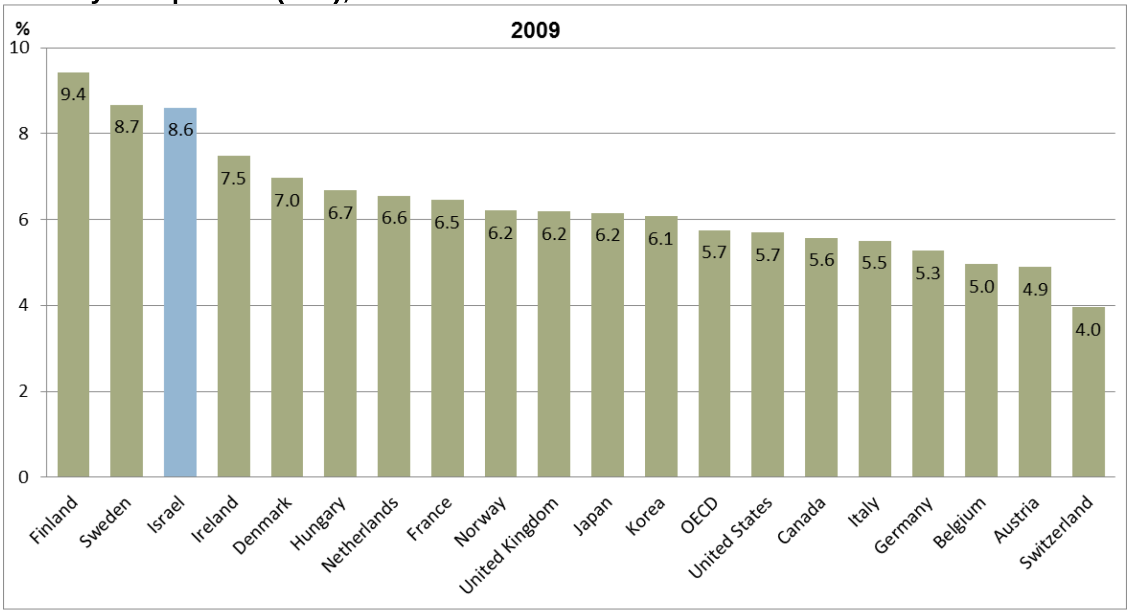


Source: Analysis of CBS data by Samuel Neaman Institute

[39] From Ora Koren, "Export Institute: Software and Computerization Service Exports have become Israel's Biggest Export Industry," *TheMarker,* February 2013, http://www.themarker.com/news/1.1921690.

The next figure presents compares Israel with other countries in the share of ICT industries in business-enterprise sector employment in 2009. In Israel that year, ICT industries accounted for 8.6 percent of business-enterprise sector employment. This places Israel near the top of the standings in this regard, besting Ireland (7.5 percent) and trailing only Finland (9.4 percent) and Sweden (8.7 percent).

Figure 6.11: Share of ICT industries in Business-Enterprise Sector Employment, Cross-Country Comparison (Pct.), 2009

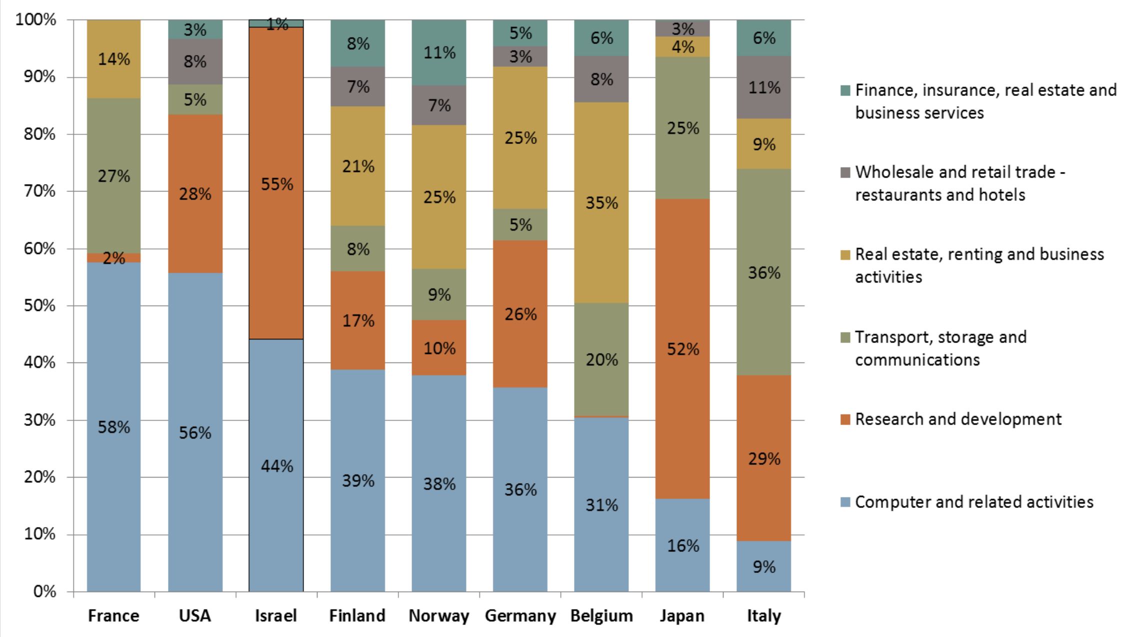


Source: Analysis of CBS data by Samuel Neaman Institute

6.3 Scientific Research and Development Industries (Division 73)

The research and development industry was first defined in *Standard Classification of All Economic Activities 1993* as Division 73 within Section K—real estate, renting, and business activities. In Israel, enterprises in the Scientific Research and Development division account for 55 percent of total R&D expenditure in business service industries. In Israel in 2008, this division along with computer services performed 99 percent of total business-service R&D expenditure. Only Israel is the concentration of business-service R&D expenditure in only two industries so acute; in most countries shown, these industries account for more than 50 percent but the rest of the expenditure is more widely distributed.

Figure 6.12: R&D Expenditure in Business Service Industries, Cross-Country Comparison, 2008



Source: Analysis of CBS data by Samuel Neaman Institute

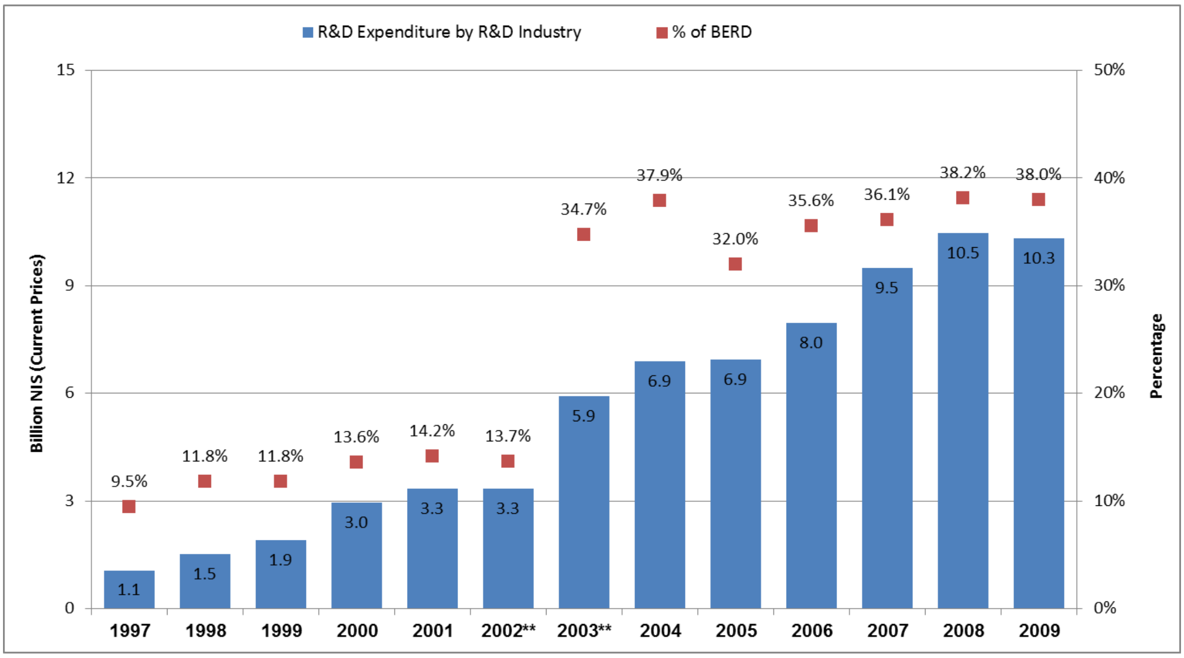
In 2012, a new classification was introduced.[40] The Scientific Research and Development Division (72) was renamed, renumbered, and assigned to a new Section M—Professional, Scientific, and Technical Activities. This section comprises firms that engage in research and development as their line of business. There are three types of R&D[41]: basic research, applied research, and experimental development. Unlike other sections in which all establishments engage in the same area of activity, this section includes establishments that engage in different areas of research activity and are of different types: start-ups, multinational firms' R&D centers, fabless companies, technological accelerators, firms that commercialize knowledge, etc. Therefore, it is immensely important to understand how this section is segmented among areas of activity. The data presented below are taken from Evyatar Kirschberg, "Business Demography and Labour Mobility in the Research and Development Industry," Central Bureau of Statistics, 2012, and relate to 2008.

[40] Division 72 in the revised *Standard Classification of All Economic Activities 1993*, 2011.

[41] **Basic research:** theoretical or experimental research performed mainly for the discovery of new information about the fundamentals on which observed phenomena and facts are based, without said new information being used or applied; **applied research:** original research for the acquisition of new knowledge for a specific practical purpose; and **experimental development:** systematic research predicated on existing information acquired in research and/or practical experimentation, for the purpose of producing new materials, instruments, and products, adopting new processes, systems, services, and significantly improving those that exist. In this classification, experimental research and development is divided into two categories: natural sciences and engineering, and social sciences and the humanities. Section M includes technological accelerators and startups in the fields of social and natural science; it excludes market research.

In 2009, establishments in this section (known then as a Division) spent NIS 10 billion on R&D, 38 percent of the total. Much of Israel's BERD is concentrated in the R&D industry because all establishments that have R&D as their main occupation are classified as belonging to it.

Figure 6.13: R&D Expenditure by R&D Industry and Its Share in Total Expenditure, 1997–2009

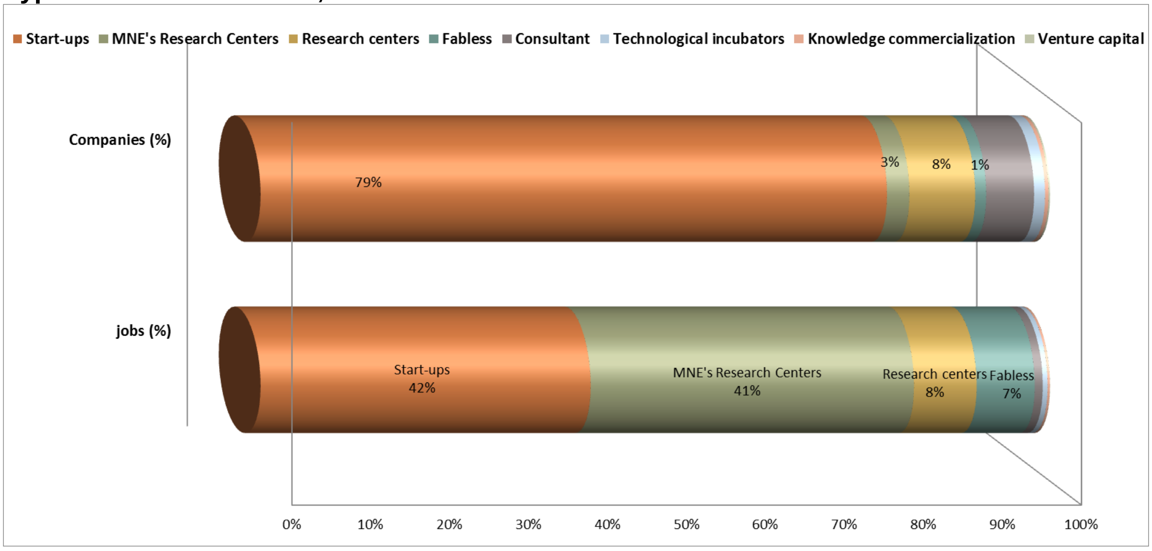


Source: Analysis of CBS data by Samuel Neaman Institute
Notes: * The performed R&D includes R&D expenditure, net of payments to outside sources, plus investments in fixed assets to R&D. ** Since 2003 a reclassification of the companies in the sample took place. This explains part of the change between 2002-2003.

In 2008, this division had 1,583 firms and a total headcount of 26,333.[42] Eighty percent of division establishments were start-ups and they employed only 42 percent of division employees. Start-ups are typified by small headcount (nine posts per establishment on average) and account for most entities in this division that were shut down. R&D centers of multinational corporations, in contrast, are 3 percent of establishments in this division but accounted for 41 percent of employee posts (240 posts per establishment on average).

[42] Among establishments that filled at least one employee post that year.

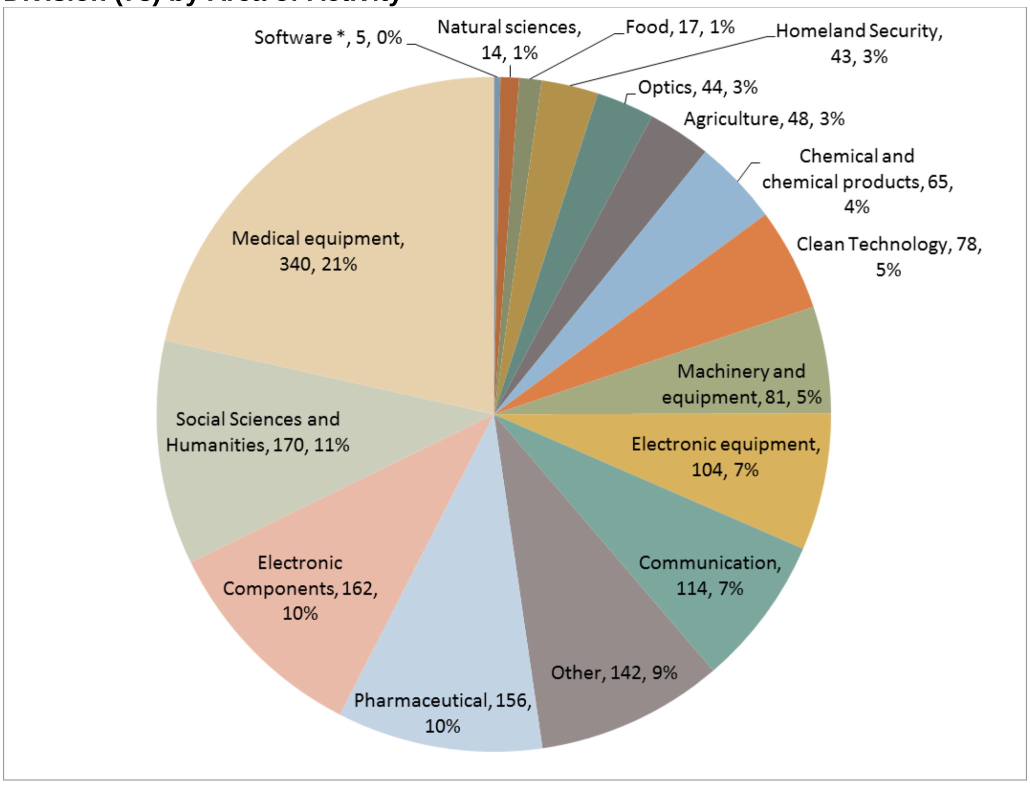
Figure 6.14: Distribution of Establishments and Employee Posts in R&D Division, by Types of Establishments, 2008



Source: Analysis of CBS data by Samuel Neaman Institute

As noted above, this division (today: section) is typified by establishments in diverse areas of activity. The next figure shows their distribution by areas of activity. It is noteworthy that one-fifth of the establishments are active in medical instrumentation R&D.

Figure 6.15: Distribution of Establishments in Scientific Research and Development Division (73) by Area of Activity



Source: Analysis of CBS data by Samuel Neaman Institute

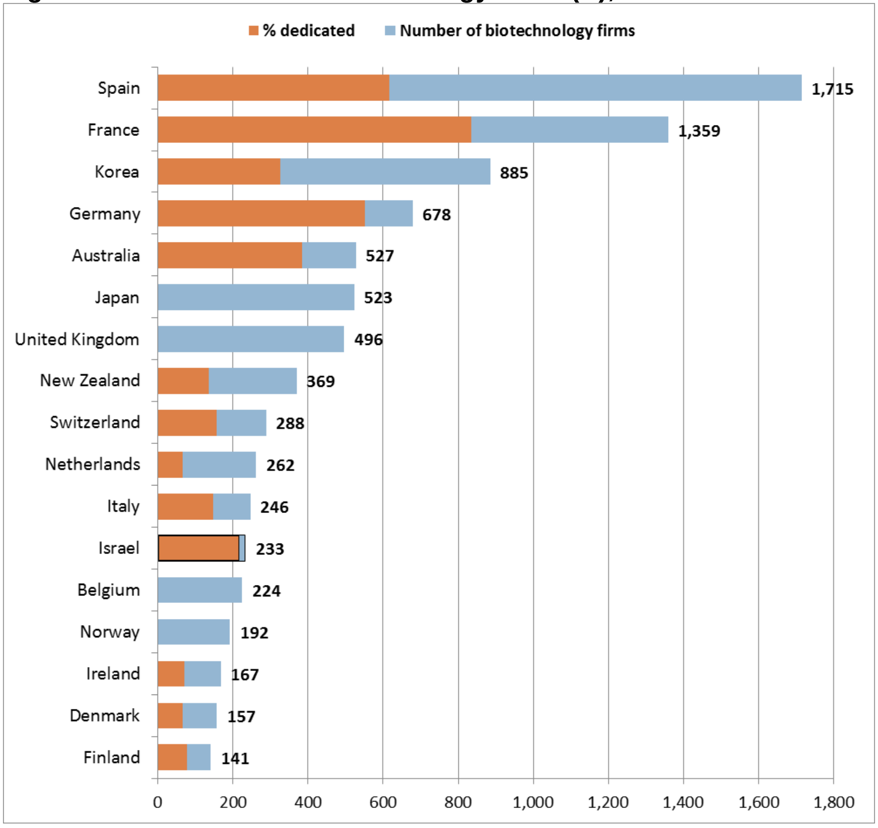
6.4 Biotechnology

The section presents data gathered by the Central Bureau of Statistics as part of a survey of biotechnology firms in 2010.[43] CBS defines biotechnology activity as "the application of science and technology originating in living organisms (including parts of organisms, plans, organism products, models, etc.) for the development, production, or modification of materials in pursuit of the production of knowledge, goods, or services."

A previous survey on the topic was conducted by CBS in 2002, allowing us to present comparisons with this year for some indicators. In 2010, Israel had 233 active establishments in biotechnology, of which 81 percent were classified in the Research and Development Division. Most establishments in this division are start-ups; a few are research institutes and laboratories. Nine biotechnology establishments are R&D centers but their share in total R&D activity is small (5 percent).

The next figure presents the number of establishments engaging in biotechnology in Israel and other countries. Typical of this industry in Israel is that 90 percent of the establishments report biotech as their main activity.

Figure 6.16: Number Of Biotechnology firms (N), 2010[1]



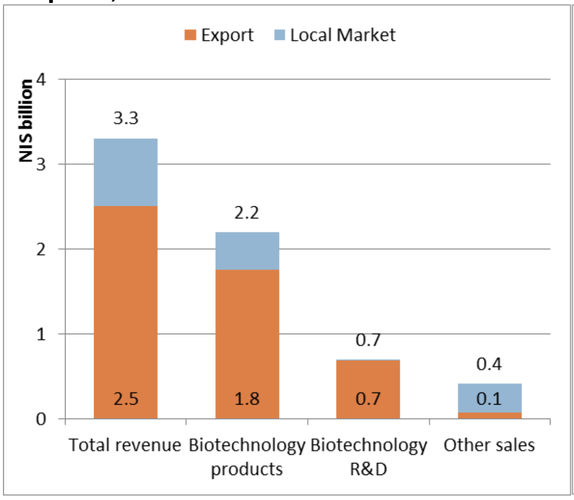
Source: CBS

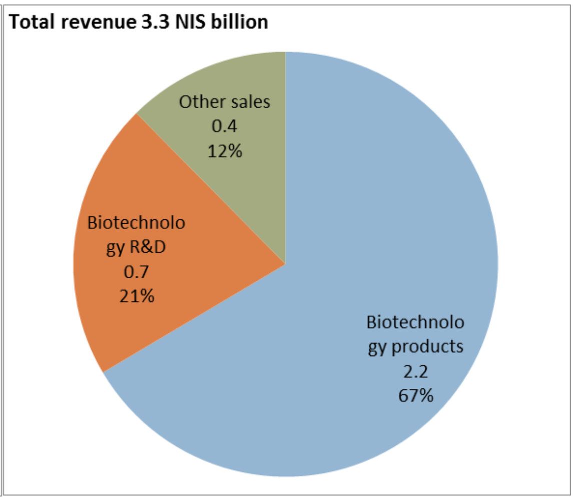
Note: 1. 2010 or latest available data

[43] Survey of Biotechnology Firms—2010, press release, November 14, 2012; Central Bureau of Statistics, http://www.cbs.gov.il/reader/newhodaot/hodaa_template.html?hodaa=201229309.

In 2010 , biotechnology establishments generated NIS 3.3 billion in income and spent NIS 1.5 billion on R&D. The next figure segments this income by types and purposes. Thus, 21 percent of sales came about as the result of sales of R&D and 76 percent (including 98 percent of income tracing to sale of biotechnology R&D) were the result of exports.

Figure 6.17: Segmentation of Biotechnology Establishments' Income by Type and Purpose, 2010[1]

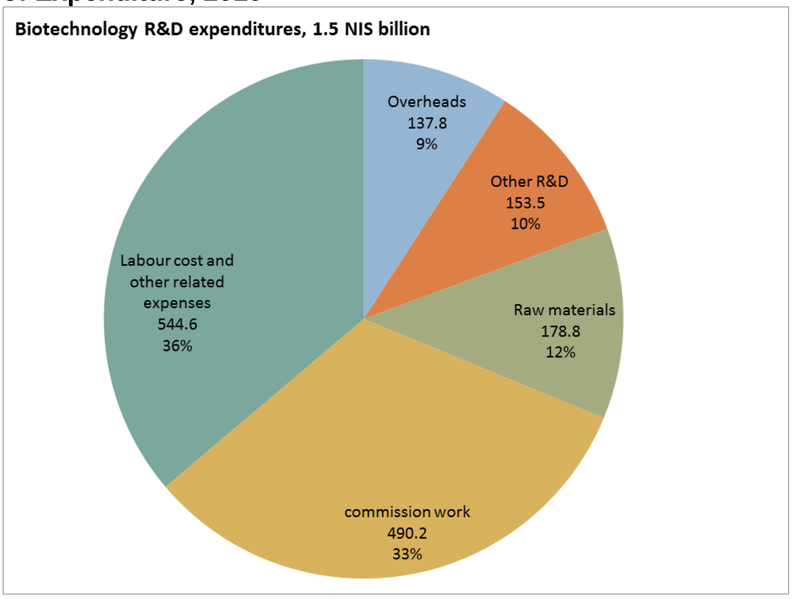




Source: CBS

As noted, biotechnology establishments spent NIS 1.5 billion on R&D, 45 percent of total income. The next figure distributes R&D expenditure by type of expenditure. Some thirty-six percent of expenditure on R&D went for wages and related outlays and 33 percent accrued to outsource providers. Half of the payments to outsource providers were made to providers abroad.[44]

Figure 6.18: Segmentation of Biotechnology Establishments' R&D Expenditure by Type of Expenditure, 2010[1]

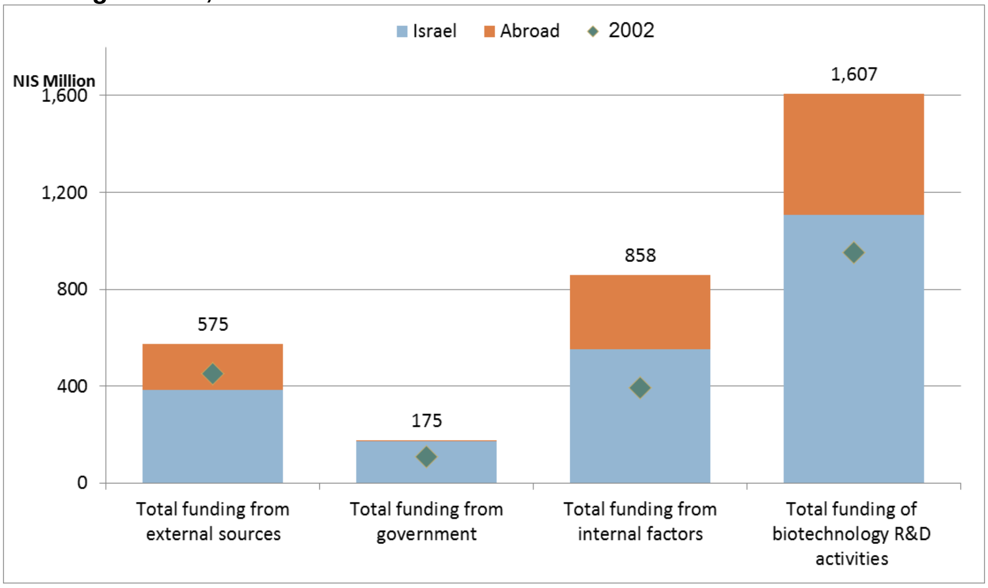


Source: CBS

[44] Survey of Biotechnology Firms—2010, press release, November 2012, p. 7.

Biotechnology R&D is funded from three sources: 36 percent from extramural sources (private capital, offerings on the stock exchange, etc.), 11 percent from government, and 53 percent intramural. The share of government funding relative to other funding sources has hardly changed since 2002.

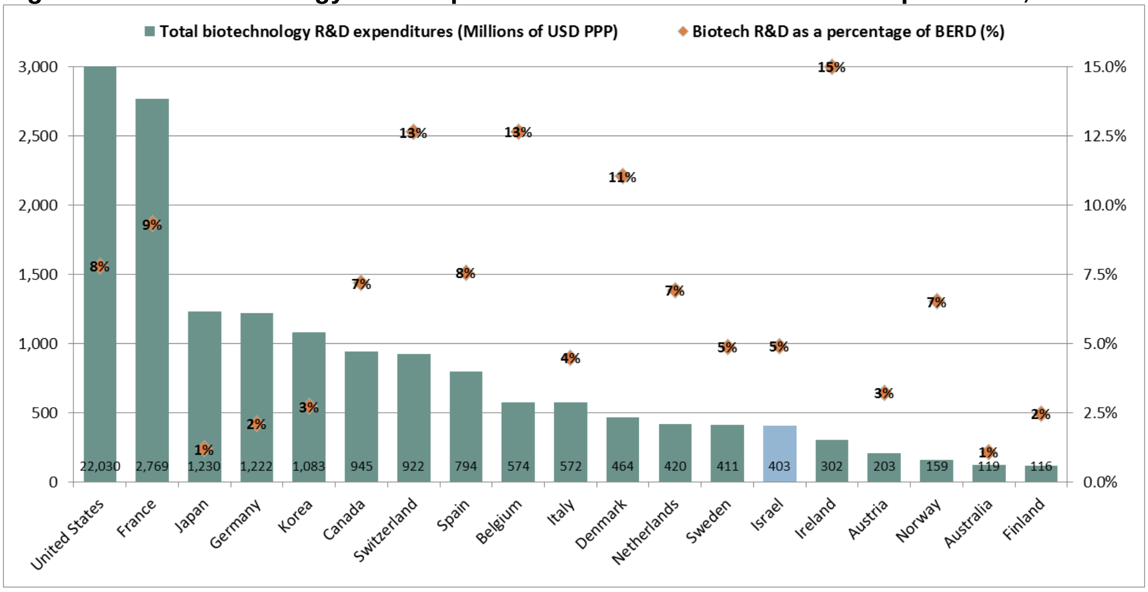
Figure 6.19: Segmentation of Biotechnology Establishments' R&D Expenditure by Funding Source, 2010[1]



Source: Analysis of CBS data by Samuel Neaman Institute

The next figure presents a cross-country comparison of business enterprise R&D (BERD) expenditure on biotechnology. In Israel, this expenditure was the USD 403 million in PPP terms. In domestic currency terms, Israel resembles similarly sized countries such as Denmark, the Netherlands, and Sweden. Normalized as a share of BERD, Israel's rate is 5 percent, trailing Ireland (15 percent), Denmark (11 percent), and Switzerland (13 percent). This relatively small share of biotechnology R&D in total BERD originates, among other factors, in extensive R&D activity in software and electronic components.

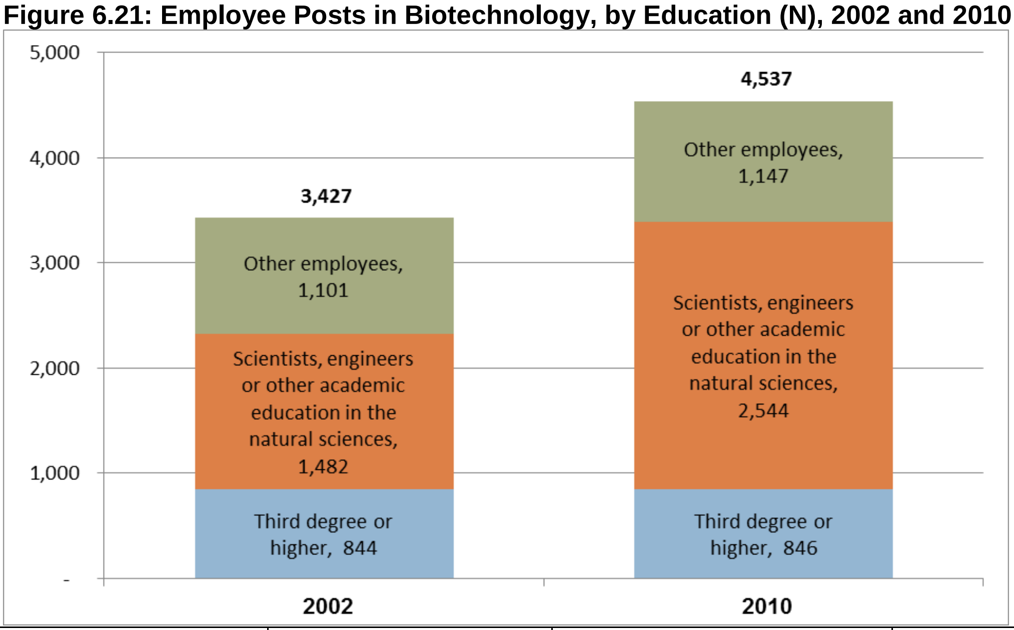
Figure 6.20: Biotechnology R&D Expenditure and Its Share in BERD Expenditure, 2010



Source: Analysis of CBS data by Samuel Neaman Institute
http://www.oecd.org/innovation/innovationinsciencetechnologyandindustry/keybiotechnologyindicators.htm

In 2010, there were 233 establishments in the biotechnology industry and 4,537 employee posts; posts increased by 32 percent relative to 2002. The main growth occurred in the education level of scientists and engineers. Some 19 percent of posts were at the Ph.D. level and most of them were for R&D. The number of posts at this level of education hardly changed since 2002 and the share of this level in total posts shrank from 25 percent in 2002 to 19 percent in 2010.

Figure 6.21: Employee Posts in Biotechnology, by Education (N), 2002 and 2010



No. of biotech companies	148	233	57%
Jobs in Biotechnology	3,427	4,537	32%
No. of jobs in biotech R&D	1,602	2,255	41%

Source: Analysis of CBS data by Samuel Neaman Institute

6.5 Survey of Business Sector Innovation in 2006–2008

- In 2008, Israel's business sector spent NIS 46.6 billion (current) on innovation in its establishments.
- Thirty-six percent of spending on innovation took place in manufacturing industries and 43 percent was performed in business services. (Most expenditure in business services was on R&D and computerization services.)
- The survey in Israel shows that 70 percent of all business establishments reported some kind of innovation process (technological or other). Comparison with data from the CIS survey shows that Israel is far above the EU-27 average (51.6 percent).
- Ten percent of establishments in Israel that reported innovation presented a new innovation to the markets in which they operate. Israel exceeds the EU average in this respect (6.4 percent).
- In the survey, 32 percent of establishments in Israel reported technological improvement in the economy at large and 13 percent reported technological innovation to the markets in which they operated.
- In Israel, 35 percent of firms that presented a technological innovation did so in collaboration with outside players—a low percentage by European standards.
- According to the CBS innovation survey, Israel is one of the leading countries in non-technological innovation.

Innovation—not only technological—abets economic growth and the empowerment of knowledge in the economy, not only in the business sector but also in domains related to the public welfare such as healthcare, green energy, and water, to name only a few. Therefore, decision-makers and policymakers attribute much importance to measuring innovation and its contribution to the economy, understanding firms' and organizations' innovative behavior, and identifying factors that encourage or inhibit innovation.

Innovation is no longer considered a linear process, i.e., development of an idea in a laboratory or an academic research facility and translating it into a new product, process, or service. Today, it is already clear that innovation is a complex and complicated multisystem process that involves many players and is influenced by the political, economic, social, political, and regulatory situation, a process that often has unforeseen results and implications.

Innovation is not only the outcome of the successful development of a new product and the surmounting of technological problems. It also requires suitable conditions for success in the business and/or public market, including adaptation to customer requirements, economic viability, and investment in infrastructures for support and marketing of the innovation.

Innovation is a broad concept that embraces R&D activity and other actions that contribute to the introduction of meaningful changes in an establishment's activity. Innovation may find expression in various ways. The *Oslo Manual OECD/Eurostat* (2005) defines it as the application of a product (a good or service) or a process, a marketing method or an organizational process, that is new or significantly improved. A product is said to be applied when it is presented to a market. New processes, marketing methods, or organizational methods are applied when they reach the level of practical use in organizations' activity.

The survey distinguished between technological and non-technological innovations. According to the international definitions that CBS has adopted, technological innovation is the kind that leads to a change or an increase in the technological diversity of an organization's products and production processes. Two kinds of innovation are included: (1) product innovation (of a good or service), i.e., the introduction in a market of a new or significantly improved product, and (2) process innovation, the application of a new or significantly improved process by an organization. Non-technological innovation (organizational and marketing) is the application of new organizational methods, not previously used by the establishment, related to the establishment's business conduct, internal management, and conduct vis-à-vis extramural players. Marketing innovation is the application of a new marketing strategy or method that is significantly different from those existing at the establishment previously.

Establishments were also divided among those that engaged in **technological innovation** (those that presented a product or process innovation or performed an innovative activity that had not matured to the level of application or was terminated), those that presented a **technological innovation** (of a product or process only), and those that engaged in **some kind of innovation** (presenting a product or process innovation or engaging in innovative activity that was terminated or not yet completed), or establishments that presented a **non-technological** [organizational or marketing] **innovation**.

In Europe, data on the topic are gathered by means of a standard innovation survey, the Community Innovation Survey (CIS), introduced in 1992 and carried out every few years since then. CBS did its first innovation survey for 2006–2008[45] on the basis of CIS.

[45] The survey questionnaire, items, and definitions may be viewed at the CBS web site.

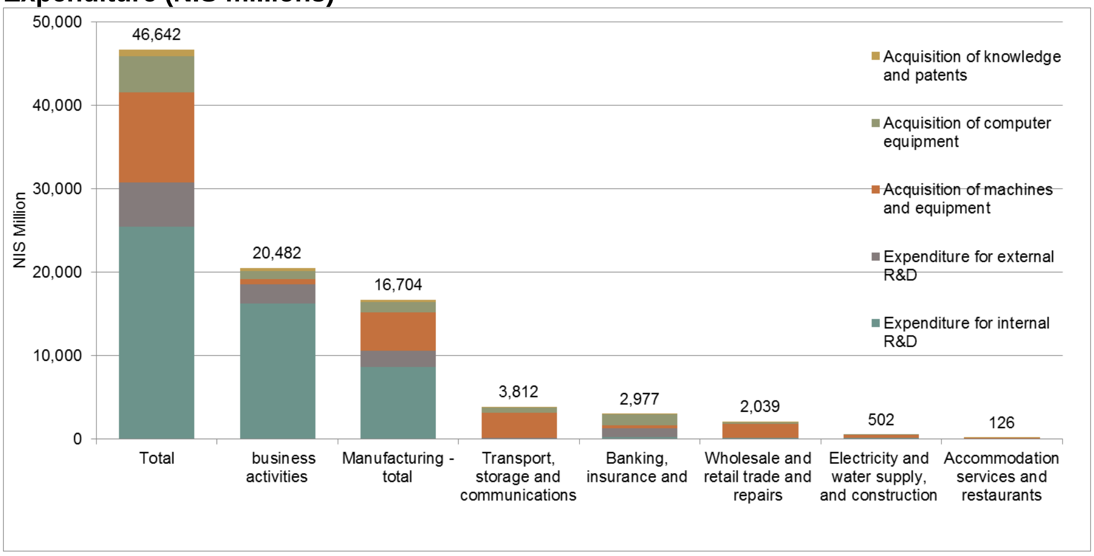
This section presents main data from innovation surveys in Israel and other countries. All data shown relate to 2006–2008 unless otherwise stated.

The Israel survey was conducted on a sample of 2,670 business enterprises among all business enterprises that had at least ten employee posts and were active in December 2007. These establishments operated in the following economic sectors (following the CBS sectoral classification): manufacturing (10–39), construction, electricity, and water supply (41–45), wholesale and retail commerce and repairs (50–53), hospitality and food services (55–56), transport, storage, and communications (60–66), banking, insurance, and other financial institutions (67–68), and business services (70–76). Most indicators in this part of the discussion are segmented on the basis of these sectors and are differentiated between manufacturing and service industries.

6.5.1 Data from the Israel Innovation Survey

Seventy percent of all business enterprises in Israel reported some innovation (technological or non-technological). In 2008, the Israel business-enterprise sector spent NIS 46.6 billion (current) on innovation activities, distributed as follows: purchase of machinery and equipment (23 percent), purchase of computer equipment (90 percent), purchase of knowledge and patents (2 percent), intramural R&D (55 percent), and extramural R&D (11 percent). Some 36 percent of innovation expenditure occurred in manufacturing and 43 percent in business services. The business service industries, comprising R&D services (73) and computerization services (72), together accounted for 99 percent of innovation expenditure in the business services. In other words, more than 40 percent of innovation expenditure in Israel is performed by R&D and computerization service enterprises.

Figure 6.22: Business-Enterprise Innovation Expenditure, by Sectors and Types of Expenditure (NIS millions)



Source: Analysis of CBS data by Samuel Neaman Institute

6.5.2 Technological Innovation

According to the survey, 32 percent of firms in Israel reported technological innovation and 13 percent reported one a technological innovation that was new to the markets in which they operate. In manufacturing, the rate of technological innovation is a steep 43 percent. Segmentation by technology intensity shows that in high-tech manufacturing the rate of technological innovation is 62 percent as against 38 percent in traditional manufacturing. In the computer-services and R&D-services sector, which are included in the business services, the innovation rates are 68 percent and 63 percent, respectively. Notably, establishments that have not yet applied technology that they are developing are not considered innovative even though they engage only in R&D.

Table 6.2: Firms Reporting Technological Innovation, by Types of Innovations and Economic Sectors (%)

		Tech. innovation	Tech. innovation new to market	Product innovation				Process innovation	Product and process innovation
				Total	Thereof: Goods	Services	Goods and services		
Manufacturing - total		43	16	34	29	13	8	31	23
Technological intensity:	High	62	25	59	50	23	14	41	38
	Medium-high	40	18	35	33	9	7	26	20
	Medium-low	44	18	33	29	12	7	33	22
	Low	38	12	29	24	12	7	29	20
Electricity and water supply, and construction		21	5	12	7	8	3	17	7
Wholesale and retail trade and repairs		24	10	20	11	15	7	16	12
Accommodation services and restaurants		23	8	14	11	9	7	19	10
Transport, storage and communications		26	6	14	4	13	2	18	7
Banking, insurance and other financial institutions		36	20	27	17	15	6	28	18
business activities		45	22	40	24	27	12	27	22
There of:	Computer and related services	68	37	64	41	47	24	41	36
	Research and development	63	33	52	48	19	15	39	28
Total		**32**	**13**	**25**	**17**	**16**	**7**	**22**	**15**

Source: CBS

6.5.3 Non-Technological (Organizational and Marketing) Innovation

Sixty-seven percent of business enterprises reported non-technological innovation, chiefly the application of new organizational and marketing methods. Among the rapporteurs, about half reported an organizational innovation and 55 percent reported a marketing innovation. Such innovation relates to organizational and methodological processes that help to bring products to the market. Non-technological innovation appears to be more common than technological innovation: 67 percent as against 32 percent, respectively.

Table 6.3: Technological and Non-Technological Innovation

		Non-technological innovation				Technological innovation	
		Total	**Organiz-ational innovation**	**Marketing innovation**	**Revealed advantage**	**Total**	**Revealed advantage**
Manufacturing - total		69	51	58	**1.03**	**43**	**1.31**
Technological intensity:	High	77	57	68	1.16	61	1.9
	Medium-high	65	48	49	0.97	40	1.24
	Medium-low	62	50	51	0.93	44	1.34
	Low	73	51	63	1.09	38	1.17
Electricity and water supply, and construction		49	37	35	0.74	21	0.63
Wholesale and retail trade and repairs		70	49	60	1.05	24	0.73
Accommodation services and restaurants		64	36	58	0.95	23	0.7
Transport, storage and communications		70	55	56	1.05	26	0.8
Banking, insurance and other financial institutions		74	62	56	1.11	39	1.19
business activities		70	53	56	1.05	45	1.39
Thereof:	Computer and related services	81	61	69	1.21	68	2.1
	Research and development	74	56	59	1.12	64	1.96
Total		**67**	**48**	**55**	**1.00**	**32**	**1.00**

Source: CBS

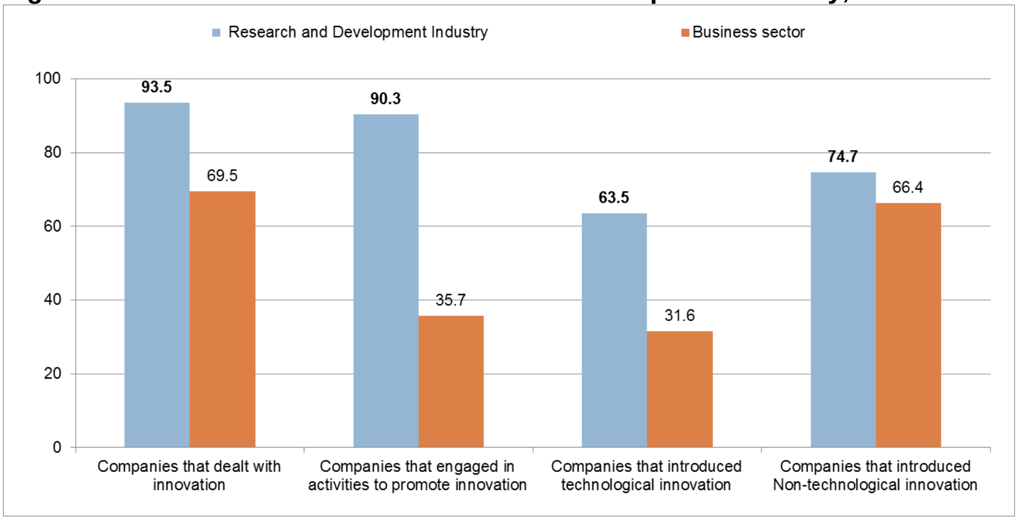
6.5.4 innovation in the Research and Development Industry

In 2009, the research and development industry spent NIS 10.3 billion (current) on R&D, 38 percent of total BERD expenditure (for elaboration, see Section 6.3—"Scientific Research and Development Industries"). The figure that follows presents data on total (technological/non-technological) innovation in the research and development industry. As stated, this industry comprises diverse firms and organizations, most engaging in the creation of knowledge and technology by means of R&D or in direct support of it.

Data from the 2006-2008 Innovation Survey[46] indicate that 93.5 percent of R&D establishments engaged in innovation as against 69.5 percent in the rest of the business-enterprise sector, and 63.5 percent of such establishments presented the markets with a new product or developed a new production process, as against 31.6 percent of establishments in the rest of the business-enterprise sector.

[46] The 2006–2008 Innovation Survey combined the 2008 R&D survey.

Figure 6.23: Innovation in the Research and Development Industry, 2006–2008

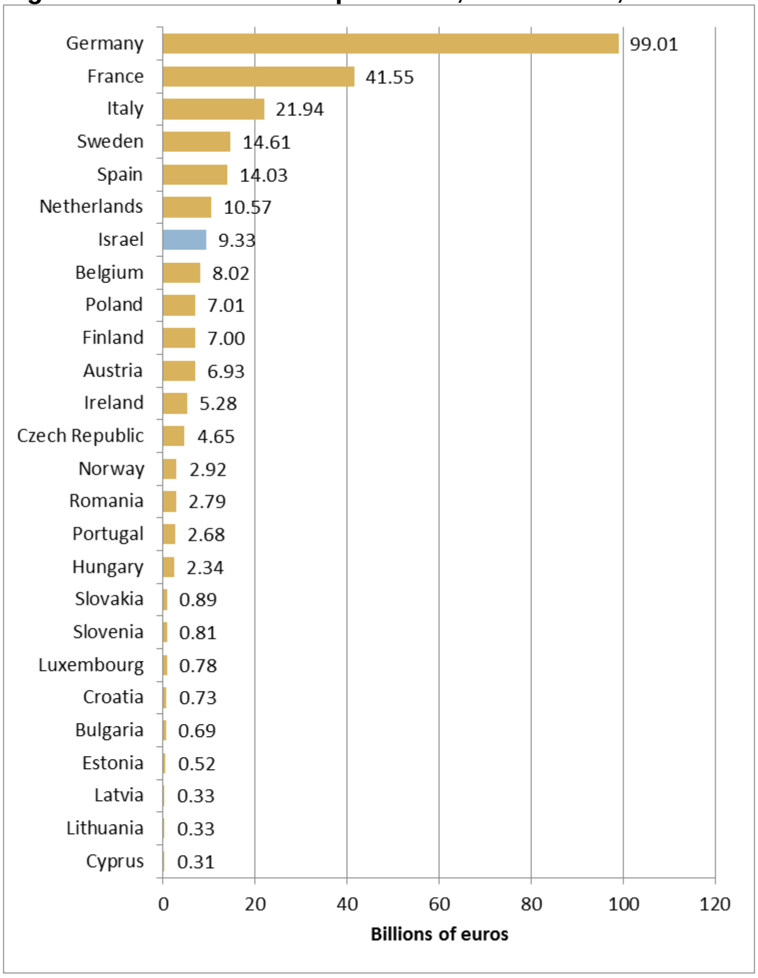


Source: Analysis of CBS data by Samuel Neaman Institute

6.5.5 Cross-Country Comparison

In 2008, Israel's business-enterprise sector spent EUR 9.33 billion on innovation. The next figure compares Israel's expenditure in this regard with other countries that year. Israel ranks seventh among the countries shown, trailing Germany, France, Italy, Sweden, Spain, and the Netherlands.

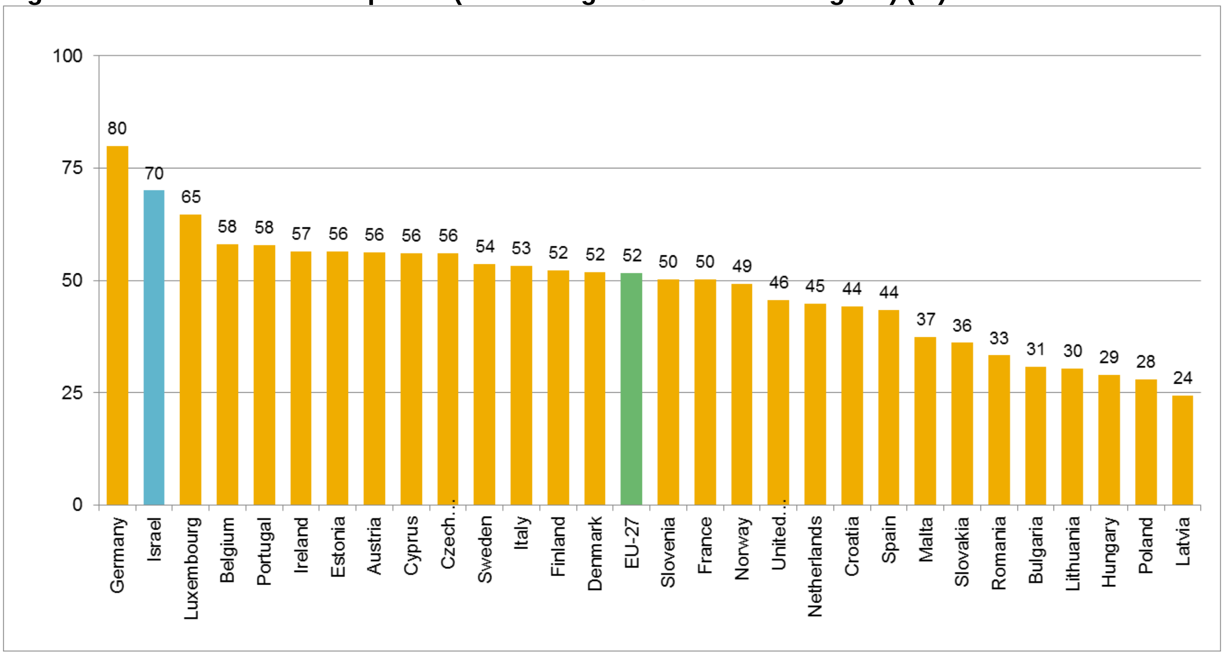
Figure 6.24: Innovation Expenditure, EUR Billion, 2008



Source: Analysis of CBS data by Samuel Neaman Institute

In the CBS survey, 70 percent of business enterprises reported some innovation process (technological or non-technological), far exceeding the European (EU-27) average of 51.6 percent according to the results of the CIS. This puts Israel in second place among the surveyed countries: Germany (79.9 percent), Israel (70 percent), Luxembourg (64.7 percent), Belgium (58.1 percent), and Portugal (57.8 percent).

Figure 6.25: Innovative Enterprises (Technological/Non-Technological) (%)



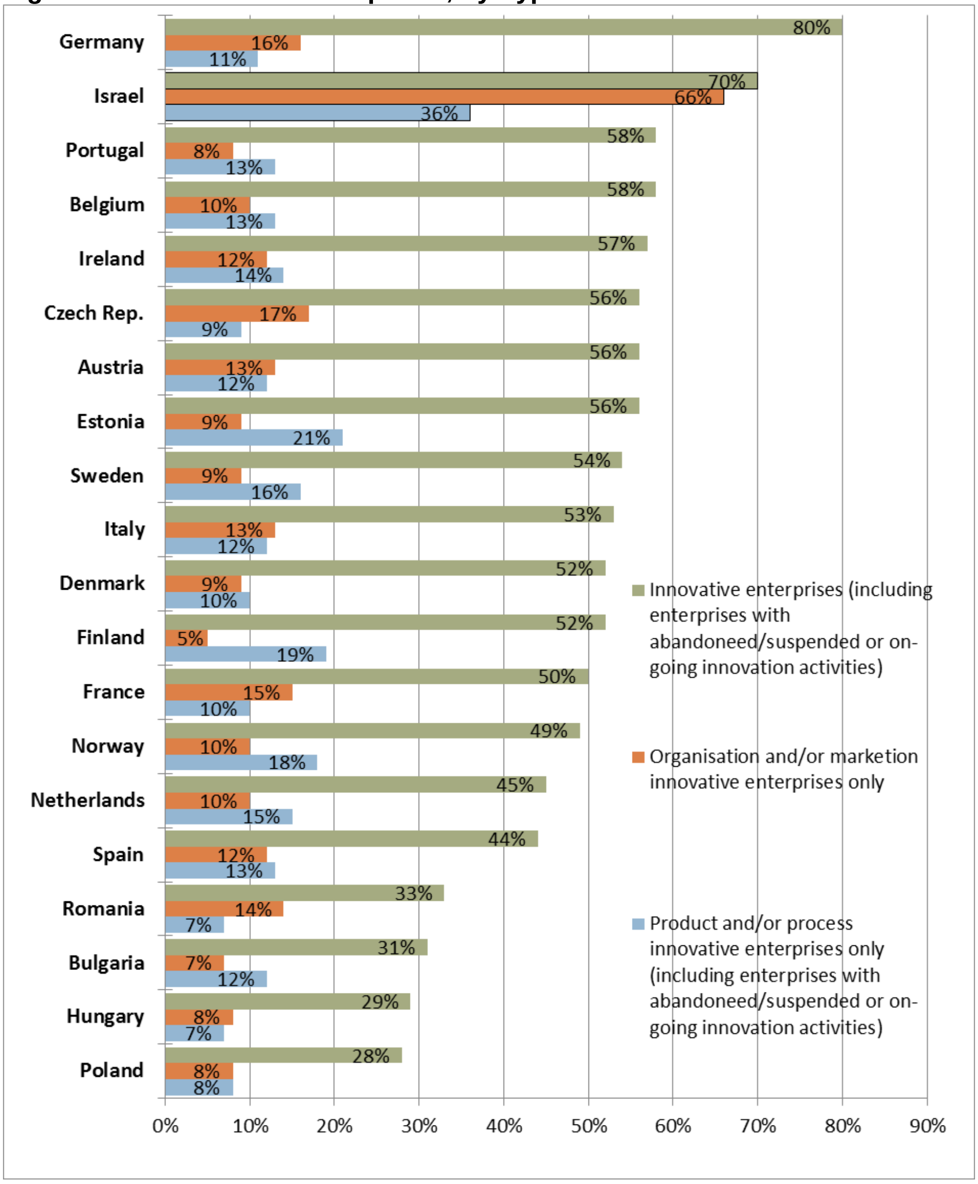
Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

The next figure parses innovative enterprises by types of innovation (technological innovation only, non-technological innovation only, or both). In Israel, 70 percent of enterprises performed both types of innovation.[47]

The data do not sum to 100 percent because some enterprises engage in both types of innovation. Sixty-six percent reported a non-technological innovation. (The OECD and Eurostat data do not include enterprises that fill fewer than ten employee posts; therefore, there is a minimal difference between the data in Figure 6.32 and those in Table 6.4.) Israel stands out for its difference in non-technological innovation.

[47] Including innovation activities that did not mature into a new product or process or were abandoned; for this reason, the rate reported differs from the data in table 6.2, which relates only to innovation actions that were completed.

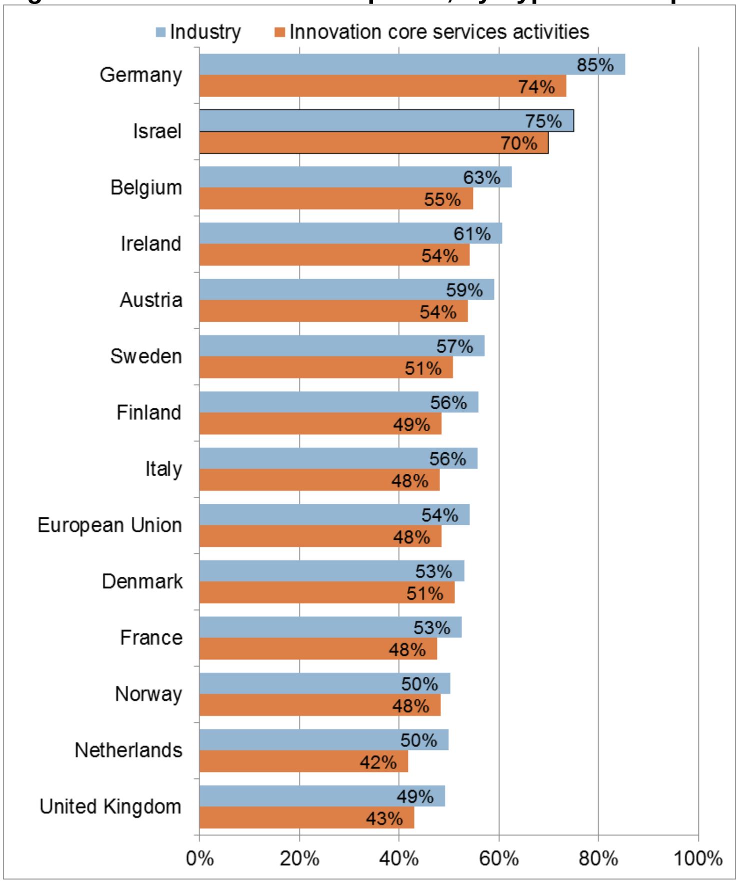
Figure 6.26: Innovative Enterprises, by Type of Innovation



Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute
Notes: The data in this figure includes enterprises that report technological innovation or non-technological innovation (product, process, ongoing or abandoned). Also OECD data and the EURUSATA do not include enterprises employing less than 10 positions so there is a difference between previous data and the data in this figure for Israel.

In Israel, 75 percent of manufacturing enterprises and 70 percent of service enterprises reported innovation. This ranks Israel second, following Germany (85 percent in manufacturing, 74 percent in services).

Figure 6.27: Innovative Enterprises, by Type of Enterprise (Manufacturing/Services) (%)

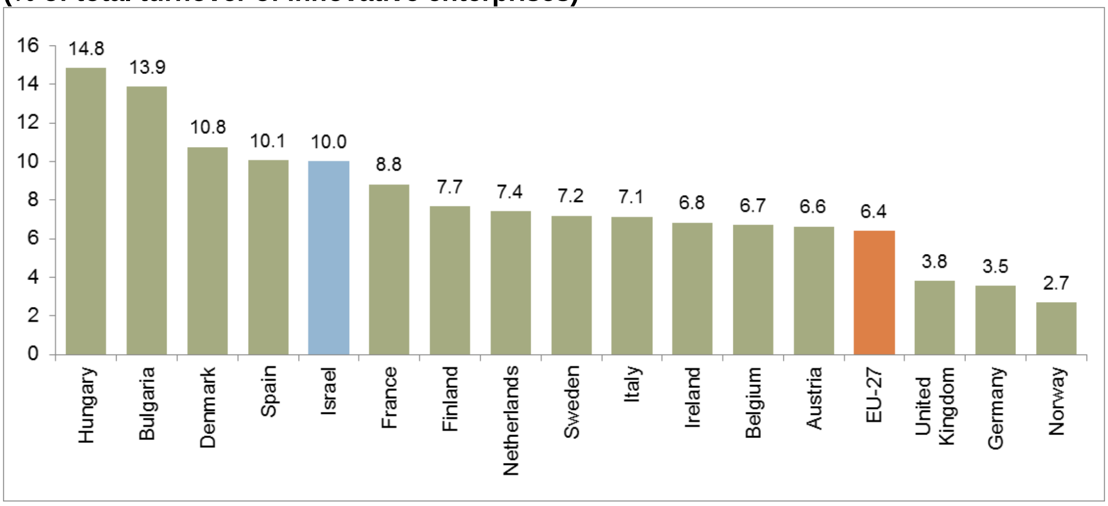


Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

6.5.5.1 Technological Innovation

The next figure shows the percent of turnover among enterprises that reported technological innovations that were new in their markets, resulting from the sale of new products there. By this parameter, too, Israel exceeds the European Union average (10 percent and 6.4 percent, respectively).

Figure 6.28: Turnover from new or significantly improved products new to the market, (% of total turnover of innovative enterprises)



Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

The table below shows the proportion of enterprises that reported innovations new to their markets and the share of these enterprises that manufactured the product themselves. In Israel, large enterprises (250 employee posts or more) are the most innovative—59 percent reported a technological innovation ,and among them, 21 percent reported one that was new to the markets in which they operated.

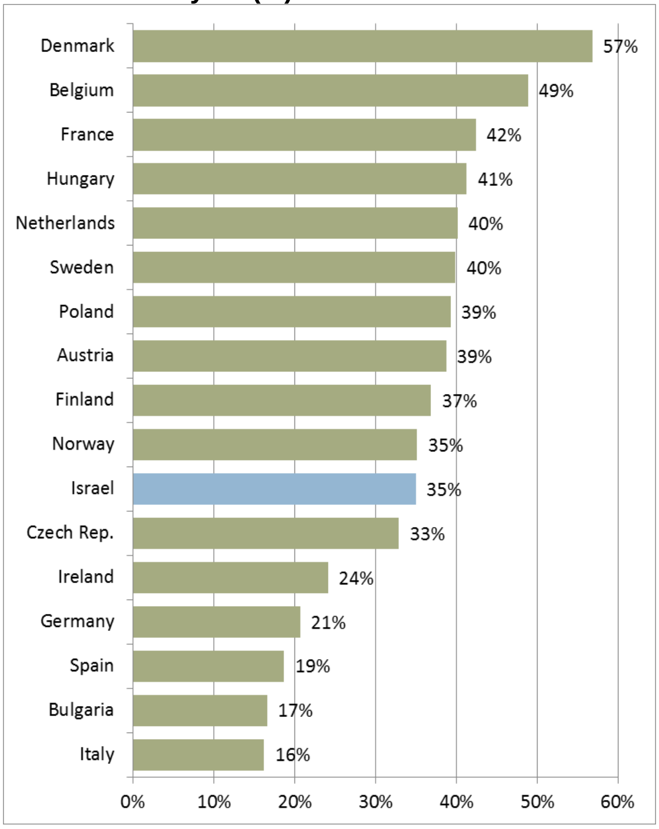
Table 6.4: Enterprises Presenting Technological Innovation and Innovation New to Their Markets, by Enterprise Size (%)

	Process innovations: developed by the enterprise or group				Product innovations: new to market			
	Total	With 10 to 49 employees	With 50 to 249 employees	With > 250 employees	Total	With 10 to 49 employees	With 50 to 249 employees	With > 250 employees
France	50.8	50.8	49.1	55.0	43.2	39.9	46.3	60
Spain	50.7	50.6	49.4	57.4	21.5	18.0	28.1	43.6
Israel	45.0	42.0	55.0	59.0	16.0	16.0	14.0	21
Italy	44.9	44.0	48.7	47.9	47.7	45.5	55.5	61.4
Poland	43.7	45.8	40.7	42.7	41.5	40.1	41.6	47.5
Belgium	42.2	42.7	39.3	47.5	47.5	47.1	45.5	59.3
Bulgaria	41.3	40.7	43.8	38.1	25.9	23.3	30.8	30.8
Finland	39.2	40.4	35.1	40.0	37.3	35.5	35.9	57.7
Czech Rep.	39.0	40.1	35.4	41.2	39.1	34.0	47.0	54.1
Austria	37.6	34.9	41.7	45.8	49.5	46.3	52.1	66.4
Sweden	33.5	33.1	33.0	39.5	50.4	48.3	53.6	62.8
Germany	30.1	27.1	35.6	42.0	26.0	23.2	29.5	43.7
Norway	27.4	28.0	25.1	29.0	34.5	36.8	28.5	34.6
Hungary	24.8	25.0	21.0	32.6	33.1	31.2	32.0	45.2
Netherlands	23.4	22.0	25.7	29.4	49.2	48.1	51.3	53.6

Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

In Israel, 35 percent of enterprises that presented a technological innovation did so in cooperation with extramural players (other business enterprises in Israel or abroad). By cross-country comparison, Israel ranks in the middle of the standings, trailing countries such as Denmark (57 percent), Belgium (49 percent), and France (42 percent).

Figure 6.29: Enterprises Reporting Technological Innovation in Conjunction with Extramural Players (%)



Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

In Israel, 27 percent of collaborations were with enterprises in Israel, 16 percent with Europe, 13 percent with the U.S., and 5 percent with China or India. The rate of Israel–U.S. cooperation resembles that of Sweden and Finland but surpasses most countries in the table, illuminating Israel's special relationship with the U.S. Israel collaboration with China and India also exceeds other countries' rates.

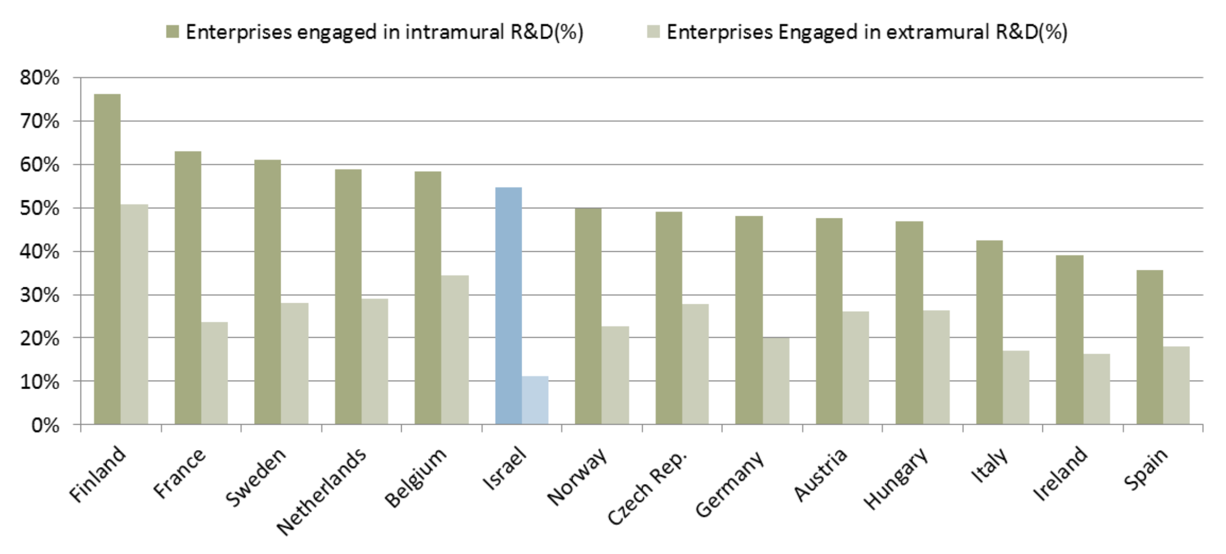
Table 6.5: Enterprises Reporting Technological Innovation in Conjunction with Extramural Players, by Countries

	Enterprise engaged in any type of innovation co-operation:				
	National	with other Europe	with the US	with China or India	with other partner countries
Belgium	41.80%	29.50%	9.40%	5.80%	7.90%
France	39.10%	15.90%	5.20%	2.40%	4.00%
Hungary	38.90%	16.70%	3.10%	2.70%	2.50%
Sweden	37.70%	24.80%	11.20%	7.30%	8.60%
Finland	36.40%	26.40%	11.10%	6.70%	7.60%
Netherlands	36.30%	21.10%	7.40%	3.10%	5.10%
Austria	33.60%	23.90%	3.10%	1.80%	2.60%
Norway	31.70%	16.10%	4.30%	2.20%	2.90%
Czech Rep.	29.10%	19.80%	2.80%	2.00%	2.80%
Israel	27.00%	16.00%	13.00%	5.00%	6.00%
Germany	19.90%	7.20%	2.40%	1.30%	1.50%
Ireland	19.30%	5.60%	2.50%	2.80%	15.90%
Spain	17.70%	4.40%	1.00%	0.40%	0.90%
Italy	14.80%	4.40%	1.30%	0.80%	0.70%
Bulgaria	14.40%	5.60%	1.10%	0.50%	1.70%

Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

Figure 6.30 shows the proportion of enterprises that reported the performance of intramural and extramural R&D. In Israel, the disparity between the two is very wide.

Figure 6.30: Enterprises Reporting Performance of Intramural and/or Extramural R&D among Those Reporting Technological Innovation (%)



Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

6.5.5.2 Non-Technological Innovation

Israel is one of the leading countries in non-technological innovation. Some 55 percent of Israeli enterprises reported a marketing innovation—a proportion surpassed only by Germany (55.7 percent) among the countries in the table below. Some 48 percent of Israeli enterprises reported an organizational innovation; again, Israel ranks second to Germany (50.3 percent). About 67 percent of Israeli firms reported an organizational and/or marketing innovation, placing their country again under Germany (69 percent).

Table 6.6: Enterprises Reporting Non-Technological Innovation, by Types of Innovation

	Enterprise introduced marketing innovation	Enterprise introduced organizational innovation	Enterprise introduced organizational and/or marketing innovations
Germany	55.70%	50.30%	69.00%
Israel	55.00%	48.00%	67.00%
Czech Rep.	35.60%	34.00%	47.00%
Belgium	29.50%	35.30%	45.00%
Austria	27.30%	34.90%	44.30%
Ireland	27.00%	32.30%	42.60%
Denmark	28.80%	33.30%	41.50%
Italy	27.10%	31.10%	41.20%
EU-27	26.60%	31.00%	40.10%
France	20.90%	33.80%	39.80%
Sweden	24.00%	28.70%	38.00%
Finland	21.70%	24.70%	33.00%
UK	17.80%	27.50%	31.50%
Norway	21.70%	20.10%	31.40%
Spain	15.50%	27.00%	30.90%
Netherlands	18.30%	21.30%	29.90%

Source: Analysis of CBS data and Eurostat data by Samuel Neaman Institute

6.6 Research and development at Government Research Institutes and Public and Private Research Institutes and Units

R&D expenditure by government research institutes is part of government R&D expenditure. Government R&D performed by research institutes is intended for the public welfare and comes with government guidance and public funding. Such research is initiated, funded, and performed by government or commissioned from an outside funder; its purpose is to help government to discharge its duties in order to apply its policies on the basis of national priorities for citizens' well-being—all of which to advance Israel's future economy and society.

Not-for-profit institutions (NPIs) fall into two categories: (1 public NPIs—those that derive the funding for most of their expenditures from government, and (2) NPIs that serve households—which get their main funding from non-governmental sources. In 2009, CBS performed a survey on research and development in government institutions and private and public NPIs in order to obtain a comprehensive snapshot of these institutes' domestic R&D activity. Such a snapshot would be helpful in generating accurate statistics on R&D activity and calculating national expenditure on civilian research and development, especially the public kind.

The survey included 104 government institutes,[48] private NPIs, and public NPIs that have R&D as their main activity. The survey data show that most expenditure (71.5 percent) is performed by government research institutes, 20.3 percent by in private NPIs, and 8.2 percent by public NPIs. Research and development expenditure by government research institutes, institutions, and units in 2009 was NIS 729 million, only 2 percent of national R&D expenditure. Expenditure on **self-performed** R&D at government research institutes was NIS 452 million, 35.3 percent of total governmental R&D expenditure.

The National Council for Research and Development also ascribed much importance to the matter of government research institutes and set up a committee to study the issue in view of these findings. In its interim report,[49] the committee states, "The civilian government research array should include those elements of applied R&D that are defined as national missions and can be carried out only a state and/or governmental framework [...]. There is R&D activity that is chiefly infrastructural and its contribution, i.e., its utility for the Israeli society and economy at large, cannot be attained at the level of a firm or other organization. Such utility justifies government involvement, be it in performing the R&D or in funding it." The committee's prime objective was to identify national needs and establish priorities on a multiannual

[48] Government offices, institutions, and auxiliary units that perform R&D independently.
[49] Gury Zilkha and Dov Mishor, Committee on Government Research Institutes, National Council for Research and Development, July 2009, in Hebrew.

basis. We hope the indicators in this chapter will help the National Council for Research and Development and the committee members to grasp the matter from a broad perspective.

As of the present writing, the data from the survey on R&D in government institutions have not been adopted for use in calculating national R&D expenditure; the amount of government institute R&D included in the calculation is different from that found in the survey. The goal of the survey is to improve the existing method of calculation. In the future, government institute R&D expenditure should be reconciled with the data on national R&D expenditure in accordance with the survey. (If this is done, government R&D expenditure and national R&D expenditure will decline.)

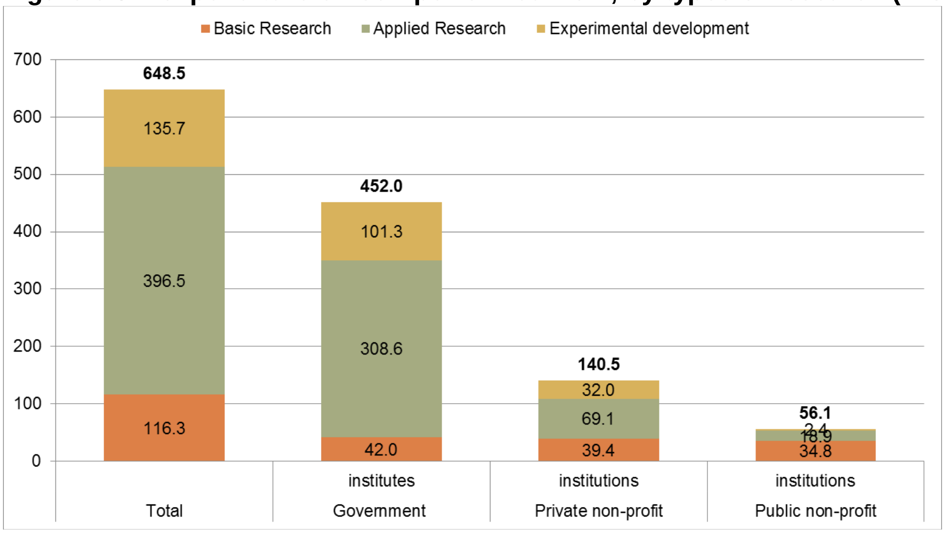
All data in this subchapter come from the CBS survey on research and development at government institutes and public and private research institutions and units, 2009.

6.6.1 Type of Research

Basic research and applied research are long-term activities that entail high financial risk because much time must pass before the research outcomes can be put to commercial or other use. Therefore, in many cases, the business-enterprise sector does not perform research of this kind, leaving universities (responsible mainly for basic research) and government with the main role.

In 2009, research institutes spent NIS 729 million on R&D, 89 percent of which (NIS 648.5 million) on research performed by themselves. The data are shown below, segmented separately for self-performed R&D expenditure only. Expenditure on self-performed R&D at Israeli research institutes was NIS 648.5 million: NIS 116.3 million (18 percent) on basic research, NIS 386.5 million (61 percent) on applied research, and NIS 135.7 million (21 percent) on development.

Figure 6.31: expenditure on self-performed R&D, by types of research (NIS million), 2009)

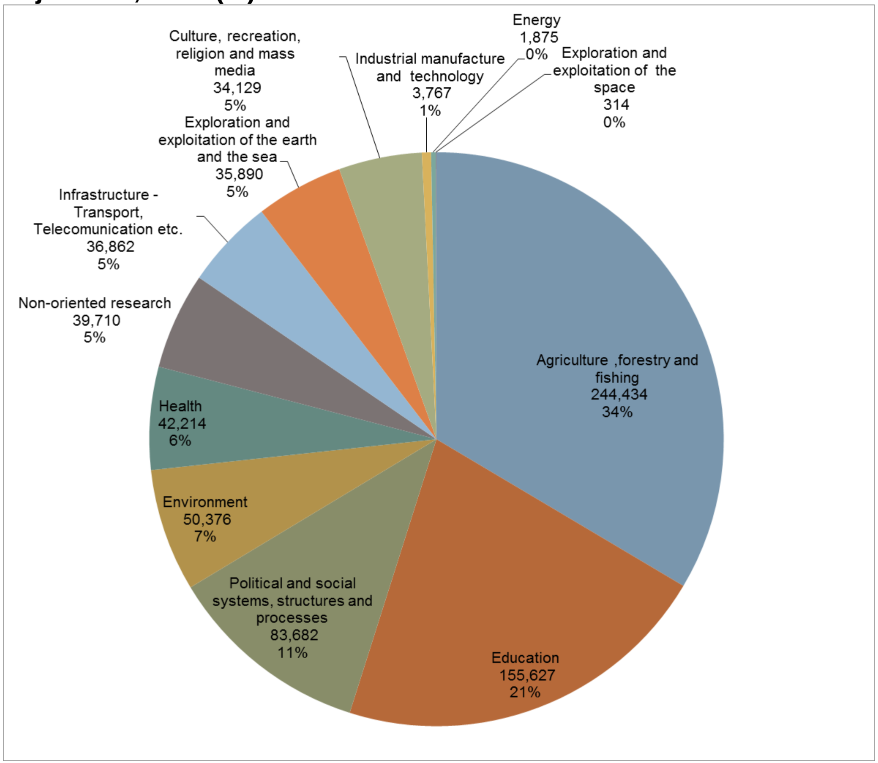


Source: Analysis of CBS data by Samuel Neaman Institute

6.6.2 Parsing of Research by Socioeconomic Objectives

The figure below shows the distribution of research institutes' R&D expenditure by socioeconomic objectives. The main objectives for the performance of research are agriculture, forestation, and fishing (34 percent), education (21 percent), and political and social systems and processes (11 percent).

Figure 6.32: Segmentation of research institutes' R&D expenditure by socioeconomic objectives, 2009 (%)



Source: Analysis of CBS data by Samuel Neaman Institute

6.6.3 Research Institute Personnel

More than half of expenditure on self-performed R&D (56 percent) is for wages. In 2009, research institutes employed 2,755 people including 1,702 degree-holders (62 percent), among whom 735 (27 percent) had doctoral degrees.

Table 6.7: Research Institute Personnel, by Levels Of Education

Education level	Employed (number)	Percentages
TOTAL EMPLOYED PERSONS	2,755	100%
Academics (including engineers and third degrees)	1,702	62%
Academics and Engineers	966	35%
Third degrees	735	27%
Practical engineers & technicians	190	7%
Other Higher education	103	4%
Secondary education	135	5%
Other kind of education*	625	23%

Note: * In Government institute, including students financed by scholarship (grant).
Source: Analysis of CBS data by Samuel Neaman Institute

Segmented by age, the percent of employees aged 55+ among degree-holders was found to be higher (42 percent) at government research institutes than at public and private NPIs (28 percent and 19 percent, respectively). Also, research institutes allow students to do their research work on their premises.

In 2009, fifty-six researchers at these institutes served as advisers on post-doctoral research projects and for 422 students—254 masters candidates and 168 doctoral candidates.

Ninety-eight percent of the masters candidates and 95 percent of the Ph.D. candidates attended Israeli universities and 73 percent of post-doctoral researchers were from Israel.

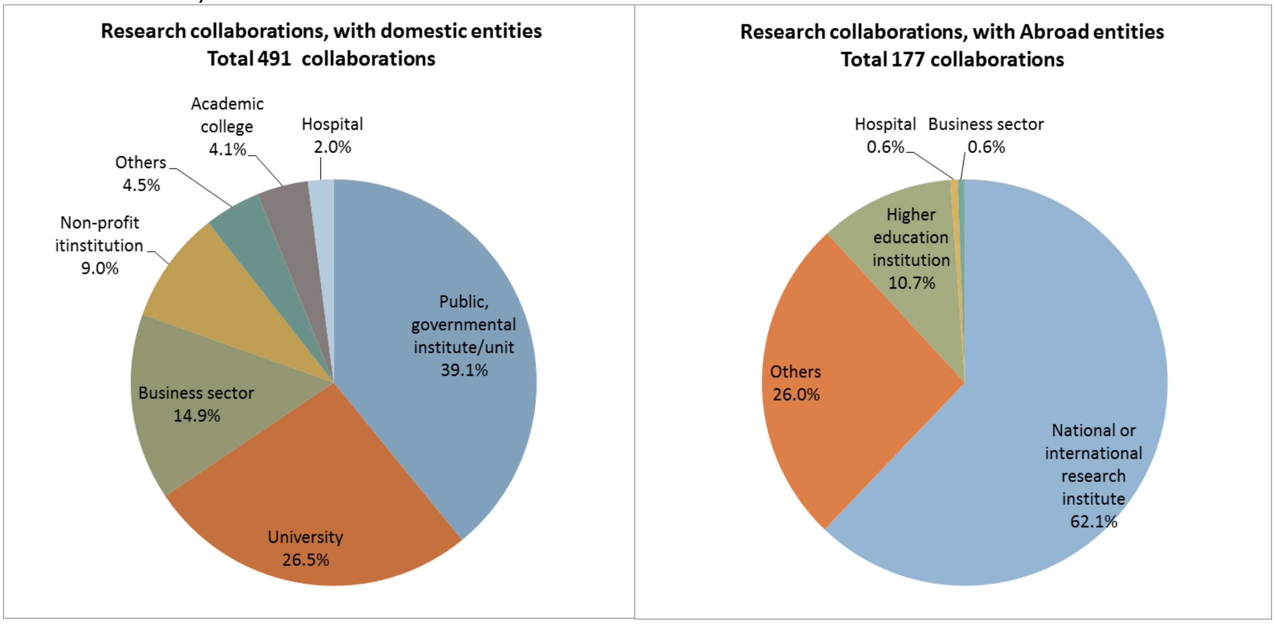
6.6.4 Collaboration between Research Institutes and Other Research Establishments in Israel and Abroad

In 2009, research institutes carried out 668 research collaborations in Israel and abroad—64 percent of them at government institutes, 21 percent at private NPIs, and 15 percent at public NPIs.

NIS 265.7 million was spent on research collaboration. Thus, 36 percent of total expenditure on research institutes' R&D was performed in cooperation with other domestic or foreign establishments. Eighty-six percent of the R&D expenditure was performed by government institutes, 8 percent by public NPIs, and 6 percent by private NPIs.

Figure 6.33 present the distributes research collaborations on the basis of collaborating establishments. 491 collaborations were performed with domestic entities—39 percent of them with public or governmental research institutes, 26 percent with universities, and 15 percent with business enterprises. Another 177 collaborations were carried out with foreign establishments—62 percent by research institutes and 11 percent by domestic institutes of higher education.

Figure 6.33: Distributes research collaborations on the basis of collaborating establishments, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

6.7 Separately Budgeted University Research and Development

University research is performed and funded in two main ways:

a. **Research funded from the regular budget**—research conducted in the course of regular activity.

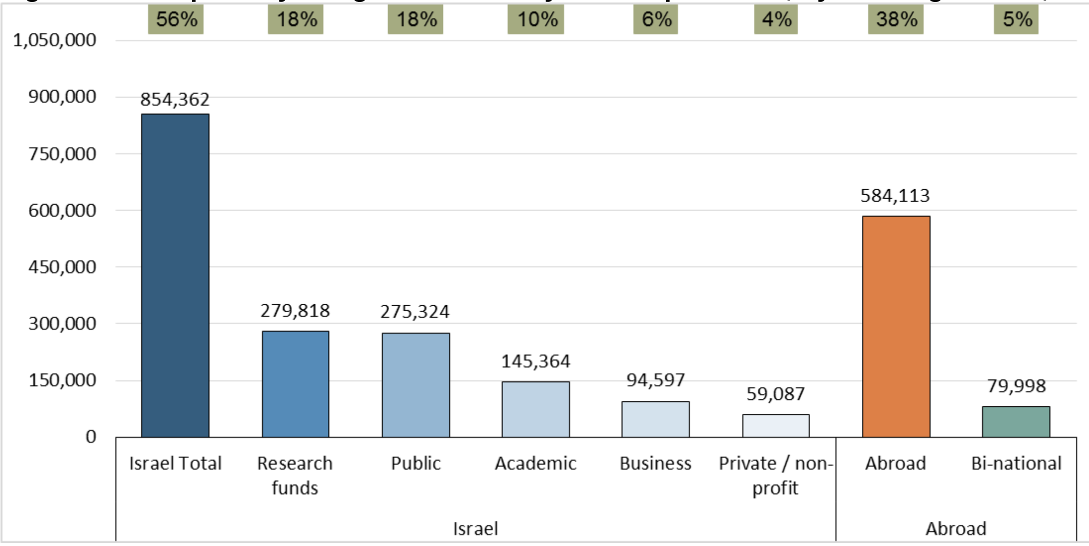
b. **Separately budgeted research**—research budgeted under research contracts and grants funded by extramural (non-university) players and intramural research funds. The accounting systems of the universities' research authorities allow expenditure on these research projects to be identified.

In 2012, the Central Bureau of Statistics released findings on separately budgeted university R&D expenditure. University R&D expenditure accounts for 13 percent of all civilian R&D expenditure in Israel.[50]

Separately budgeted university R&D research expenditure was NIS 1,521.7 in 2009, 60 percent domestically sourced and 40 percent from abroad. The public sector (general government) funded 36 percent of expenditure on separately budgeted research, research funds covered another 30 percent, and the business-enterprise center sourced only 8.8 percent.

[50] Central Bureau of Statistics, press release, Hanan Zackay, Yifat Klopschtock, "Research and Development in Universities—Expenditure for Separately Budgeted Research (2006/7–2008/09)," in Hebrew.

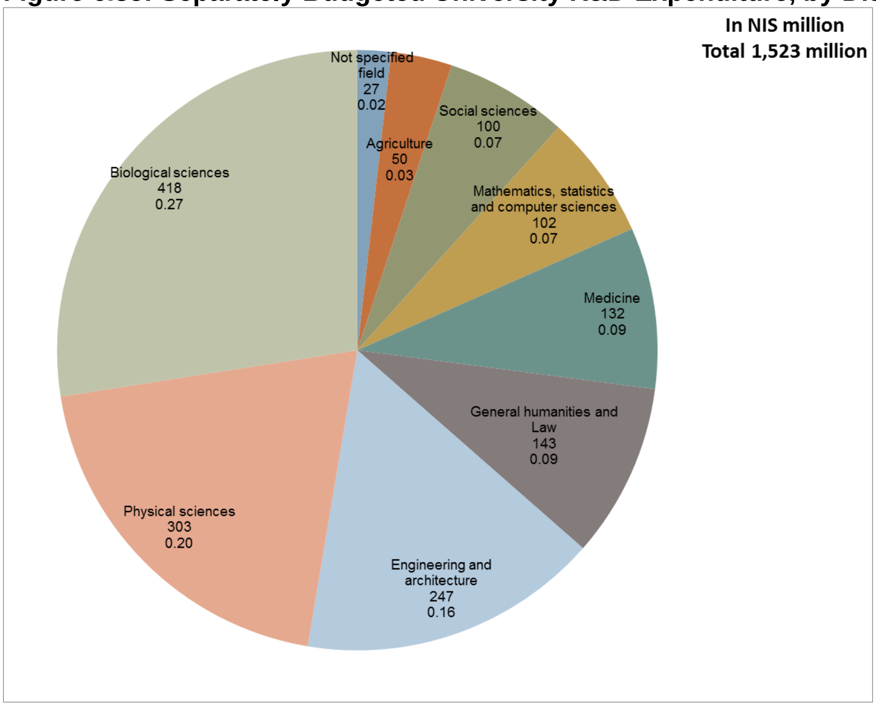
Figure 6.34: Separately Budgeted University R&D Expenditure, by Funding Source, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

The figure below parses separately budgeted R&D expenditure by disciplines. Most expenditure was in the natural sciences (47 percent): 20 percent in physical science, 27 percent in biological science, and 16 percent in engineering and architecture.

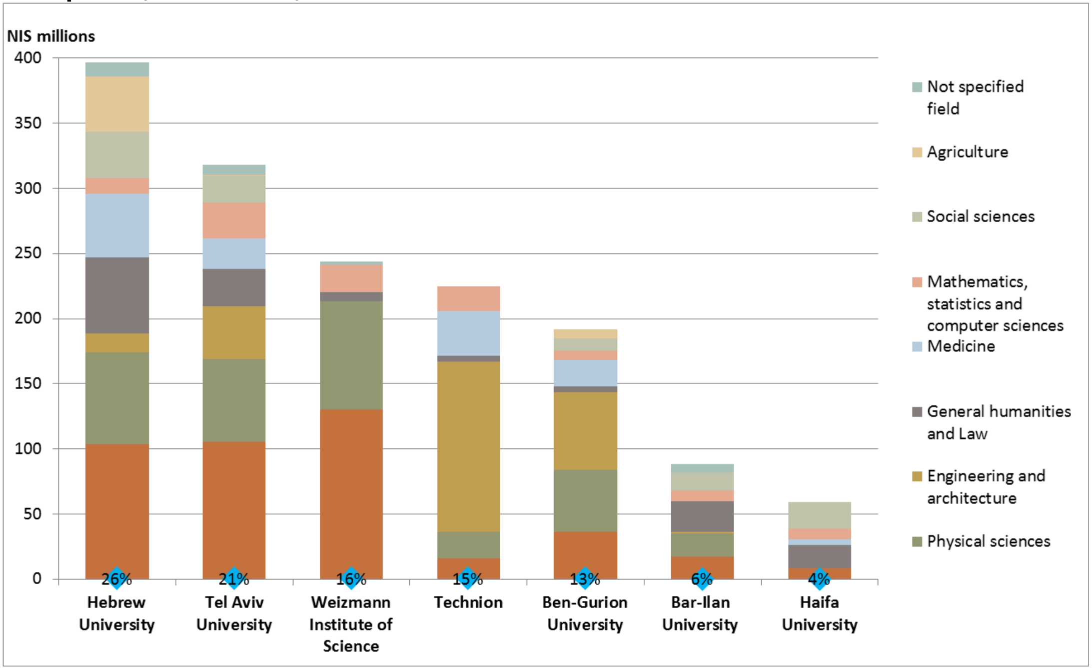
Figure 6.35: Separately Budgeted University R&D Expenditure, by Disciplines, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

Segmented by institutions, the Hebrew University of Jerusalem accounted for 28 percent of total separately budgeted university R&D expenditure. Some 47 percent of this university's expenditure was in the natural sciences (physical science, biology, mathematics, statistics, and computer science).

Figure 6.36: Separately Budgeted University R&D Expenditure, by Institution and Disciplines, NIS Million, 2009



Source: Analysis of CBS data by Samuel Neaman Institute

7. Globalization

- High-tech manufacturing exports were USD 21,517, 47 percent of all exports (2011).
- R&D and computer and information services account for 50 percent of exports of business services (USD 8,939 million in 2011).
- More than two-thirds of business-enterprise R&D is performed by foreign-owned firms. Among OECD members, only Ireland has a higher percentage (2009).
- R&D intensity—the share of R&D expenditure in a firm's sales was 18.6 percent among "IN" firms (foreign-owned firms operating in Israel), ten times the corresponding share of the runner-up, Japan (2009).
- Some 34.7 percent of employees in the electronic components industry and 29.1 percent of employees in computer and R&D services work for IN firms; They generate 66.1 percent and 43.1 percent of these industries' output, respectively (2010).
- All large establishments (500+ employees) in Israel's R&D industry are R&D centers of foreign firms (2008).
- In 2010, Israel's technological balance of payments posted a $6,980 million surplus, 3.2 percent of Gross Domestic Product.
- In the 2009/10 academic year, for the first time, more students from North America attended Israeli institutions of learning than Israeli students did in the United States (3,146 vs. 2,778)..

The past two decades have seen an upsurge in globalization trends, reflected in economic integration and cross-border flows of knowledge, technology, capital, human resources, services, and goods. Globalization has advantages and drawbacks. The main advantages are manifested, on one hand, in openness to global markets, more efficient resource allocation, attraction of foreign investment, greater productivity, the creation of technology knowledge spillovers, and larger sales in international markets. However, economic openness inheres to acute volatility in the labor market and wages (layoffs, corporate shutdowns due to mergers and acquisitions), foreign utilization of knowledge and intellectual property in host countries, greater exposure to financial crises, and greater dependency on international markets. All the foregoing is especially the case in a small country such as Israel, which bases its economy on a dominant high-tech sector and a skilled labor force.

It is customary to speak of Israel's ostensibly successful integration into the global market; the country definitely benefited from it in the past. Recent trends and projections, however, reveal a complex picture replete with challenges and threats, a picture that raises questions of priorities in investment, the creation of cooperative mechanisms, and examination of the fruits of globalization in profit-and-loss terms. In this chapter, an attempt will be made to shed light on at least some of these phenomena.

The extent and characteristics of international trade and multinational firms' activity are the accepted indicators that are used to describe globalization processes. This chapter will relate to these metrics with emphasis on activity in industries and fields related to research, development, and innovation. In many cases, too, it will relate to the intensity of Israel's international relations in science, technology, and knowledge-sharing.

7.1 international trade

The fundamental indicator of the strength of relations with other economies is the level of foreign trade—import-export. In foreign trade, it is customary to distinguish between manufactures (goods) and services.

Trade in goods is usually analyzed on the basis of divisions that are often aggregated into four groups differentiated by technology intensity. (See detailed explanation in the section on economic indicators). In trade in services, however, this method may create a distortion because firms in different divisions may provide the same service and firms in one division may provide different services. For example, information services may be provided by a computer services establishment (Division 73), a manufacturing firm (Divisions 10–39), and even an educational institution such as an academy (Division 80). Therefore, when tracking trade in services one differentiates among types of services.

The data in this chapter distinguish among several types of services:

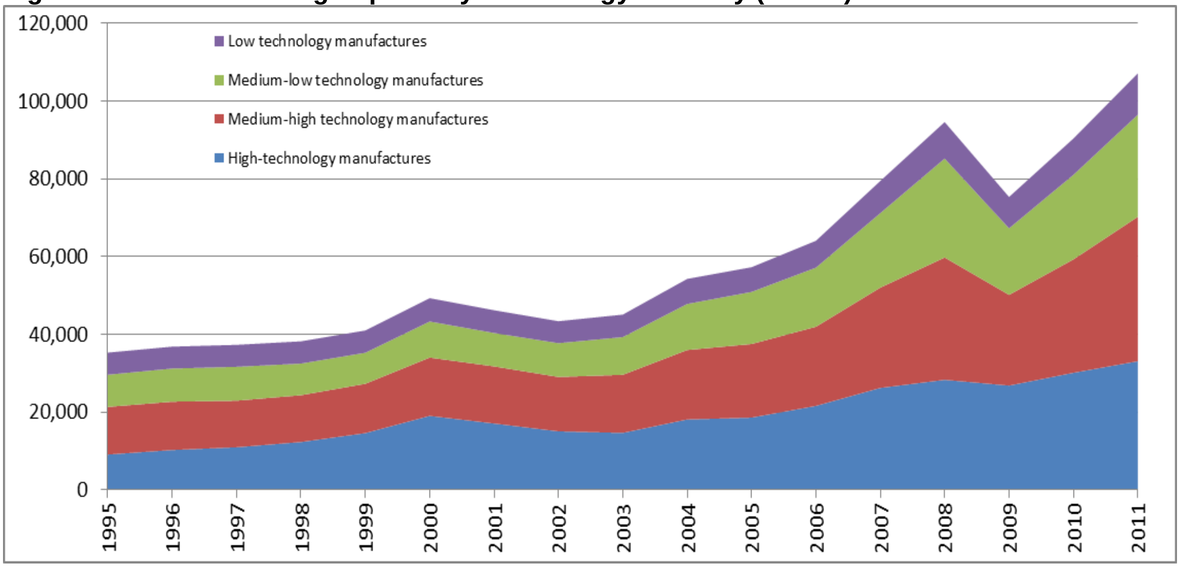
- R&D services;
- computer and information services;
- other technology-intensive services—architecture services, engineers and practical engineers, and royalties and license fees;
- other knowledge-intensive services—communication services, legal services, financial services, accounting services, business consulting, and advertising, public-relations, and market-research services.

This section focuses on the analysis of Israeli exports. The trends that typify this indicator resemble those of international trade at large. The “Trade Balance” subchapter analyzes trends in the import–export ratio.

7.1.1 Exports of goods

Manufacturing exports have increased by 272 percent since 1995 (from USD 12,302 million that year to USD 45,752 million in 2011). Exports of high-tech goods have grown even faster, by 373 percent (from USD 4,549 million in 1995 to USD 21,570 in 2011, Figure 7.1). The difference boosted the share of high-tech industrial products in total exports of goods from 37 percent in 1995 to 47 percent in 2011.

Figure 7.1: Manufacturing Exports by Technology Intensity (mUSD)



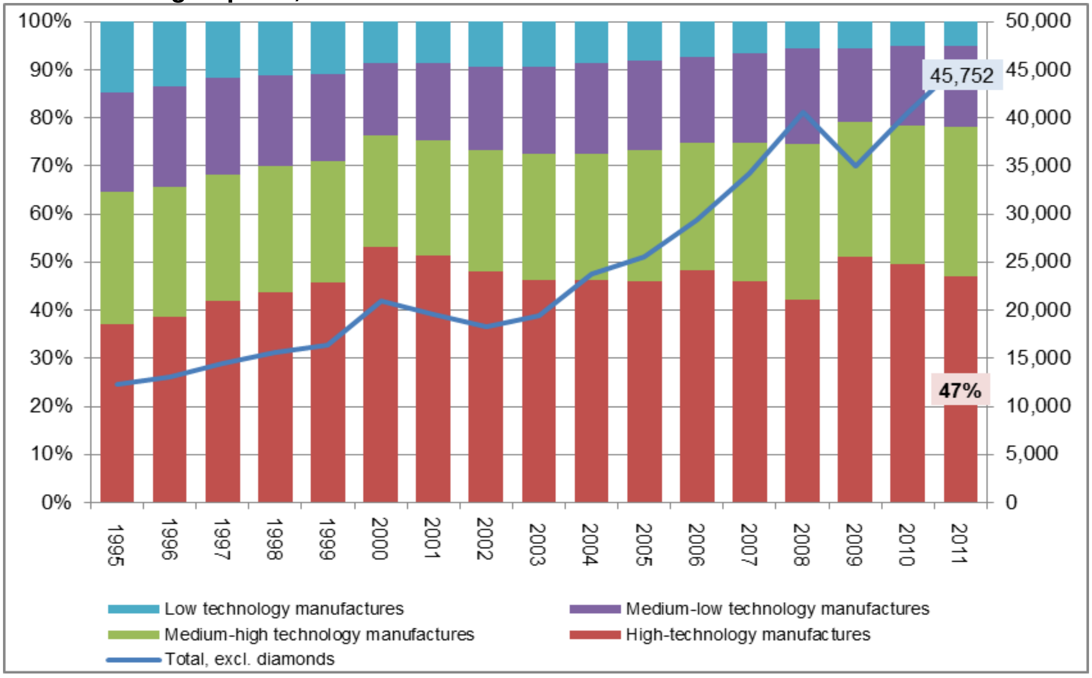
Sources: Analysis of CBS data processed by Samuel Neaman Institute

The process, however, has not been smooth. In 2000, high-tech accounted for 53 percent of manufacturing exports (USD 11,188 vs. USD 21,005) but from then on the rate steadily declined to 42 percent in 2008 (USD 17,150 out of USD 40,634) (Figure 7.2).

The 2008 crisis had a weaker effect on high-tech manufacturing exports than on total exports. It was reflected in only a slight slowdown in the growth rate of high-tech manufacturing exports (4 percent in 2009 as against 14 percent on average in 2003–2008) while total exports contracted by 14 percent. This elevated the share of high-tech manufacturing exports in total exports to 51 percent in 2009. In subsequent years, the contraction trend resumed.

Conversely, mixed-high-technology exports were 23 percent of total exports of goods in 2000, 32 percent in 2008. After a dip to 28 percent in 2009, occasioned by the crisis, the growth trend resumed (29 percent of total exports in 2010 and 31 percent in 2011).

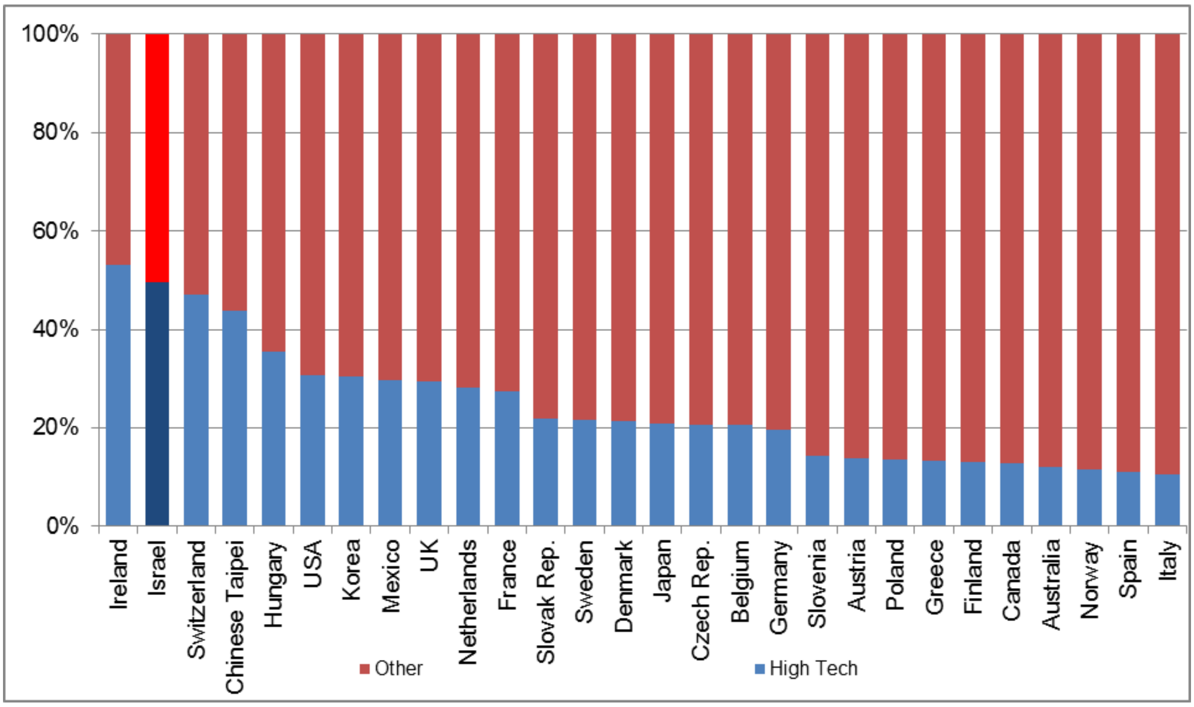
Figure 7.2: Manufacturing Exports by Technology Intensity, mUSD and Share in Total Manufacturing Exports, 1995–2011



Sources: Analysis of CBS data processed by Samuel Neaman Institute

The share of high-tech manufacturing in Israel's exports exceeds the share of high-tech in total international trade (51 percent vs. 36 percent) and corresponding rates in other OECD countries (Figure 7.3). In 2009, only Ireland surpassed Israel (52 percent). It bears repeating, however, that 2009 was not a representative year and should not be used as a sole basis for inferences.

Figure 7.3: Manufacturing Exports by Technology Intensity, International Comparison, 2009



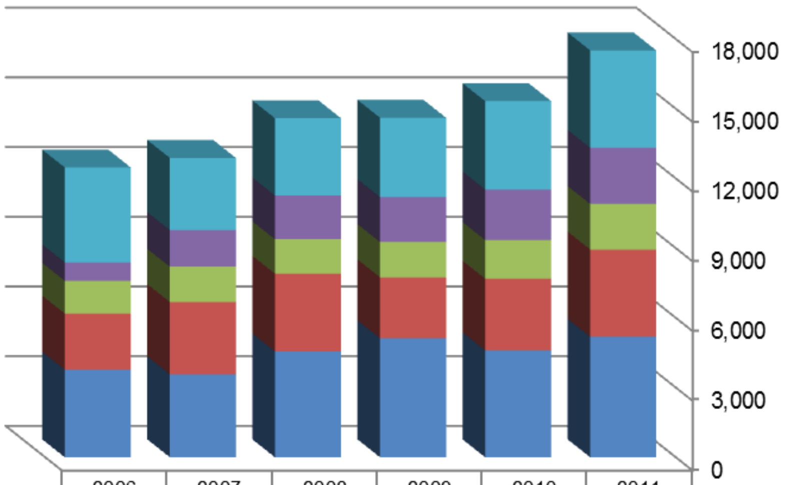
Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

7.1.2 <u>Exports of services</u>

Data on exports of services have been gathered only since 2006 and the internal distribution was revised in 2007 (due to the addition of another type of service, financial services). Consequently, multiannual trends may be analyzed only from that year on. One may say, however, that the share of knowledge- and technology-intensive services in exports has been relatively large in all years.

Thus, in 2011, exports of knowledge- and technology-intensive services were USD 13,315 million (76 percent of total exports of services). The two most conspicuous categories are R&D services (30 percent of total exports) and computer and information services (21 percent).

Figure 7.4: Exports of Services by Type of Service, mUSD, 2006–2011

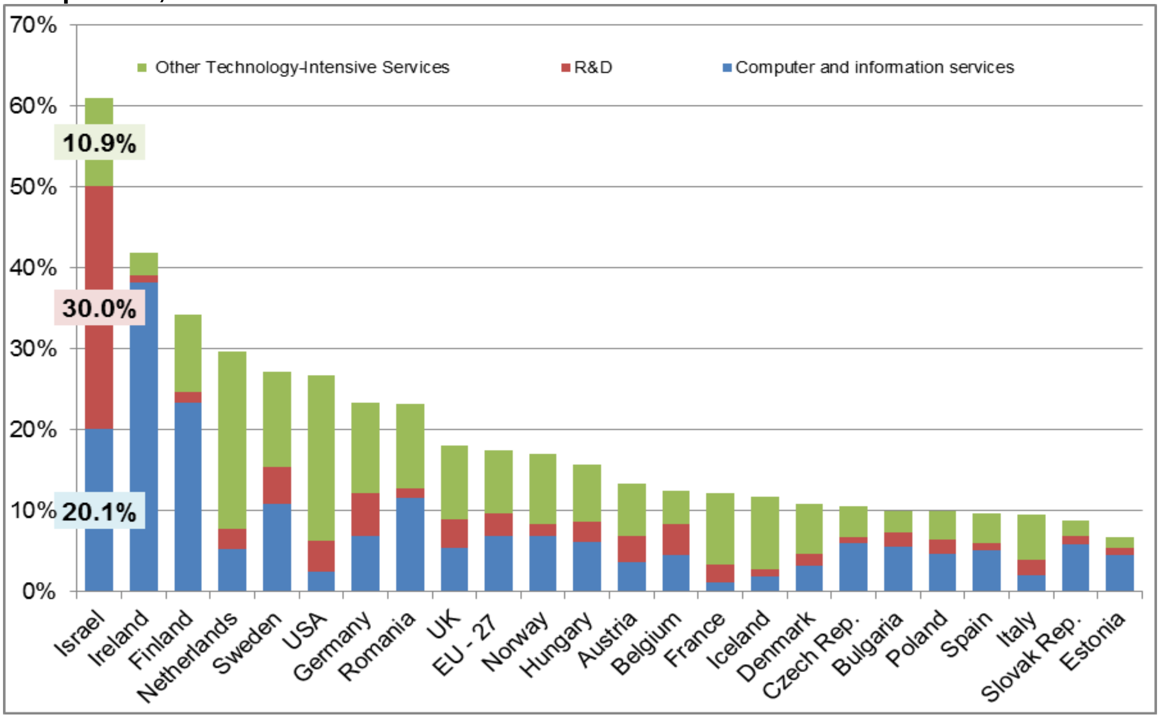


	2006	2007	2008	2009	2010	2011
Other Services	4,084	3,108	3,328	3,413	3,803	4,194
Other Knowledge-intensive Services	789	1,570	1,878	1,932	2,171	2,411
Other Technology-intensive Services	1,415	1,526	1,487	1,524	1,670	1,965
Computer and information services	2,411	3,103	3,341	2,620	3,078	3,752
R&D	3,770	3,573	4,556	5,121	4,605	5,187

Sources: Analysis of CBS data processed by Samuel Neaman Institute

In 2010, technology-intensive services (not including exports of other knowledge-intensive services—see breakdown above) accounted for 61 percent of total exports of services, with R&D services figuring importantly (30 percent of total exports). As may be seen, this share of technology-intensive services—R&D services within it—is very large by world standards.

Figure 7.5: Exports of Technology-Intensive Services by Type of Service, International Comparison, 2010



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

7.1.3 <u>Trade balance</u>

To assess the contribution of technology intensity to the trade balance, this section measures the combination of imports and exports in various manufacturing divisions sorted by technology intensity. This integration of data allows us to examine the relative effect of each division on the total trade balance. For each division (or each partial aggregate of industries), the difference between the division's actual trade balance and its share in the total trade balance in volume terms is calculated using the following formula:

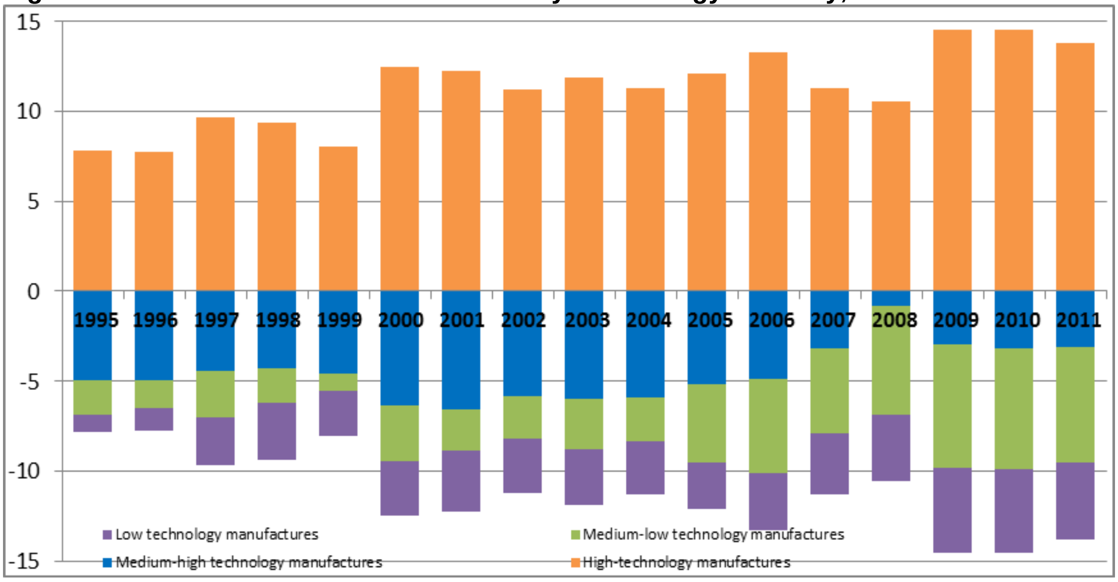
$$\frac{(X_i - M_i) - \left[(X - M)\frac{(X_i + M_i)}{(X + M)}\right]}{X + M}$$

where:
M = total imports
X = total exports
Mi = imports by technology intensity
Xi = exports by technology intensity

If this indicator carries a positive value, the division 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, yielding a common denominator that allows us to compare different countries' data at different times.

As Figure 7.6 shows, high-tech manufacturing appears to be carrying the other manufacturing industries on its back. Throughout the years, only high-tech has made a positive contribution to the trade balance. In 2001–2008, the trade deficit in mixed-high-technology goods contracted and almost climbed to zero in the latter year (a deficit of 0.8 percentage points). In the wake of the 2009–2011 crisis, however, the gap between high-tech and other industries reopened.

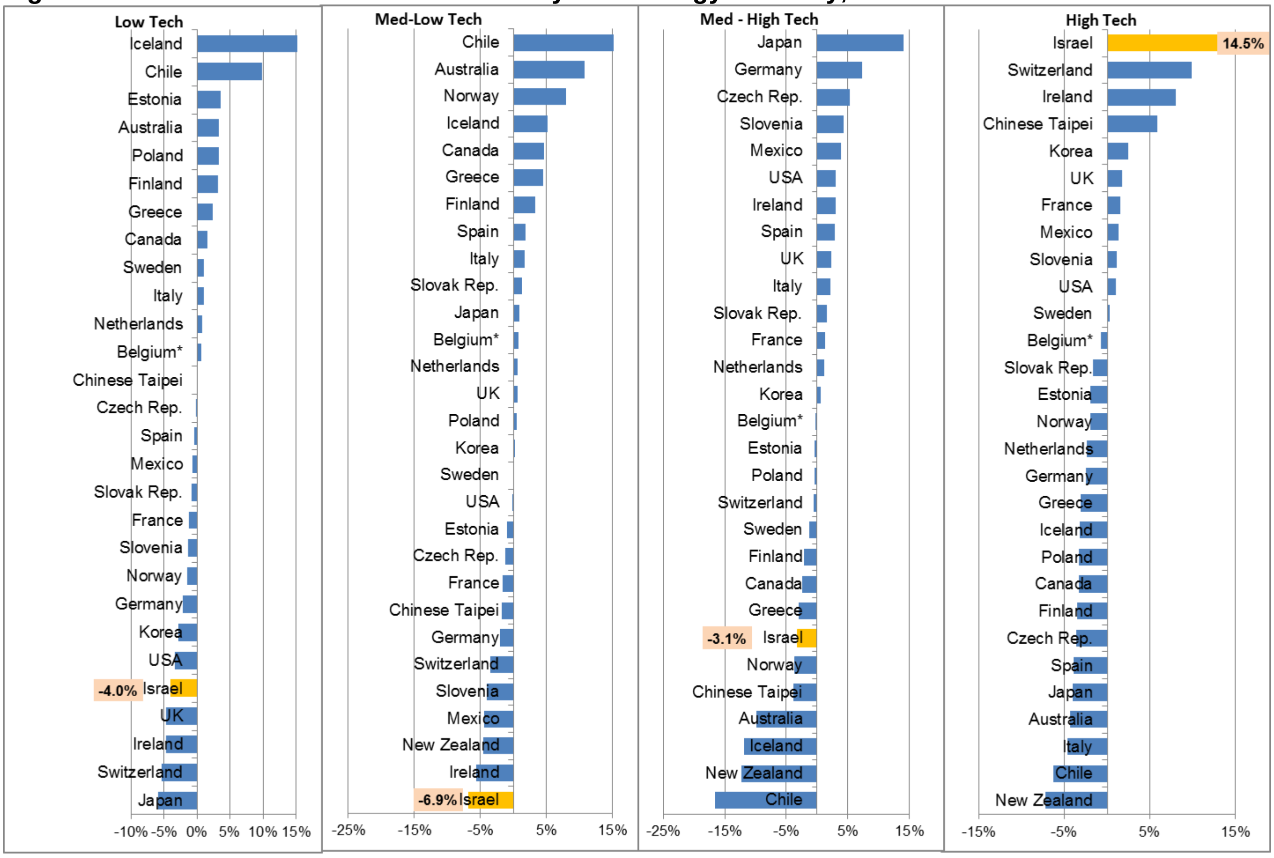
Figure 7.6: Contribution to Trade Balance by Technology Intensity, Pct.



Sources: Analysis of CBS data processed by Samuel Neaman Institute

Israel's trade balance tends to chronic extremes by other countries' standards (Figure 7.7). Only one type of manufacturing—high-tech—posts a surplus, but this surplus is the world's highest. The other manufacturing industries, in contrast, run a trade deficit—it, too, one of the world's largest. In other words, Israeli high-tech has done exceptionally well in the global market and other industries have done exceptionally poorly.

Figure 7.7: Contribution to Trade Balance by Technology Intensity, 2009



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

As Table 7.1 and Figure 7.8 show, the late-2008 crisis abetted an improvement in the trade balance of most high-tech manufacturing industries. The total surplus climbed by 50 percent between 2008 and 2009, from USD 6,007 million to USD 9,024 million. All divisions other than Division 33 (Electronic Communication Equipment) showed improvements in their trade balance. In some divisions, the upward trend continued in subsequent years as well. The trend in Division 32 (Electronic Components) slowed, evidently in reaction to a 322 percent (!) increased in 2009. The improvement in the trade balance of Division 245 (Pharmaceuticals), which began back in 2000, retreated somewhat in 2009 (down 9 percent relative to 2008) but rebounded in 2010–2011. During these two years, this division's trade surplus increased by 74 percent—from USD 2,940 million to USD 5,112 million.

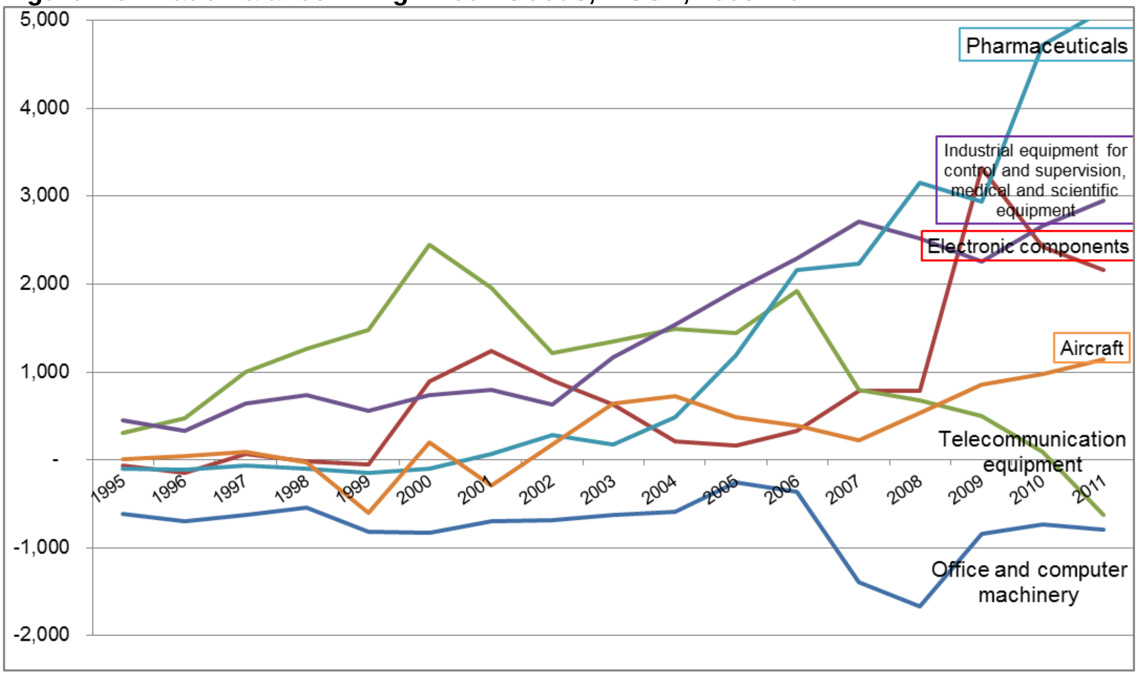
The aforementioned Division 33 has been in retreat since 2007; in 2011 it posted its first deficit since the surveillance began.

Table 7.1: Trade Balance in High-Tech Goods, mUSD, 1995–2011

	30	32	33	34	245	355	
	Office machinery and computers	Electronic components	Electronic communi-cation equipment	Industrial command and control equipment and 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	1005	636	-60	96	***1118***
1998	-544	-15	1265	738	-103	-29	***1312***
1999	-815	-55	1476	557	-152	-600	***411***
2000	-825	896	2444	738	-106	196	***3343***
2001	-698	1238	1953	792	67	-296	***3056***
2002	-688	900	1219	627	288	180	***2526***
2003	-628	631	1346	1168	177	640	***3334***
2004	-594	206	1488	1536	488	723	***3847***
2005	-255	158	1441	1933	1188	484	***4949***
2006	-365	329	1920	2286	2157	390	***6717***
2007	-1394	786	681	2716	2228	218	***5354***
2008	-1664	786	681	2516	3163	535	***6007***
2009	-836	3316	496	2253	2940	855	***9024***
2010	-736	2429	96	2659	4719	973	***10139***
2011	-791	2160	-630	2945	5112	1148	***9945***

Source: Central Bureau of Statistics

Figure 7.8: Trade Balance in High-Tech Goods, mUSD, 1995–2011



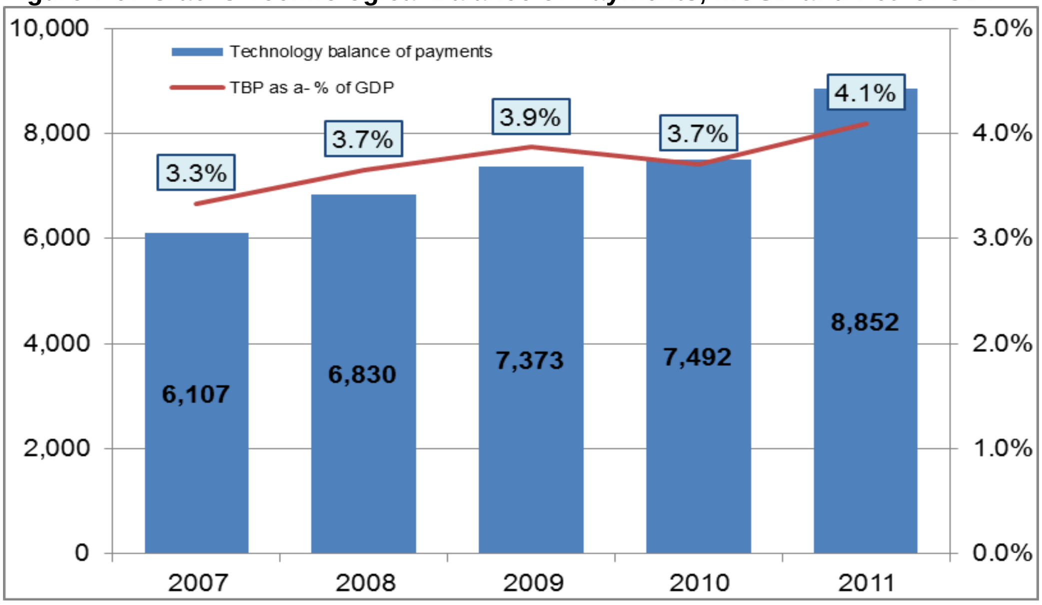
Source: Central Bureau of Statistics

7.1.4 Technological Balance of Payments

The Technological Balance of Payments (TBP) sums the monetary values of international business purchases and sales of technology and knowledge (OECD definition). It includes data on international trade of patents, licensing agreements, knowledge, brand names, models, technical services (including technical-support services), R&D commissioned abroad, etc. Despite limitations occasioned by different coverage of the same data in different countries, TBP is a good indicator of scientific and technological competitiveness in the global market.

The Central Bureau of Statistics gathered data about Israel's TBP in 2007–2011. During these years, TBP posted a surplus of 3.3–4.1 percent of GDP at all times (Figure 7.9). Notably, the surplus increased by 45 percent during those years.

Figure 7.9: Israel's Technological Balance of Payments, mUSD and Pct. of GDP

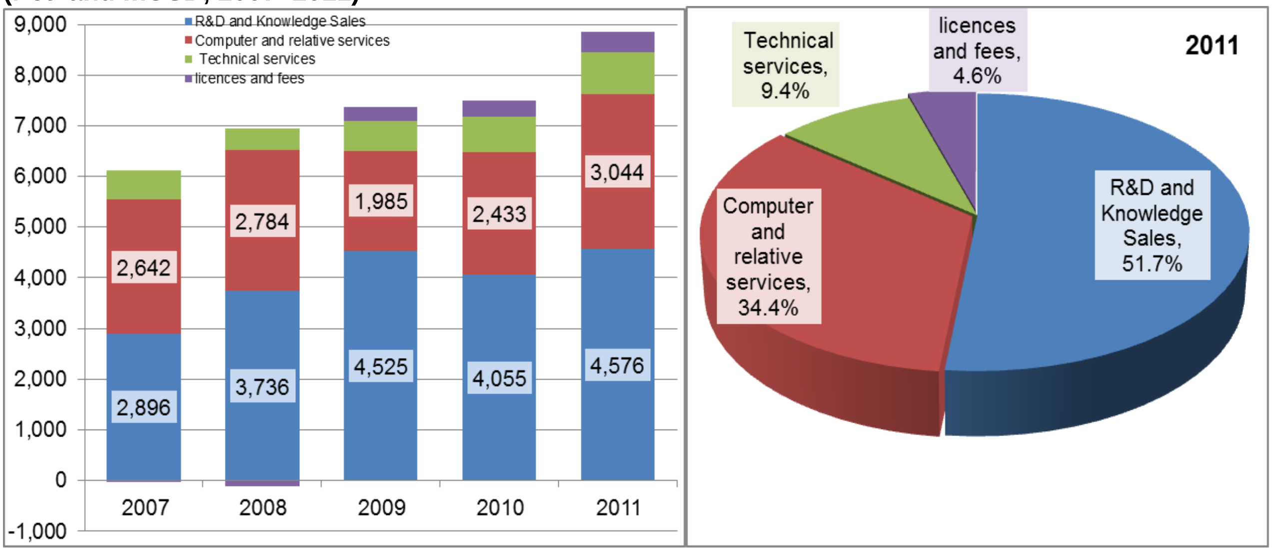


Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

The surplus traces mainly to sales of R&D and knowledge (including patents) and computer services. Fluctuations in these divisions' trade are the main reasons for changes in TBP (Figure 7.10).

It may also be seen that most components of TBP were in surplus throughout this period. The only exception was royalties and license fees, with deficits of USD 8 million and USD 113 million in 2007 and 2008, respectively. After 2009 (USD 4 million surplus) and 2010 (USD 8 million surplus), however, things improved—surpluses of USD 286 million in 2009, USD 303 million in 2010, and USD 403 million in 2011. Also, the share of R&D services and sales of knowledge in TBP fell steadily, from—from 61.4 percent in 2009 to 51.7 percent in 2011.

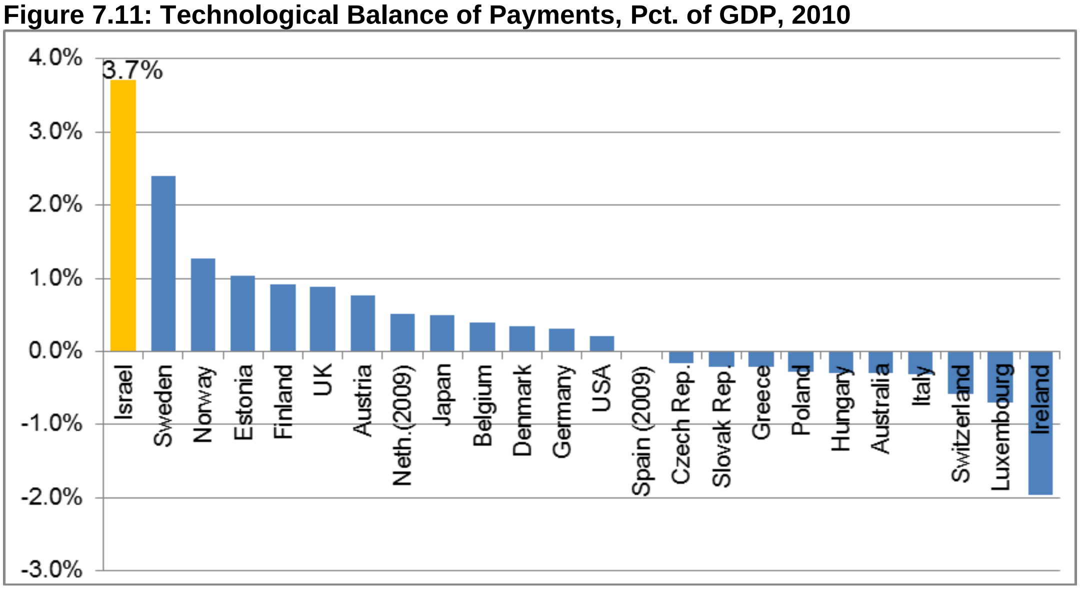
Figure 7.10: Israel's Technological Balance of Payments, by Main Types of Services (Pct. and mUSD, 2007–2011)



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

Israel's technological balance of payments has the largest percent-of-GDP surplus among OECD member states (Figure 7.11). In 2010, it was far above the runners-up among OECD countries—Sweden (2.4 percent of GDP), Norway (1.3 percent) and Estonia (1.0 percent).

Figure 7.11: Technological Balance of Payments, Pct. of GDP, 2010

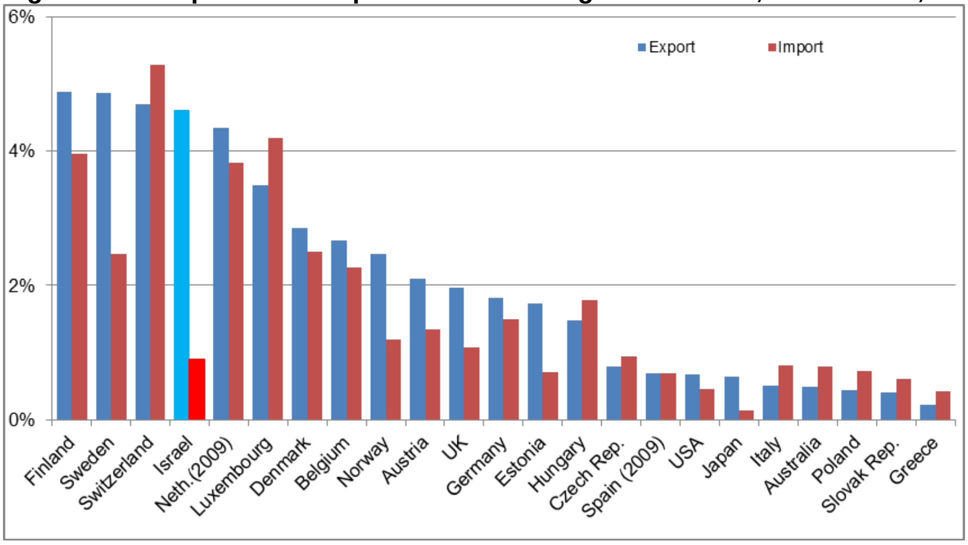


Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

Figure 7.12 shows that a large surplus does not necessarily signify a large amount of trade in technology and knowledge goods. In 2010, exports of such goods were equal to 4.6 percent of Israel's GDP and imports were 0.9 percent. Exports of Israeli science goods resemble those of Finland, Sweden, Switzerland, and the Netherlands, but Israel's imports of such goods were far below those of the countries compared.

It is worth bearing in mind again, however, that this indicator is of limited reliability for international comparisons because different countries' statistical bureaus treat the data differently.

Figure 7.12: Imports and Exports of Technological Services, Pct. of GDP, 2010



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Institute

7.2 Corporate international relations

This section presents another set of indicators that may be used to examine globalization and assess the strength of international relations at the firm level. Within this framework, the discussion that follows will review activities of Israeli firms controlled by nonresidents (IN firms), including international R&D centers;, operations of Israeli firms' foreign subsidiaries (OUT firms); foreign investments in Israeli firms and Israelis' investments in foreign firms; and nonresident funding and acquisition of Israeli start-ups. The indicators presented below place special emphasis on activities in technology-intensive divisions.

7.2.1 IN Firms

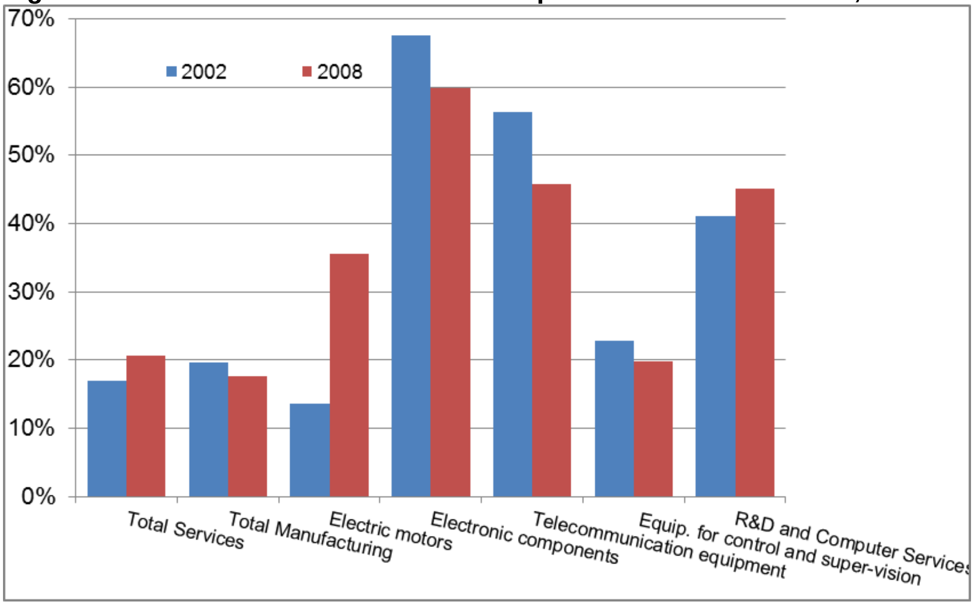
An IN firm is one that operates in Israel and is held by a nonresident (corporation or individual) at a rate exceeding 50 percent of its share equity.

Output

In 2008, IN firms generated 20.6 percent of total output in the service divisions and 17.5 percent of total output in manufacturing (Figure 7.13). The share of such firms in the high-tech manufacturing divisions and in computer and R&D services is higher. IN firms account for 45.7 percent of total output of the Communication Equipment division and 59.8 percent in Electronic Components. The picture in the services sector is similar—in 2008, IN firms generated 45.1 percent of total computer and R&D services.

Comparison with the 2002 data shows that the share of output generated by IN firms in the manufacturing sector and the leading high-tech divisions (except electrical motors) has contracted somewhat. In the services, in contrast, computer and R&D services have increased perceptibly.

Figure 7.13: Share of IN Firms in Total Output of Selected Divisions, 2002 vs. 2008



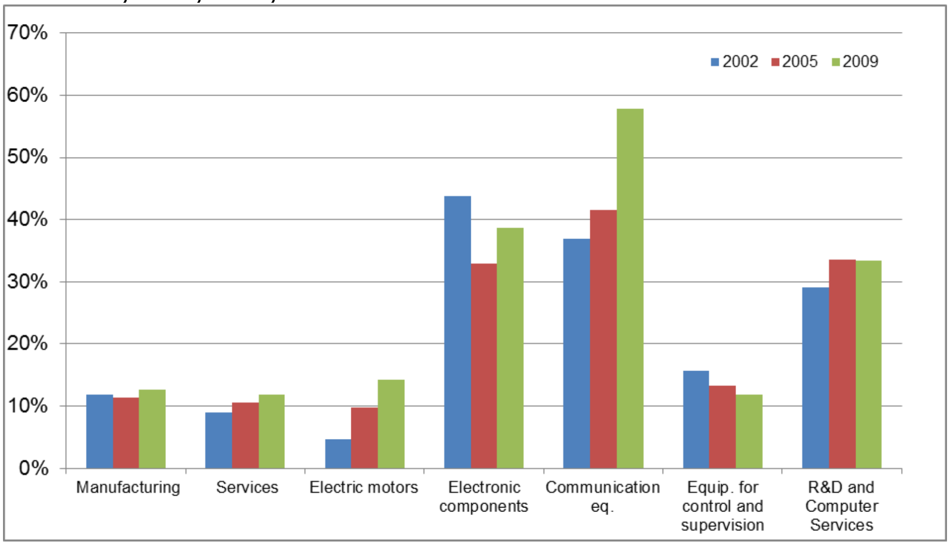
Sources: Analysis of CBS data processed by Samuel Neaman Institute

Employment

Figure 7.14 shows the share of IN firms in employment. Foreign-owned enterprises employ 12.6 percent of all manufacturing workers and a much larger share in two manufacturing divisions, Electronic Components and Electronic Communication Equipment (38.7 percent and 57.8 percent, respectively). Similarly, IN firms employ 33.4 percent of all workers in computer and R&D services, as against 11.9 percent in the services sector at large.

It is also of interest that IN firms generate a smaller share of employment than of output. This means that the average output per worker in such firms exceeds that in locally owned enterprises. This relation is observed in all divisions examined with the exception of Electronic Communication Equipment in 2008. The share of employment in this division decreased in 2009 much more than in other divisions examined. Generally speaking, the share of employment at IN firms was basically unchanged between 2008 and 2009. Enterprises active in the manufacture of electrical motors and electronic components even increased their stake in the domestic labor market. In contrast, IN firms belonging to the Electronic Communication Equipment division downsized their headcount in 2009—from 64.6 percent of total headcount in this domain in Israel to 57.8 percent.

Figure 7.14: Share of IN Firms in Total Employment and Employment, Selected Divisions, 2002, 2008, and 2009



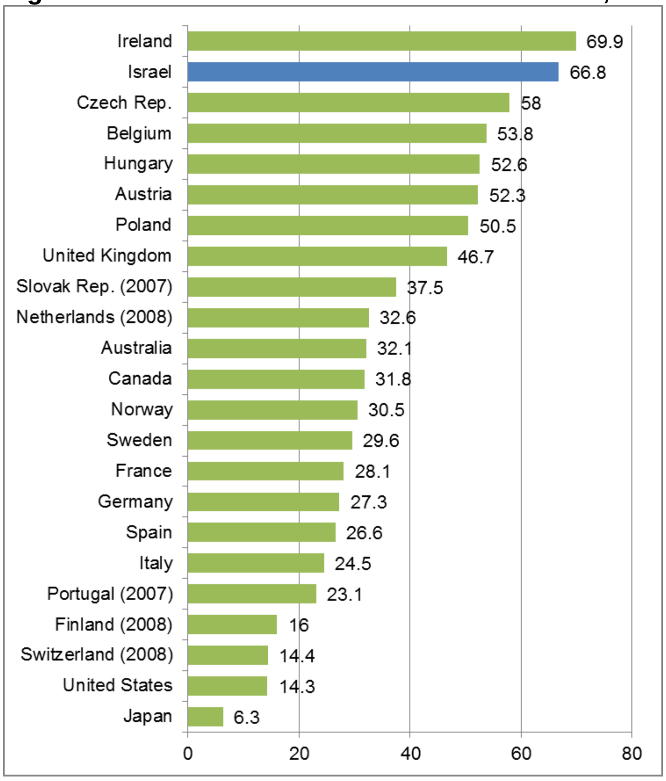
Sources: Analysis of CBS data processed by Samuel Neaman Institute

Notably, due to the small number of observations, the possibility of drawing conclusions is limited and the data should be treated cautiously.

Share of IN firms in performance of business R&D

The share of IN firms in performing business R&D appears in Figure 7.15, showing that in 2009 Israel was one of the leaders among OECD countries in this respect. Only Ireland had a larger share of foreign-owned firms in the performance of business R&D.

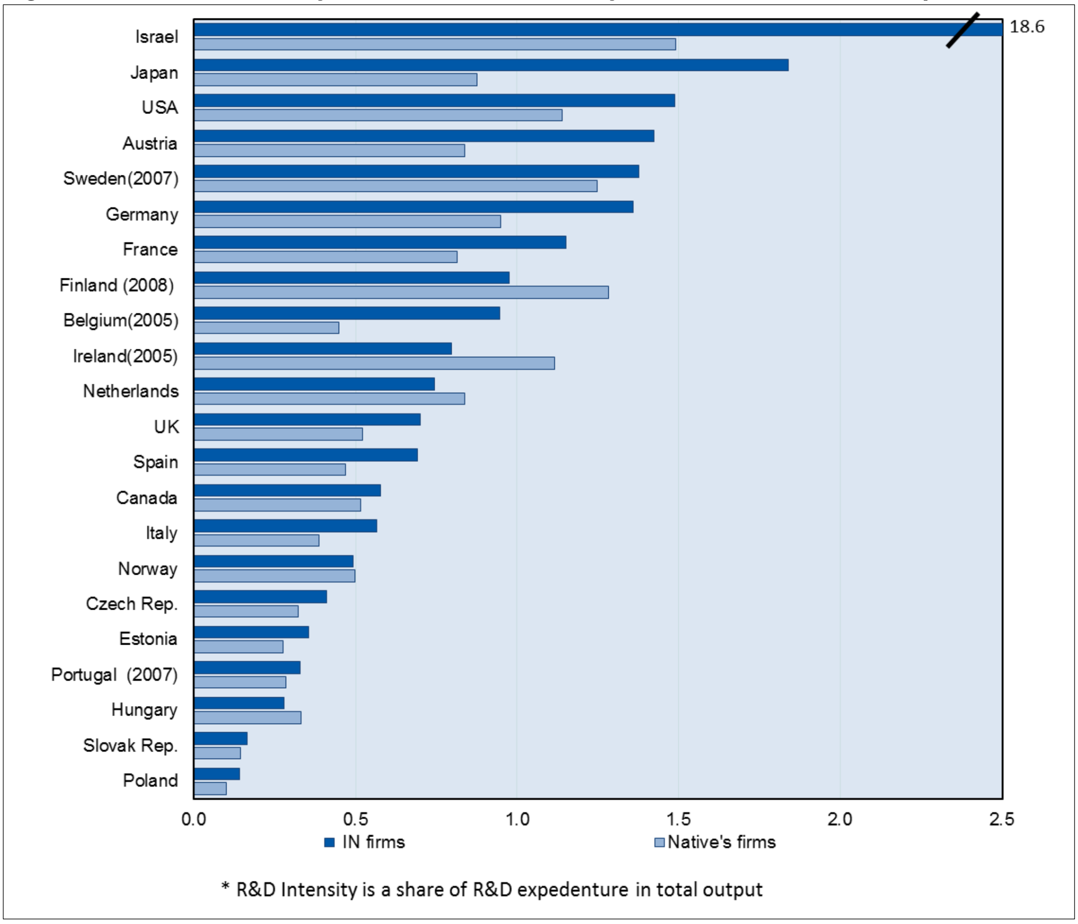
Figure 7.15: Share of IN Firms in Business R&D, OECD Countries, 2009



Sources: OECD, The data for Spain is for mining and construction only

The uniqueness of Israel's globalization process stands out even more in "research and development intensity," measured as the share of R&D expenditure in sales. Figure 7.16 presents R&D intensity of IN firms relative to locally-owned ones in OECD countries. The share of R&D expenditure by IN firms in Israel (18.6 percent) is the highest among OECD countries and ten times that of the runner-up (Japan—1.84 percent). The evident reason for this large proportion of R&D expenditure is that a large share of foreign-owned firms operating in Israel are international R&D centers. R&D expenditure of all Israeli firms countrywide was 1.49 percent of sales in 2009—again the highest among OECD countries but not exceptional (Finland 1.28 percent, Sweden 1.25 percent, U.S. 1.14 percent).

Figure 7.16: R&D Intensity in IN and Domestically Owned Business Enterprises, 2009



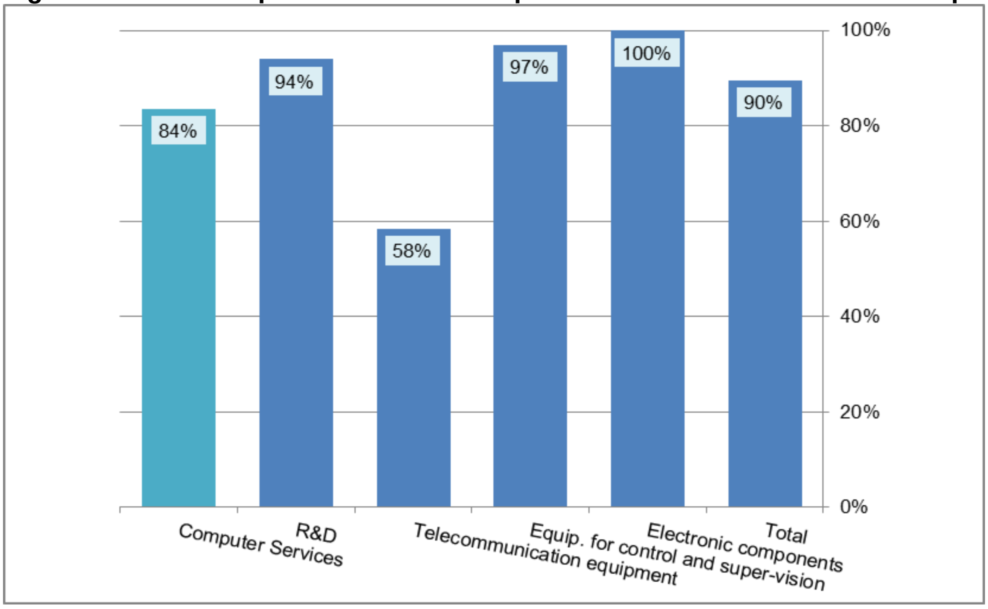
The data for Norway is for mining and manufacturing; the data for Hungary, Netherlands, Slovak Rep. and Spain is for construction and manufacturing; the data for Czech Rep., Estonia, Finland, Germany and Poland is for manufacturing and service
Sources: OECD

The data on exports of R&D services substantiate this claim. In 2009, R&D exports of IN firms were USD 3.4 billion, 92 percent of all business-enterprise R&D exports that year.[51] Some 90 percent of this total was destined to parent companies

[51] "Research and Development by Multinational Firms in Israel: 2008–2009," press release, August 8, 2012. The data do not include sales of start-ups and income from the sale of knowledge.

(Figure 7.17); in several divisions, the rate was even higher. Here again, the obvious explanation is that many of these firms are international R&D centers that forward the results of their research to their parent companies.

Figure 7.17: R&D Exports to Parent Companies as Pct. of IN Firms' R&D Exports, 2009



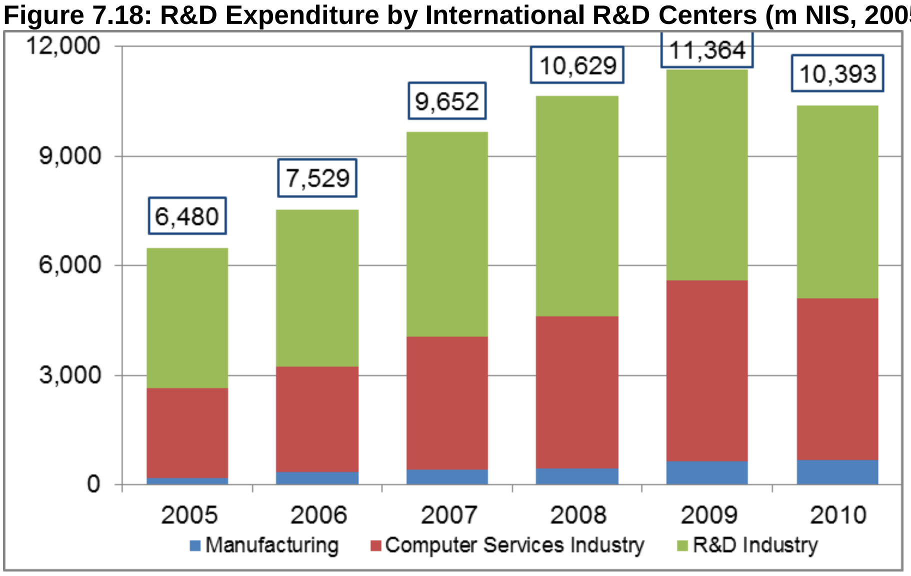
Sources: Analysis of CBS data processed by Samuel Neaman Institute

The dominance of international R&D centers is a phenomenon unique to Israel. The next section illuminates additional attributes of these centers.

7.2.2 International R&D centers

International R&D centers are unique among subsidiaries of multinational firms in that they specialize in research and development. The activity of such centers expanded considerably between 2005 and 2010, total R&D expenditure increasing by 88 percent and sales income by 60 percent (Figure 7.18).

Figure 7.18: R&D Expenditure by International R&D Centers (m NIS, 2005 Prices)

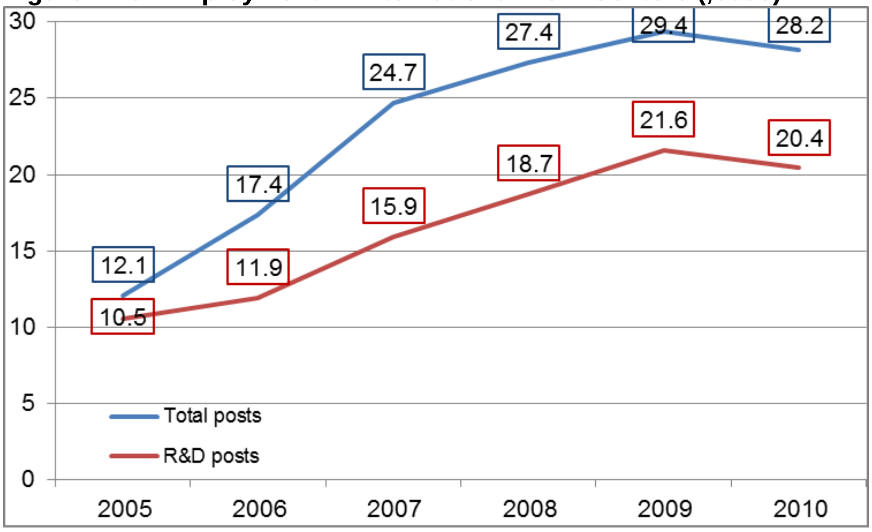


Sources: Analysis of CBS data processed by Samuel Neaman Institute

Most expenditure of this type is divided between two divisions: R&D (Division 73) and Computer Services (Division 72), which accounted for 59 percent and 38 percent of total R&D investments by international centers in 2005 and 51 percent and 42 percent in 2010 (both respectively).

During this time, the number of employee posts in international R&D centers increased by 133 percent and the number of posts in research and development itself rose by 94 percent (Figure 7.19).

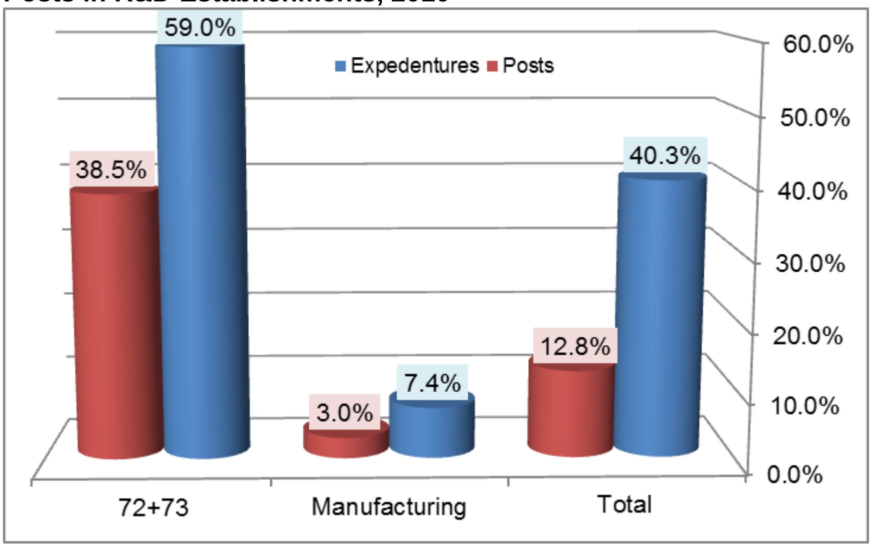
Figure 7.19: Employment in International R&D Centers (,000s)



Sources: Analysis of CBS data processed by Samuel Neaman Institute

As stated, international R&D centers are important players in R&D activity in Israel. They perform 40 percent of total R&D expenditure by establishments that engage in research and development in Israel (Figure 7.20) and account for a majority of expenditure (59 percent) in Divisions 72 and 73.

Figure 7.20: Share of International R&D Centers in R&D Expenditure and Employee Posts in R&D Establishments, 2010

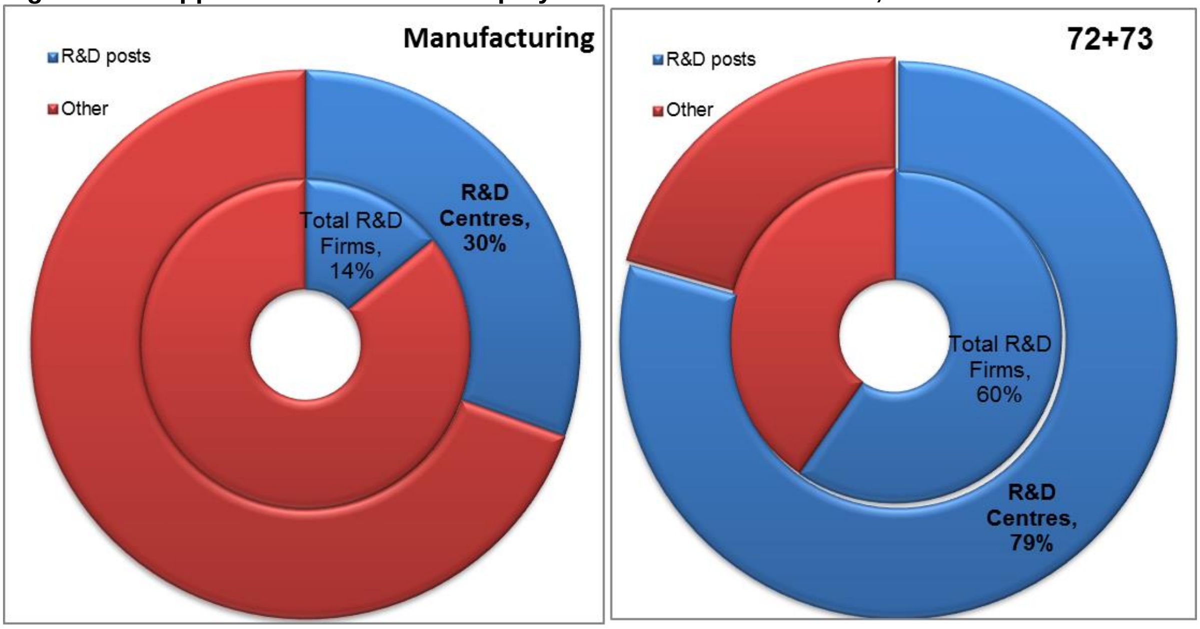


Sources: Analysis of CBS data processed by Samuel Neaman Institute

The data also show that the share of employee posts in international R&D centers in total posts in R&D establishments is also high but lower than the share of R&D expenditure. By implication, R&D expenditure per employee post in R&D centers exceeds the average in the business-enterprise sector. In the manufacturing divisions, R&D expenditure by R&D centers in 2010 was NIS 210,000 per employee post—2.5 times the average among all enterprises engaging in R&D in Israel (NIS 69,100). In Divisions 72 and 73, R&D expenditure that year was NIS 401,500 per employee posts as against NIS 262,000 on the average.

Importantly, the data relate to all employee posts—in R&D *and* in other fields such as marketing and administration. The share of R&D posts among all posts is greater in international R&D centers than in R&D establishments at large (Figure 7.21). This is because, in many cases, international R&D centers destine their main activity to the parent company and have no need for many organs such as marketing departments.

Figure 7.21: Apportionment of R&D Employee Posts and Other Posts, 2010



Sources: Analysis of CBS data processed by Samuel Neaman Institute

Consequently, the ratio of R&D posts in R&D centers to total posts at R&D establishments exceeds that of total posts (Table 7.2).

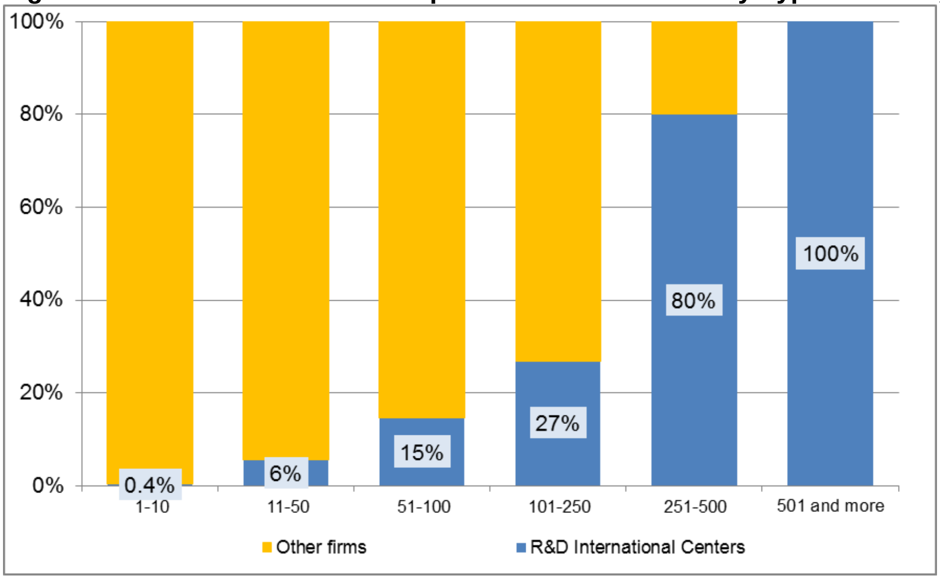
Table 7.2: R&D jobs in international R&D centers of the total R&D jobs in R&D Enterprises, 2010

	R&D centers (,000s)	R&D establishments (,000s)	Pct.
Total	20.4	56.6	36.1%
Manufacturing	1.2	18.7	6.5
Divisions 72 + 73	19.2	37.5	51.2%

Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

If so, international R&D centers account for an important share of research and development in Israel. Several years ago, the Central Bureau of Statistics published a report with data that typified these centers and their role in Israeli R&D. Although the report provides information only on firms active in the R&D Services division and stops at 2008 (omitting the crisis period), even these data allow initial inferences.

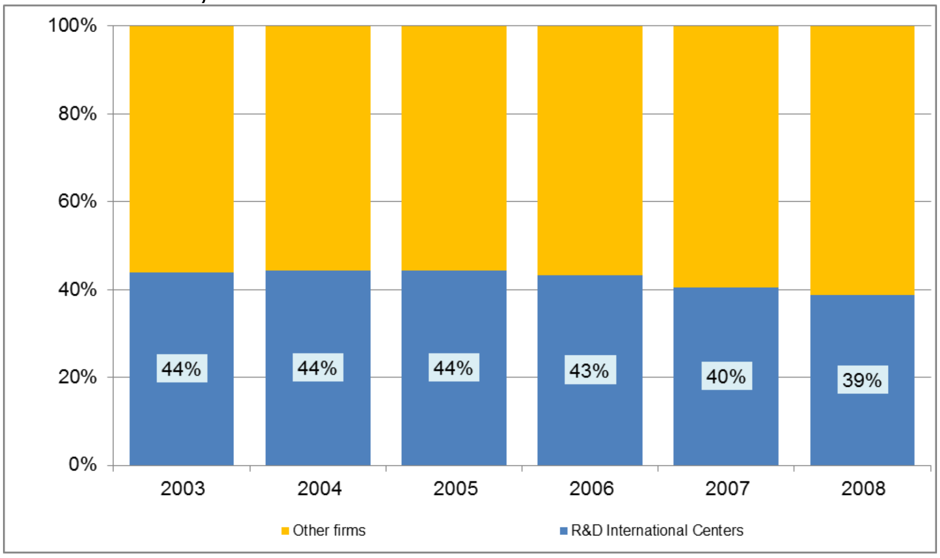
Figure 7.22: Research and Development Establishments by Type and Size, 2008



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

This makes it clear why, even though international R&D centers account for a paltry share of establishments in Division 73 (forty-five centers among 1,583 establishments in the division in 2008—2.8 percent), they employ a large proportion of staff (Figure 7.23). The share of employment in such centers has fallen somewhat over the years, from 44 percent in 2003 to 39 percent in 2008.

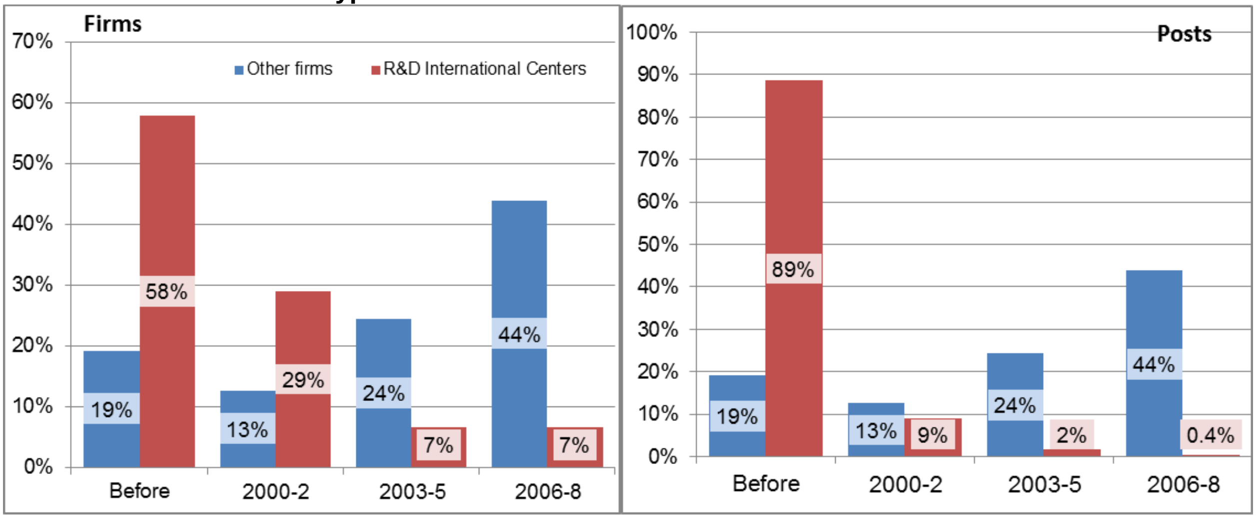
Figure 7.23: Share of Employment in International R&D Centers and Other R&D Establishments, 2003–2008



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

The data in Figure 7.24 also highlight differences in trends of development between R&D centers and other establishments.

Figure 7.24: R&D Establishments in R&D Division, by Year of Founding (Pct. of All Establishments of Same Type

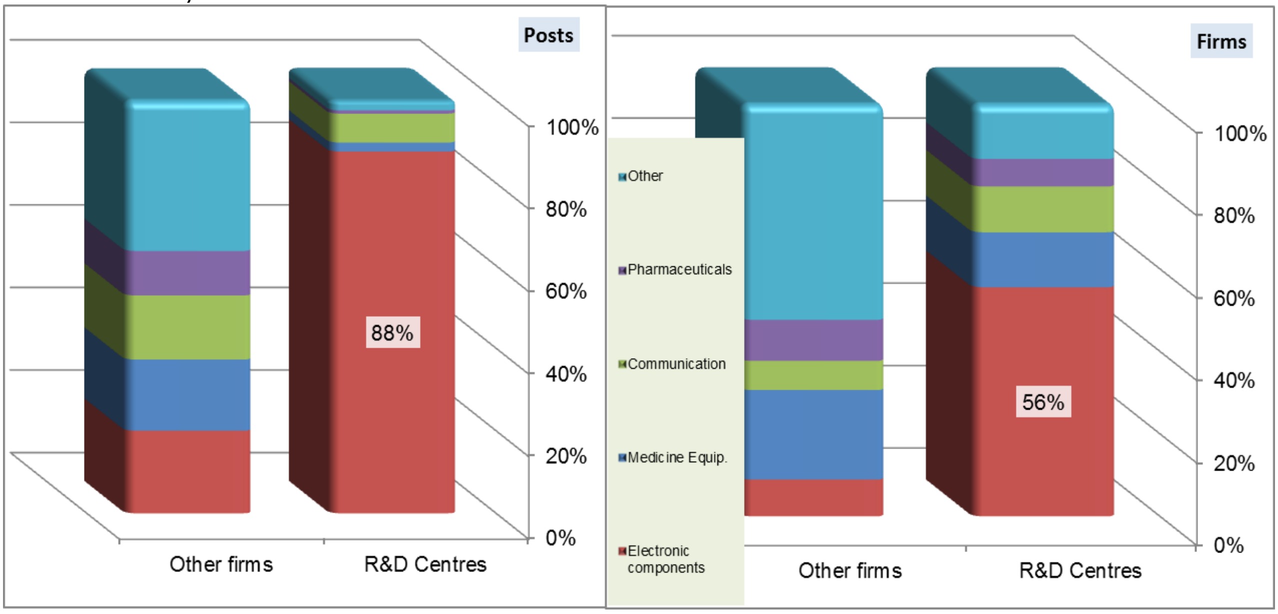


Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

Some 44 percent of other establishments in the R&D Division in 2008 were founded between 2006 and 2008. It should be remembered that most of them (82 percent) were start-up enterprises, members of a class typified by relatively short life spans. Most R&D centers that are active today, in contrast, were opened before 2000 (twenty-seven of forty-five). In 2006–2008 (or, to be more exact, in 2006), only three new establishments were opened. These firms employ 0.4 percent of total headcount at international R&D centers; 89 percent of headcount are employed by establishments opened before 2000.

International R&D centers are also different from other establishments in their area of activity (Figure 7.25). International R&D centers in Israel focus mainly on electronic components research—56 percent of firms and 88 percent of persons employed in this field (around 380 people per company on average). Other leading areas of activity are the development of medical instrumentation (13 percent of firms, 2 percent of employees, thirty-nine employees per firm on average) and communications (11 percent of firms, 7 percent of employees, 152 employees per firm on average). R&D by other establishments is spread more equally. The medical instrumentation development field is noteworthy—in 2008, 22 percent of firms were active in this domain and they employed 17 percent of headcount (eight employees per firm on average).

Figure 7.25: R&D Establishments and Employee Posts, by Area of Activity and Type of Establishment, 2008



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

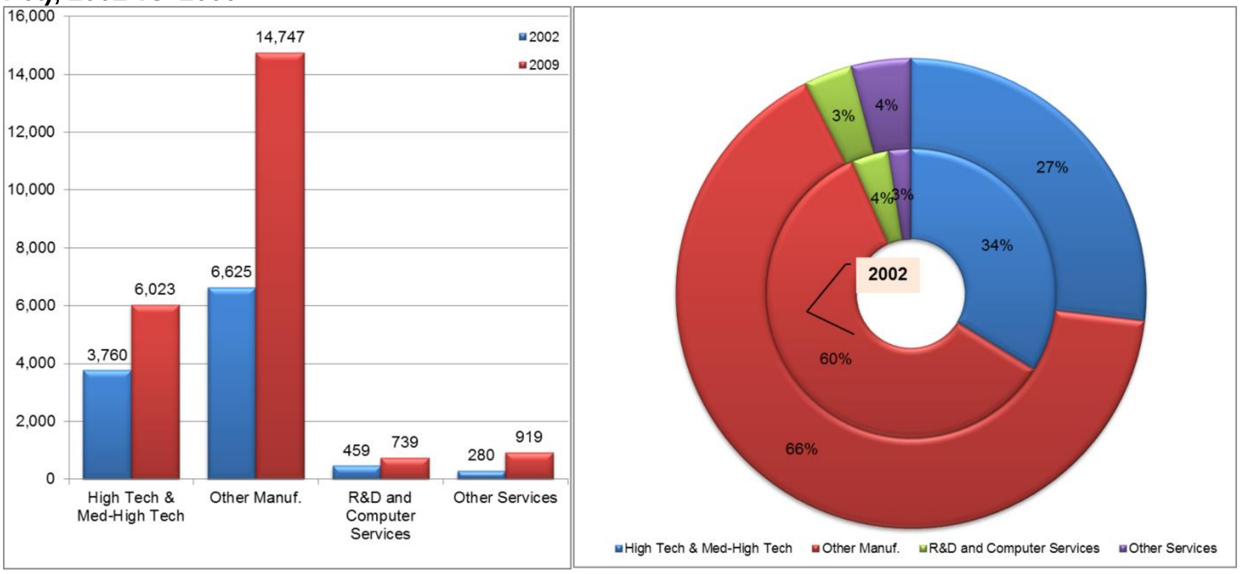
In sum, **most large establishments in Division 73 are international R&D centers. They congregate mainly in electronic components R&D and the number of new centers opening in Israel has been declining since 2000.** Again, these data relate to only to one division and only to the period preceding the economic crisis in 2008.

7.2.3 OUT Firms

OUT firms are Israeli companies that own subsidiaries abroad. The extent of such firms' activity is an indicator of the intensity of the Israeli economy's involvement in the international market.

Figure 7.26 shows the dynamic of OUT firms' exports of goods. Between 2002 and 2009, exports increased by 102 percent, from USD 11,125 million to USD 22,428 million. The internal distribution of this activity, however, hardly changed: companies in traditional and mixed-traditional manufacturing divisions continue to account for most of it (60 percent of exports of goods in 2002 and 66 percent in 2009). Notably, in 2008 OUT firms' exports were USD 26,859 million, i.e., exports in 2009 shrank by more than 16 percent due to the crisis.

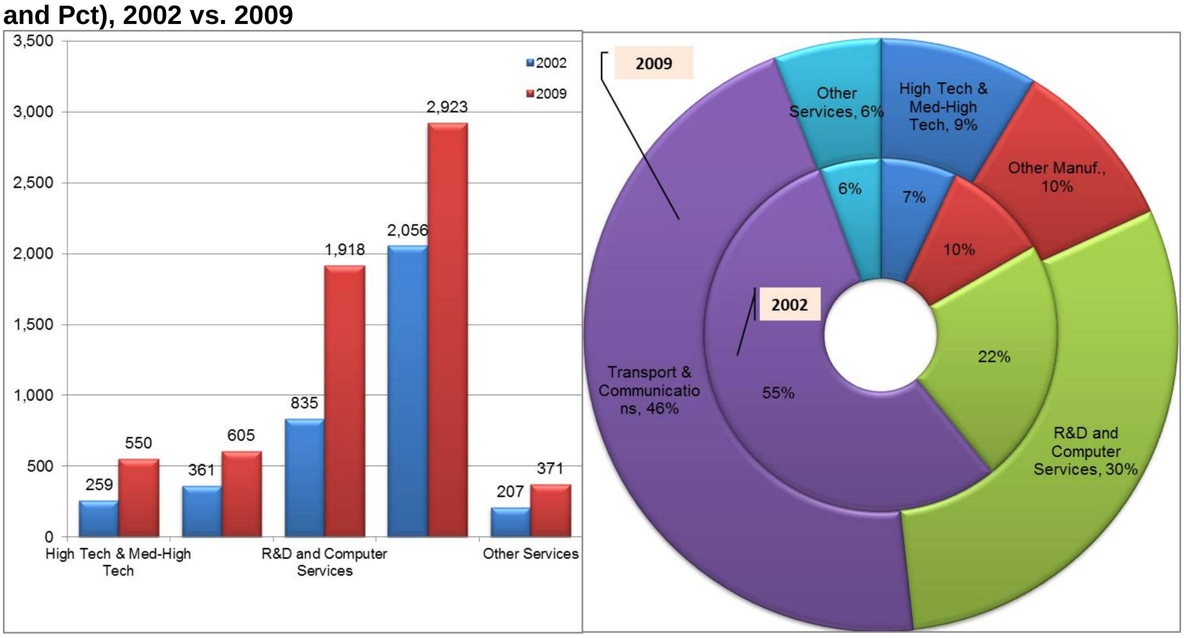
Figure 7.26: Exports of *Goods* by Foreign Subsidiaries, Selected Divisions (mUSD and Pct), 2002 vs. 2009



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

OUT firms' exports of services, too, increased vigorously between 2002 and 2009 (Figure 7.27)—from USD 3,704 million to USD 6,367million (up 72 percent). Some 76 percent of services exports were performed by establishments in technology-intensive service divisions—Communication Services, R&D Services, and Computer and Information Services. This proportion was basically unchanged from 2002 but the internal division among types of services did change. The share of exports of communications services fell from 55 percent to 46 percent and that of computer and R&D services rose by 130 percent, to 30 percent of total exports of services in 2009.

Figure 7.27: Exports of *Services* by Foreign Subsidiaries, Selected Divisions (mUSD and Pct), 2002 vs. 2009



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

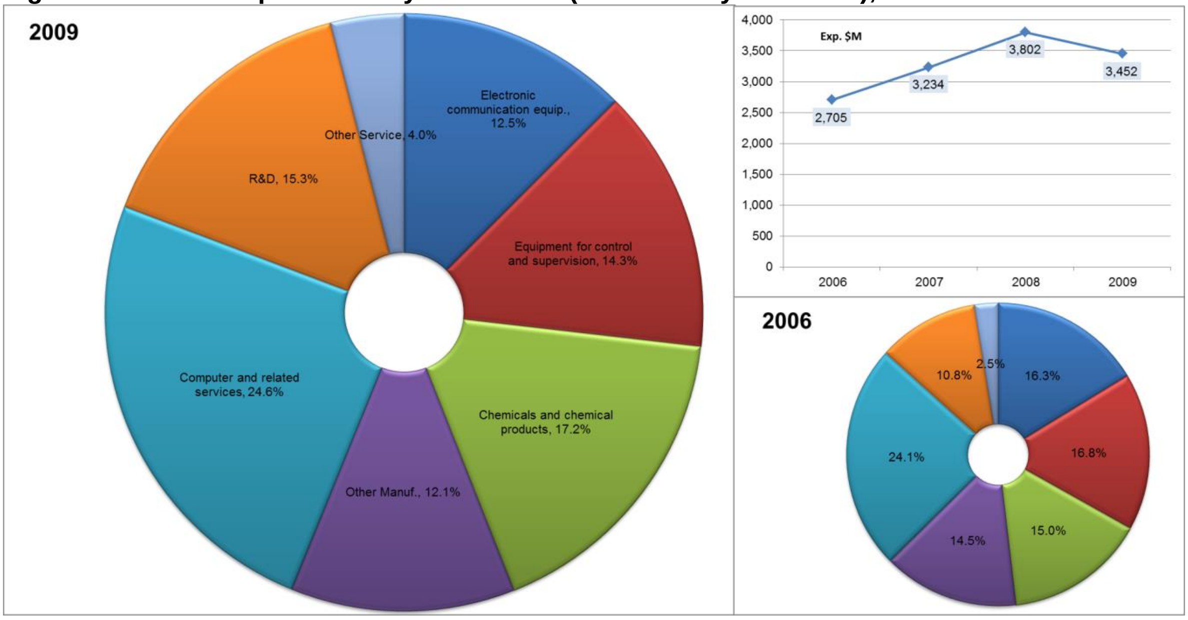
Importantly, the change in the internal distribution was first observed in 2009, after the 2008 crisis. Between 2002 and 2008, the share of Communication Services and Computer and R&D Services in total service exports by OUT firms was basically unchanged.

Another parameter of OUT firms' activity that relates directly to technological innovation is these firms' expenditure on research and development. In 2009, Israeli parent companies spent USD 3,452 million on R&D in Israel (Figure 7.28), 46 percent of total R&D expenditure by the business-enterprise-sector. Notably, this share has been constant since 2007 (when it was first measured), notwithstanding a decrease in expenditure in 2009.

Most of this R&D expenditure—56 percent of the total in 2009—was performed by OUT firms in manufacturing divisions. This proportion, however, represents a steady contraction from 63 percent in 2006 (Figure 7.28). The decrease does not trace to changes in any particular division and/or year. On the contrary: the share of R&D expenditure of almost all manufacturing divisions declined during the review period. The only exception was Chemicals and Chemical Products (up from 15.0 percent in 2006 to 17.2 percent in 2009), evidently abetted by the activity of one large Israeli firm that has several subsidiaries in this division.

The proportional contraction of R&D expenditure by OUT firms in manufacturing means a proportional increase in expenditure by firms specializing in services. In this sector, the major increase was by OUT firms that engage in research and development—from 10.8 percent of all R&D expenditure by OUT firms in 2006 to 15.3 percent in 2009. The share of firms in other service divisions also grew during this time. Computer Services remained the leading division in R&D expenditure—24.1 percent of the total in 2006 and 24.6 percent in 2009.

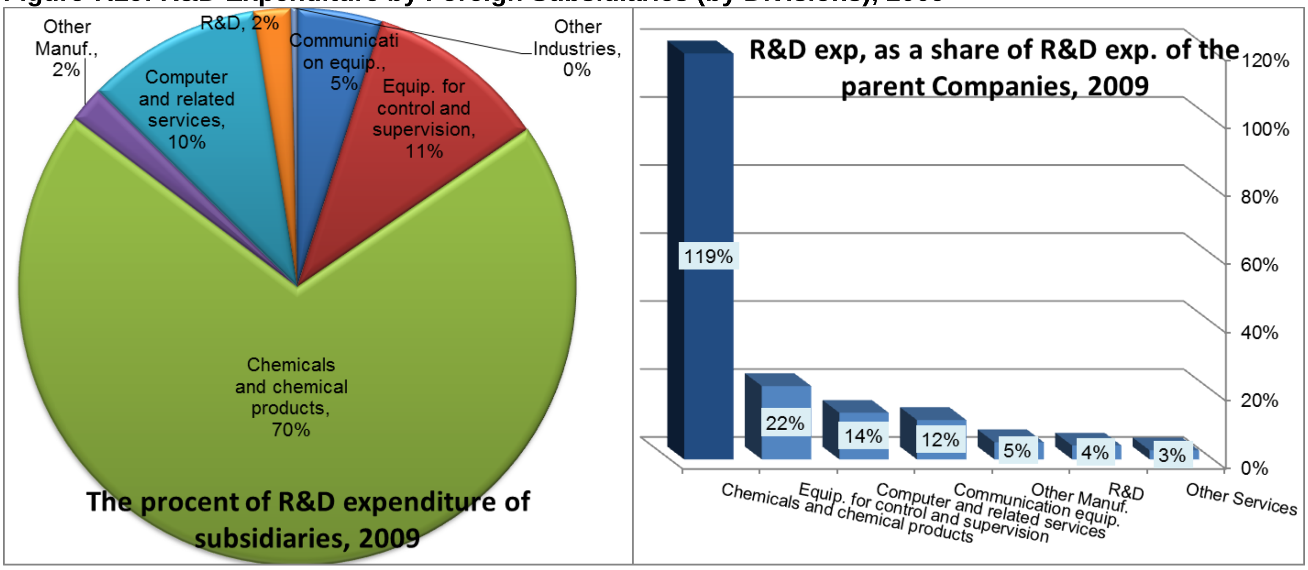
Figure 7.28: R&D Expenditure by OUT Firms (Total and by Divisions), 2006–2009



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

The picture in R&D activity by OUT firms' subsidiaries is different. Subsidiaries' R&D investments in 2009 are shown in Figure 7.29. Most R&D activity abroad was performed by subsidiaries of chemical manufacturing firms. The figure also shows why this is so—only firms active in this Division (perhaps one firm) do most of their R&D abroad.

Figure 7.29: R&D Expenditure by Foreign Subsidiaries (by Divisions), 2009



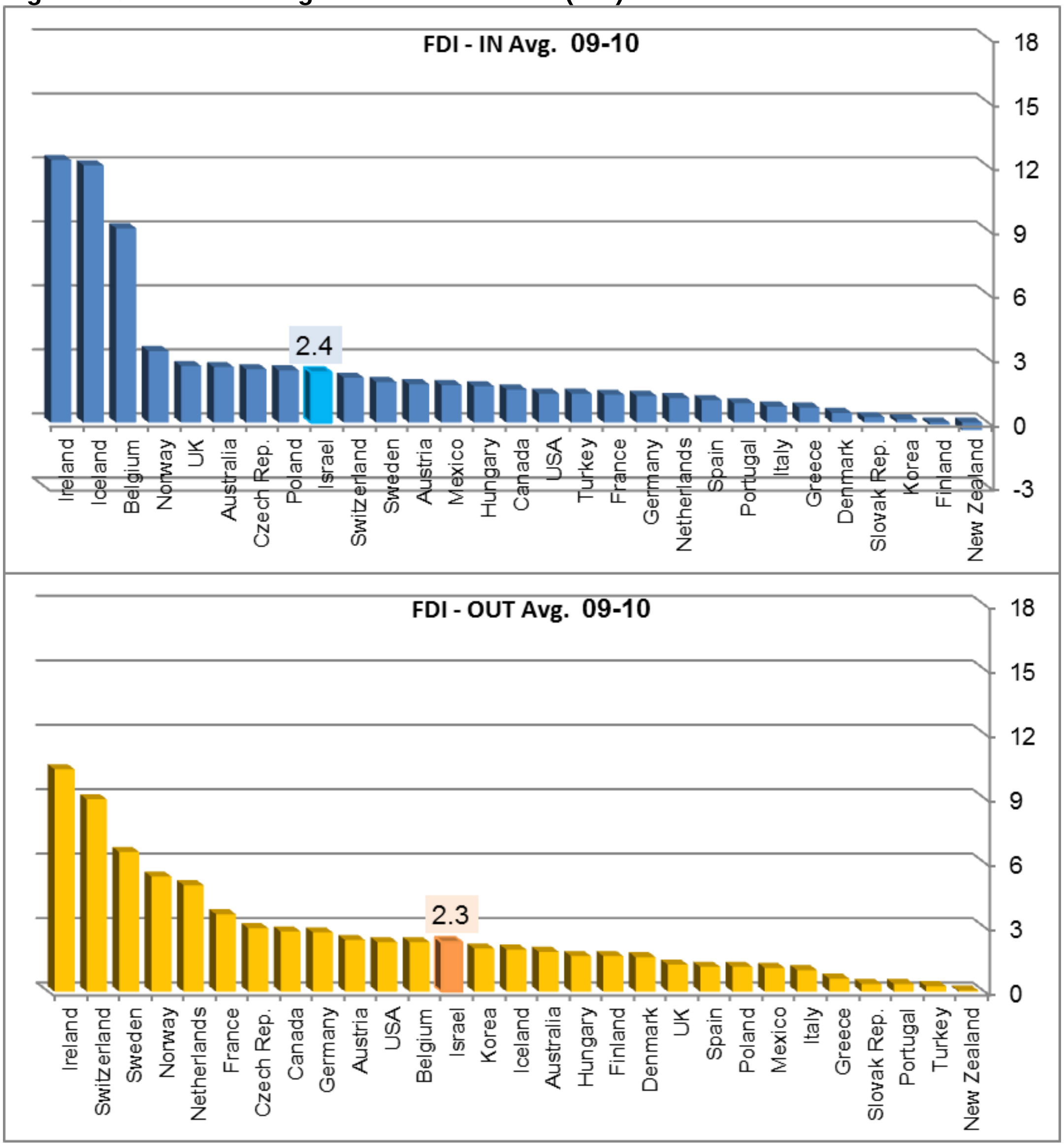
Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

7.2.4 Foreign Direct Investment

Foreign direct investment (FDI) is investment in the acquisition of a significant controlling interest (more than 10%) in a firm that operates outside the investor's country. It includes acquisition of equity, principals' loans, and reinvestment of earnings. FDI is an indicator of investors' confidence in the stability of the target country's economy and firms.

Both "FDI In" (the share of FDI in Israel) and "FDI Out" (the share of Israelis' investments abroad) are not exceptional by OECD standards (Figure 7.30). Interestingly, even though the level of investment has declined considerably, Israel's place in the standings has hardly changed. This is because most OECD countries reported major decreases in this parameter in 2009–2010, evidently due to the 2008 crisis.

Figure 7.30: Israel Foreign Direct Investment (FDI) Position as Pct. of GDP



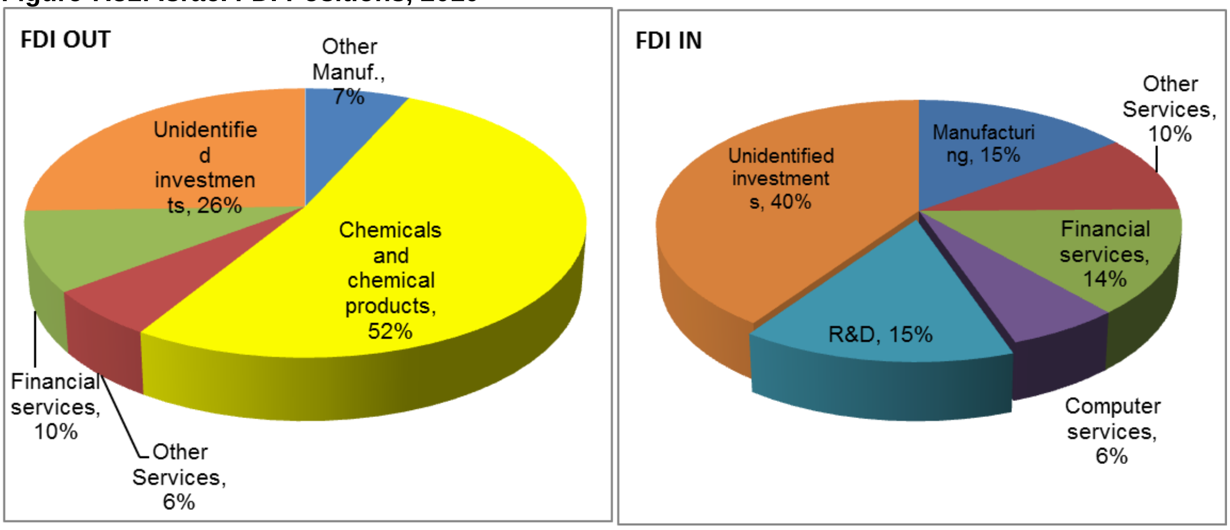
Sources: Analysis of CBS and OECD data by Samuel Neaman Institute

The composition of Israel's direct investment position is an outlier among OECD countries. In 2010, the R&D Services Division was the main investee, attracting 15 percent of total investment (Figure 7.31), a very hefty share by global standards. In other developed countries, according to OECD.Stat, the position of foreign investment in this division did not exceed 1 percent of the total FDI position.

Notably, according to the same data, the foreign-investment position in the Communications and Communication Services divisions was around 0 percent in 2010 as against 18.5 percent in 2008 (12.2 percent of total position invested in Communications and 6.3 percent in Communication Services). Although the data are preliminary, they are nevertheless meaningful, especially when examined in conjunction with data on the decline in employment at IN firms that operate in this division. (See section on IN firms.)

In 2010, 52 percent of total “FDI Out” was made in the chemical industry, also a very high rate by global standards. Two relatively large investors in this division—Norway (13 percent of total investment position) and Sweden (12 percent)—lagged far behind.

Figure 7.31: Israel FDI Positions, 2010



Sources: Analysis of CBS and OECD data processed by Samuel Neaman Center

7.2.5 <u>Venture Capital and Sale of Start-Ups</u>

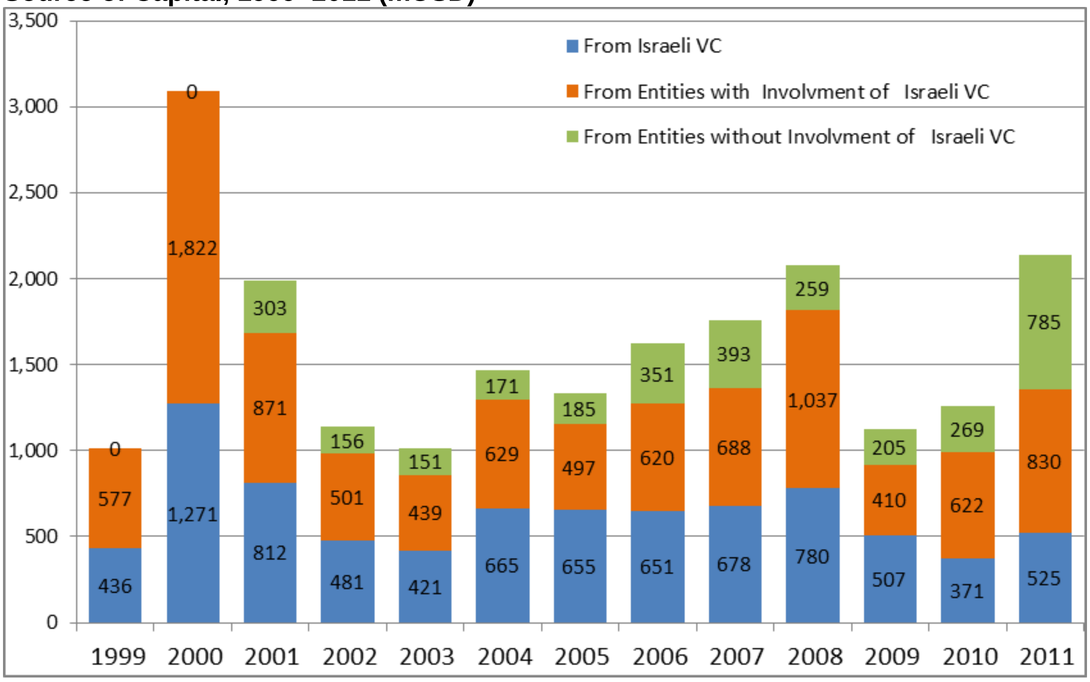
Start-ups are quintessentially identified with research and development and also account for a rather large share of this division (Division 73) as well as Division 72. Therefore, foreign investors’ activity in raising venture capital may be considered an indicator of the level of globalization of Israeli R&D.

Start-ups rely heavily on venture capital. According to data on changes in how much capital of this kind is raised (Figure 7.32), VC capital raised by Israeli start-ups tumbled heavily after the 2008 crisis, from USD 2,076 million to USD 1,122 million. Only a small portion of the decrease, however, traced to foreign investors. Thus, USD 259 million was raised from foreign VC funds in 2008 and USD 205 million in 2009, down 21 percent. Investments by foreign funds that had Israeli involvement, in contrast, declined by 60 percent and investments by Israeli funds shrank by 35 percent.

Israeli capital funds continued to downscale their investments in 2010. Foreign funds with Israeli involvement, in contrast, increased their investments over 2009 and foreign funds invested even more than in 2008. As a result, total VC investments surpassed the 2009 level and came to USD 1,262 million. The share of Israeli funds in the total, however, fell to 29 percent, a record low.

Only in 2011 did the behavior of Israeli funds change. That year, funds that had no Israeli involvement invested a record USD 785 million, up 190 percent from 2010, and USD 2,140 was invested in Israeli high-tech establishments—the highest since 2000. The 2012 data, however, do not show that investment continued to expand. Investment in the first half of 2012 was USD 936 million—down USD 112 million from the year-earlier period.

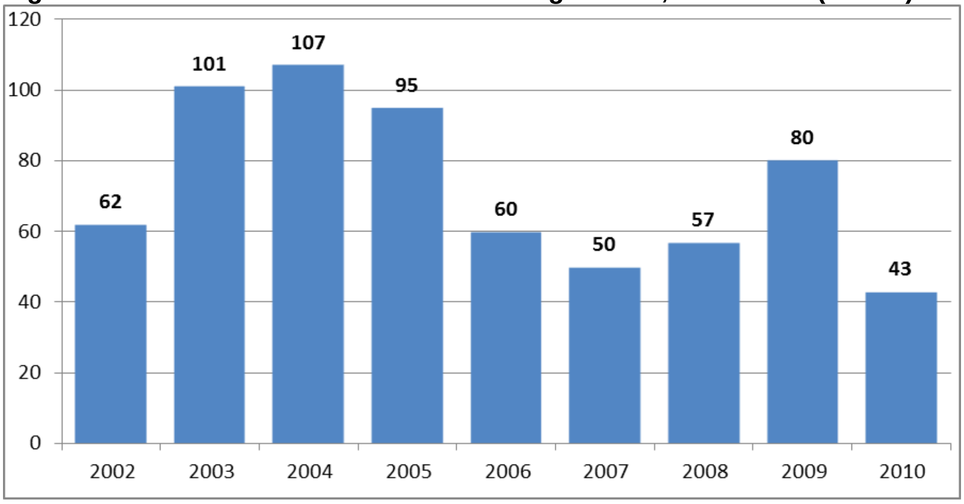
Figure 7.32: Venture Capital Investments in Israeli High-Tech Establishments, by Source of Capital, 1999–2011 (mUSD)



Source: IVC Research Center data processed by Samuel Neaman Center

Israeli VC funds also invest in foreign firms (Figure 7.33). Such investment is not large and has been trending down since 2004. However, a major increase occurred in 2009. It is hard to tell whether Israeli funds detected business opportunities abroad in the aftermath of the crisis or whether a nonrecurrent investment was made in an individual project. Either way, this class of investment declined by 46 percent in 2010 and the downward trend resumed.

Figure 7.33: Israeli VC Investments in Foreign Firms, 2002–2010 (mUSD)



Source: IVC Research Center

7.3 Globalization in Science and Technology

As noted above, science and globalization are strongly related. International cooperation facilitates better scientific achievements and abets the creation of a global market for the outcomes of scientific and technological progress—patents, publications, etc.

This section presents several indicators that test these aspects of international relations in science.

7.3.1 Patents

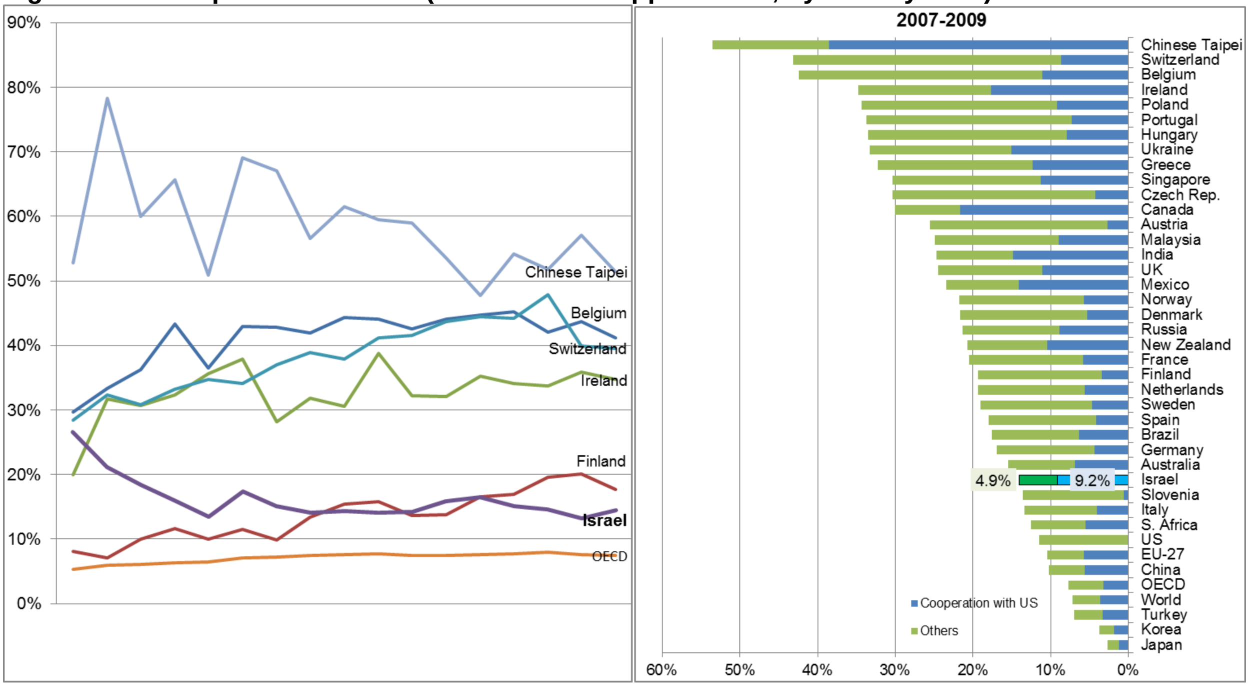
International cooperation in registering patents is an important indicator of a country's status in the global technological arena. It reflects both the quality of the country's R&D by world standards and the country's importance as a participant in the global markets for knowledge-intensive products.

Israel is not a particularly outstanding player in this field (Figure 7.34). In 14.1 percent of total PCT patent applications[52] by Israeli investors in 2007–2009, co-applicants from abroad were involved (65 percent of whom were U.S. citizens). In Taiwan, the share of joint patents was 53.6 percent, in Switzerland and Belgium it was 43.1 percent and 42.4 percent, respectively.

It is also evident that the rate of cooperation between Israeli inventors and colleagues abroad has been trending down over the years—from 18.4 percent of PCT applications in 1995 to 14.5 percent in 2009. These data show that Israel is relatively independent in its R&D and that its senior partner abroad is the U.S.

[52] The PCT (Patent Cooperation Treaty) deals with international patent applications. It was executed in Washington in 1970 to establish a standard mechanism for patent registration in multiple countries on the basis of one international application. By June 2010, 142 countries including Israel had ratified it.

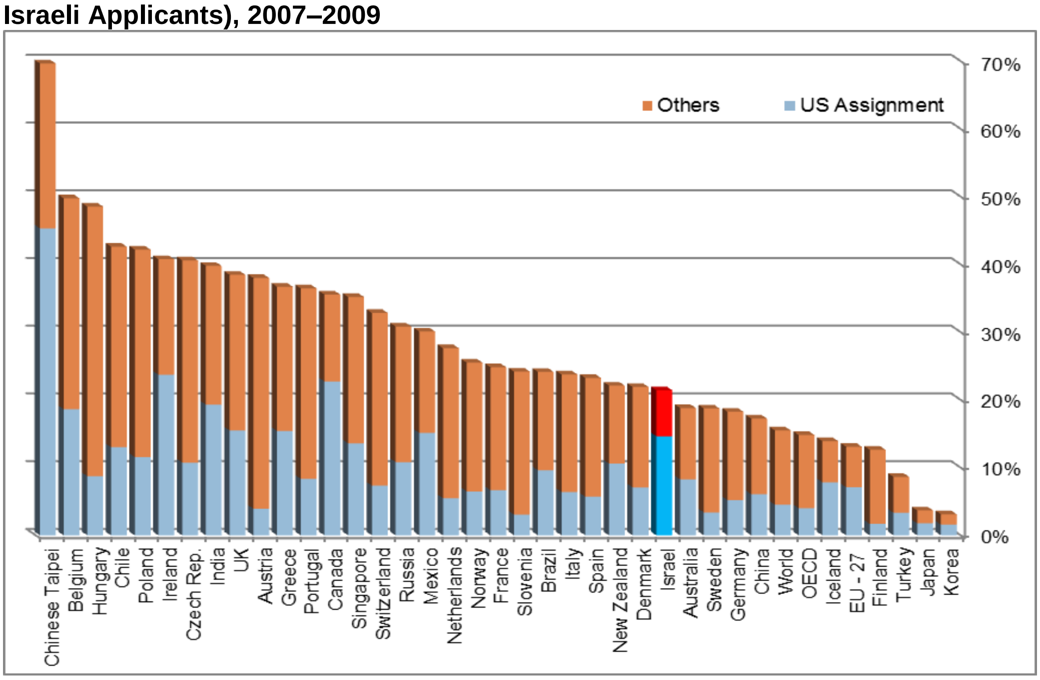
Figure 7.34: Cooperative Patents (Pct. of Patent Applications, by Priority Date)



Source: OECD data processed by Samuel Neaman Center

The pattern recurs in the share of foreign ownership of original patents. Among PCT applications submitted by Israel citizens, 21.4 percent were assigned to foreign residents or firms, as against 70 percent in Taiwan and 60 percent in Belgium. Furthermore, a large majority of foreign assignees—68.3 percent (14.6 percent of all assignees)—were American, the highest rate among all countries examined (Figure 7.35).

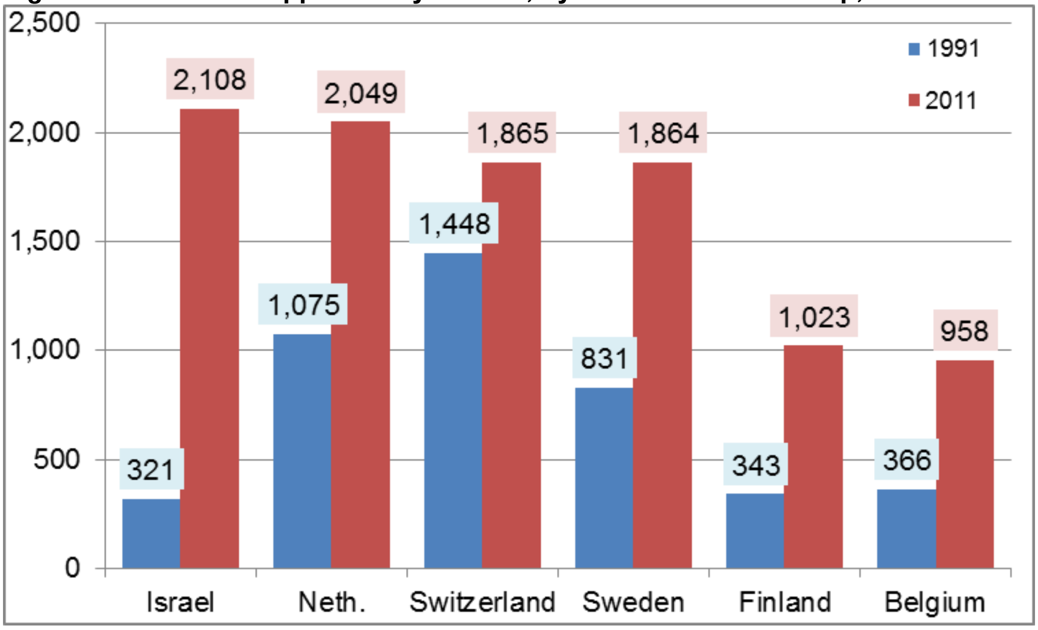
Figure 7.35: Foreign-Owned Patents (Pct. of PCT Patent Applications Submitted by Israeli Applicants), 2007–2009



Source: IVC Research Center data processed by Samuel Neaman Center

Data on the number of patents submitted by Israel citizens that were approved by the United States Patent and Trademark Office (USPTO) give further evidence of the strength of Israel–U.S. scientific relations. Between 1991 and 2011, the number of Israeli patents approved by USPTO increased more than 6.5 times over—more than any European country that resembles Israel in size (Figure 7.36).

Figure 7.36: Patents Approved by USPTO, by Inventors' Citizenship, 1991–2011



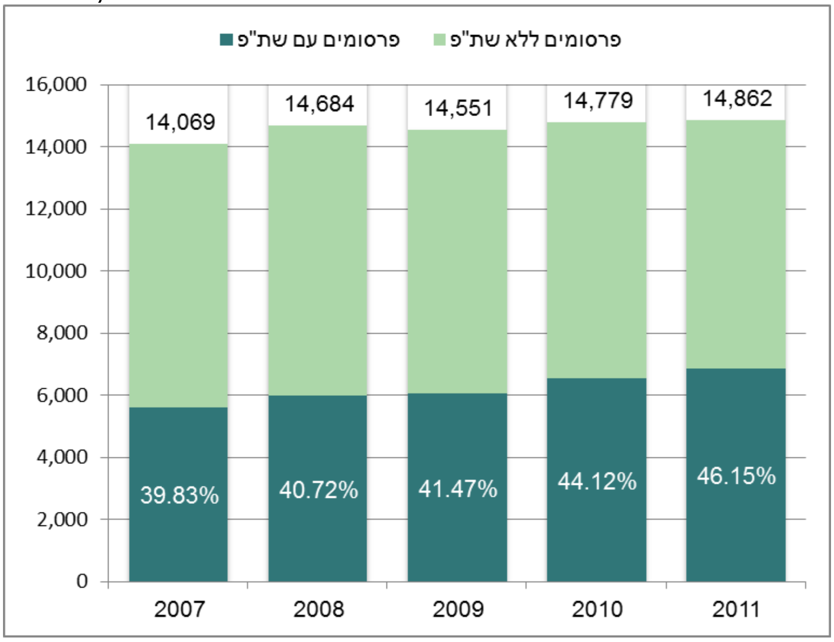
Source: USPTO data processed by Samuel Neaman Center

7.3.2 <u>Publications</u>

International research collaboration is one of the quintessential markers of globalization in the scientific world. The number of collaborative publications involving researchers from other countries and the share of such publications in all publications are considered good indicators of the intensity of cooperation.

Notably, Israel has been climbing steadily in these indicators: from 3,006 collaborative publications in 1995 (29.8 percent of all publications) to 5,980 in 2008 (breaking the 40 percent barrier), and 6,868 in 2011, 46.1 percent of all publications. Thus, 6,858 scientific works (all disciplines) in which an Israeli researcher collaborated with a colleague/colleagues abroad were published that year (Figure 7.37).

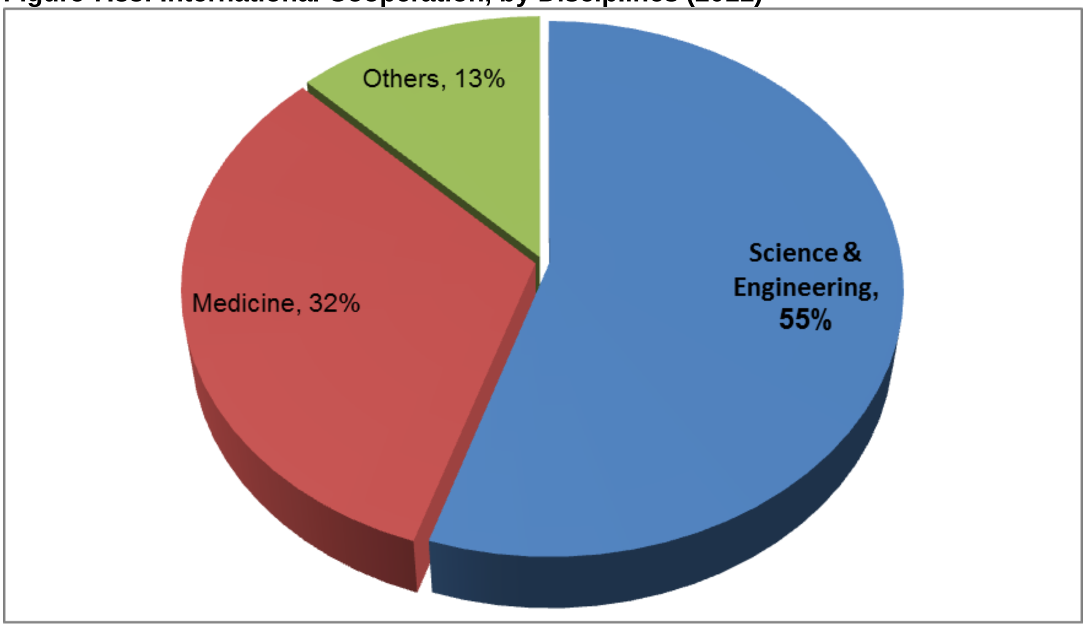
Figure 7.37: Publications by Israeli Researchers in Conjunction with Researchers Abroad, 2007–2011



Source: Thomson Reuters data processed by Samuel Neaman Center

Most collaborative publications fall into the fields of science and engineering. Figure 7.38 shows the distribution of collaborative publications with researchers in the United States, Canada, Europe, and Southeast Asia. In 2011, most such publications were carried out in conjunction with researchers from these countries and regions.

Figure 7.38: International Cooperation, by Disciplines (2011)



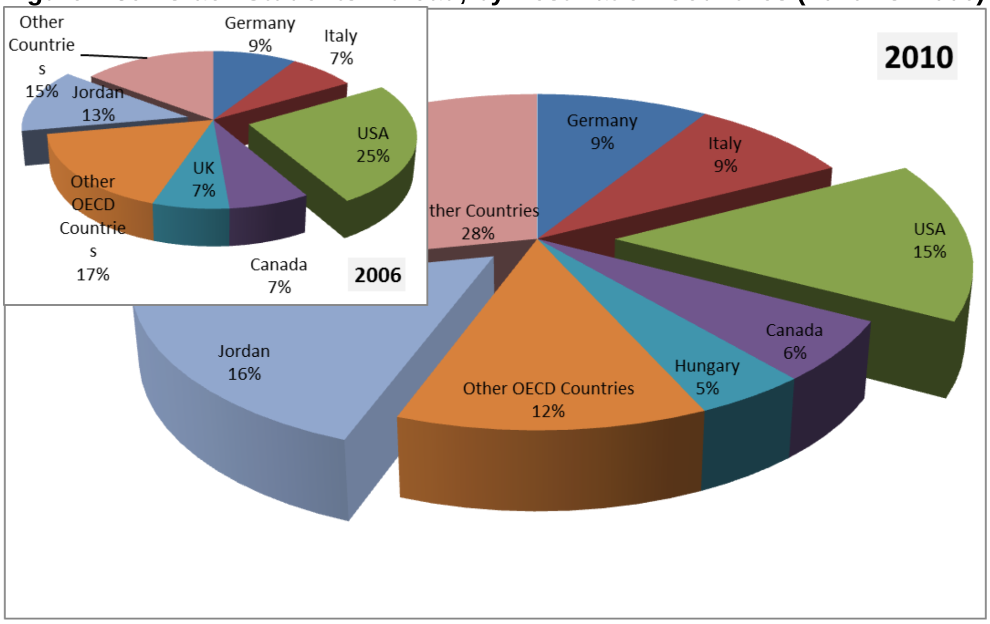
Source: Thomson Reuters data processed by Samuel Neaman Center

7.3.3 Students

Here we examine the main trends among Israelis who go abroad for studies. Migrating to a foreign country for academic studies is indicative of the intensity of relations—both scientific and cultural—with the destination country. Conversely, one of the leading considerations in choosing a foreign destination for studies is the possibility of finding employment there. If so, student mobility is an indicator not only of the intensity of globalization also of future brain drain.

Figure 7.39 parses Israeli students abroad by destination countries. In 2008, their favorite countries were Jordan and the United States, chosen by 16 percent and 15 percent, respectively, of all Israeli students attending institutions abroad.

Figure 7.39: Israeli Students Abroad, by Destination Countries (2010 vs. 2006)



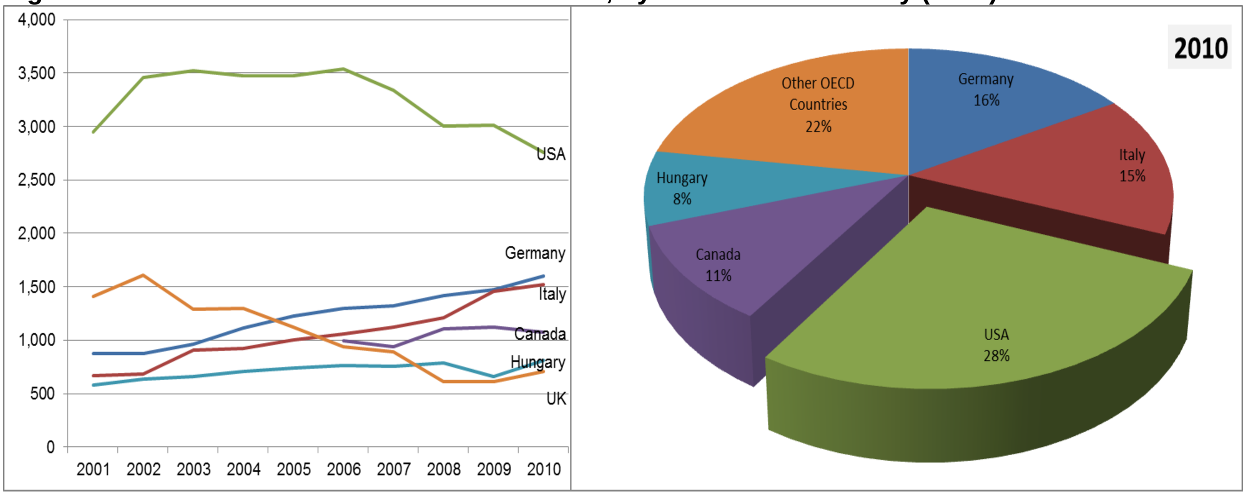
The data for Jordan is by UNESCO, the data for other countries is by OECD
Source: OECD and UNESCO data processed by Samuel Neaman Center

Comparison with the 2006 data (small pie graph in the corner) shows that the number of students who chose Jordan as their destination has grown swiftly (1,863 in 2006, 2,911 in 2010). This population, however, is different from other students: they are young adults who belong to one group (Israeli Arabs) and, in most cases, go abroad to study medicine. Therefore, the discussion below focuses on trends among those who study in OECD countries.

Figure 7.40 plots changes in Israeli students' preferences between 2001 and 2010. The United States was the favorite destination throughout this time, although the number of Israeli students who chose to study there has declined in recent years. In contrast, the attitude toward other countries has been changing over the years. Thus, the UK has lost almost all its attractiveness to Israeli students. Between 2002 and 2010, the number of students who chose the United Kingdom fell by 56 percent, from 1,609 to 711. The UK, long the second-most-favored country behind the U.S., did not rank even among the five leading countries in the number of Israeli students in 2010.

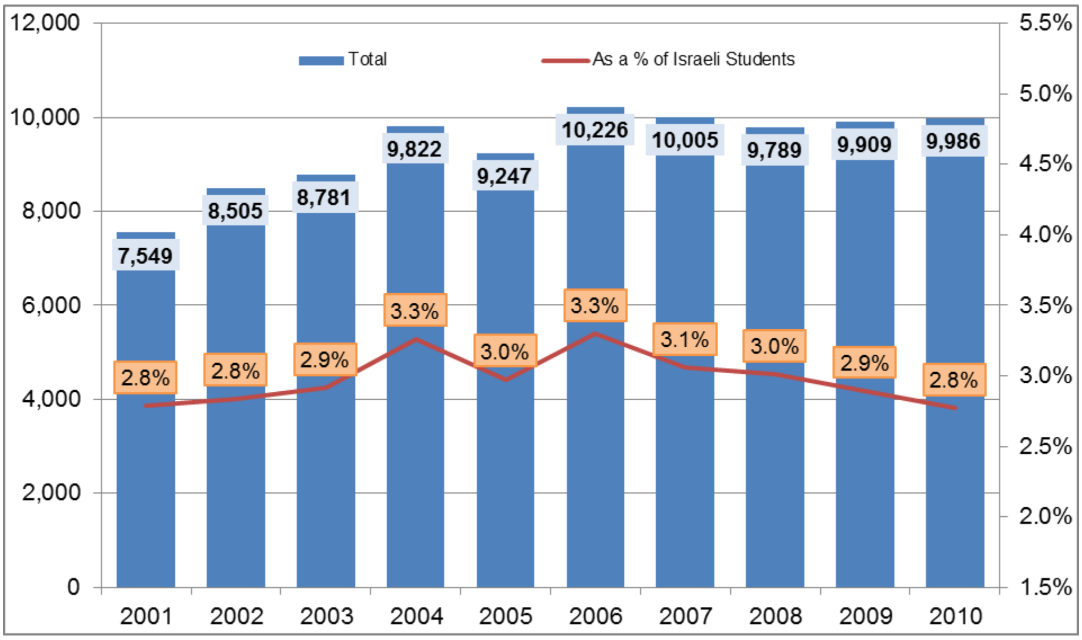
This trend may have been abetted by the intensive involvement of British academia in attempts to boycott Israel. It also stands to reason that British universities are struggling to withstand competition from Germany and Italy. Indeed, the latter countries became much more popular between 2001 and 2010. The number of Israeli students who preferred to attend institutions in Germany went up by 83 percent (from 876 to 1,601) and those preferring Italy leaped by 128 percent (from 670 to 1,525). Overall, the number of Israeli students who attended institutions in OECD countries hardly changed between 2004 and 2010 and their share among all Israeli students actually decreased (Figure 7.41), in contrast to the global trend.

Figure 7.40: Israeli Students in OECD Countries, by Destination Country (2010)



Source: OECD data processed by Samuel Neaman Center

Figure 7.41: Israeli Students in OECD Countries

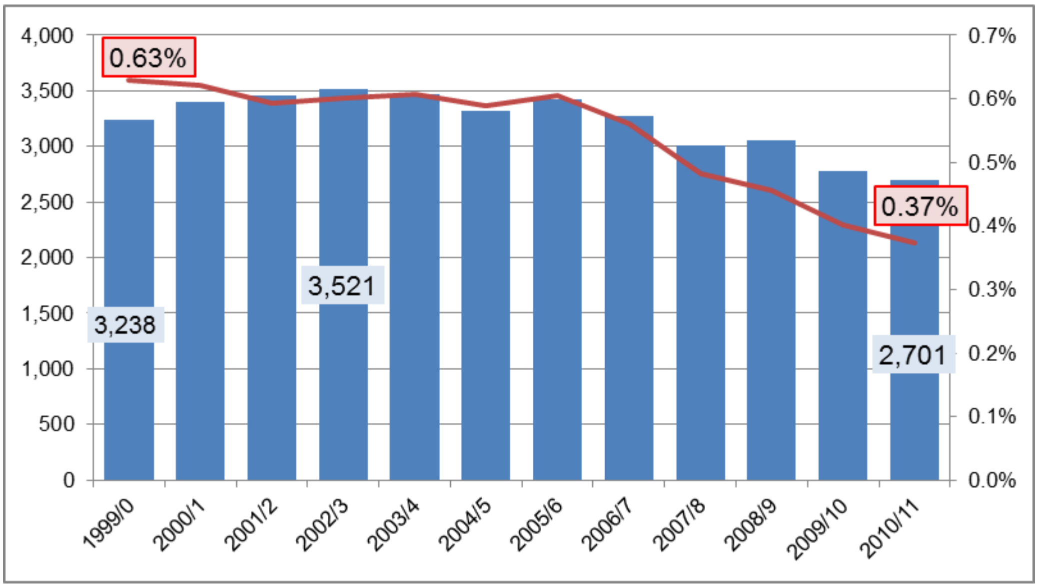


Source: OECD data processed by Samuel Neaman Center

As stated, the United States is the OECD country most favored by Israeli students and has been a main destination for them for many years. The number of Israeli students who headed to the U.S. for study increased steadily, from 251 in the 1949/50 academic year to 3,521 in 2002/03, and then receded to only 2,701 in 2010/11 (Figure 7.42).

The proportion of Israelis among all foreign students in the U.S. has been declining continually. Figure 7.42 shows the changes in the past twelve years (a decline from 0.63 percent to 0.37 percent). In fact, this proportion has been falling at least since the 1954/55 academic year, when it was 2.31 percent.

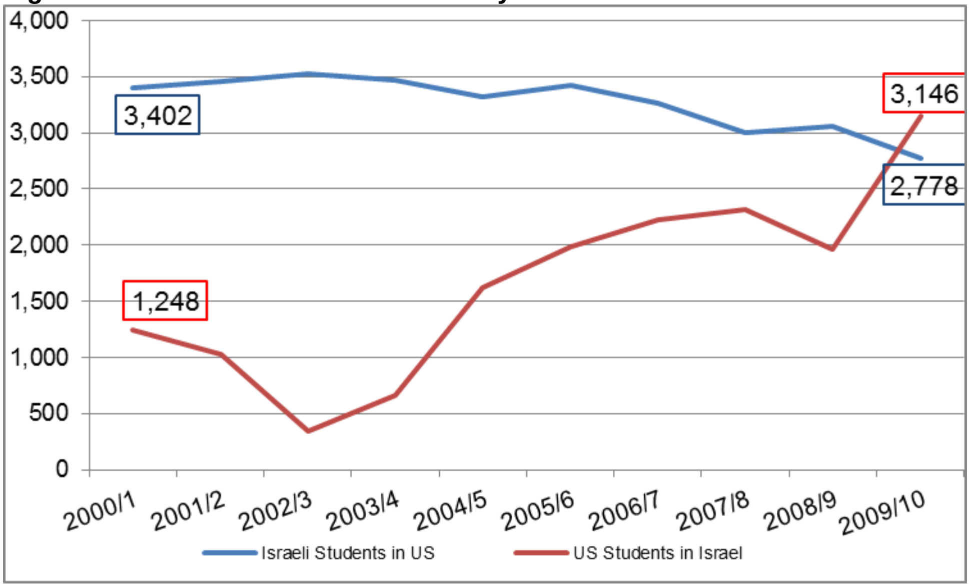
Figure 7.42: Israel-Citizen Students in the U.S., Total and Percent of All Foreign Students in the U.S.



Source: Institute of International Education

As fewer Israeli students chose the U.S. as their place of study, the number of American students who come to Israel has been growing Israel. The two decreases in this indicator (in 2001–2003 and in 2008/09) evidently traced to fear of visiting Israel due to waves of terror and missile attacks that the country experienced at the time. Overall, however, in the 2000/01–2009/10 decade, the number of American students who chose Israel as their place of study surged by 152 percent (Figure 7.43) and in 2009/10, for the first time, the mobility balance tilted in Israel's favor (more American students coming to Israel that Israeli students going to the U.S.). Importantly, these data do not take account of the duration of studies and include students who came for several courses and enrolled for several years to complete their degree studies.

Figure 7.43: Israel–U.S. Student Mobility Balance



Source: Institute of International Education

Table 7.3: Israeli Doctoral Candidates in Science and Engineering who Attend U.S. Institutions (Total and Pct. of Doctoral Candidates of All Origins)

	1998	1999	2000	2001	1002	2003	2004	2005	2006	2007	2008
Total	34	26	31	33	25	40	53	55	54	59	51
Pct. of worldwide total	0.4%	0.4%	0.4%	0.4%	0.3%	0.6%	0.6%	0.5%	0.5%	0.5%	0.4%

Source: NSF

8. Technological Readiness

- Seventy percent of the Israeli population had Internet access in 2011, low by the standards of similarly populous countries such as Norway (97 percent), Sweden (93 percent) and the Netherlands (90 percent). A possible explanation for this low share is that various population groups in Israel use neither computers nor the Internet.
- In the comprehensive UN E-Government Readiness Index for 2012, Israel ranked sixteenth among 192 participating countries (with a relative score of 81 percent).
- In the four components of the UN Index, Israel ranked thirteenth in Web measure and telecommunication infrastructure, fourteenth in human capital, and sixth in online participation.

Since the 1990s, the penetration of technology and computer revolution has changed much of our daily lives and wielded much influence on our way of life. The Internet and its ubiquity via desktop computers, mobile computers of various kinds, and smartphones gives its users a tremendous advantage in the celerity of their sharing and receiving of information and in access to limitless databases that influence all areas of life from working patterns via consumption habits to leisure consumption. Plainly, a population that uses advanced technologies has better chances of social and economic development than those that eschew them.

The rapid pace of development of information and communication technologies (ICT) and their availability to the public has created disparities between populations that have access to various ICT-based products and those that do not. This disparity—known as the digital gap or the digital divide—is a social and political issue that pertains to the disparity between population groups that have regular and efficient access to digital technologies and those who lack it. Information technologies give an edge to population groups that use digital technologies and leave behind those who do not use them, for whatever reason. Access to digital technologies confers advantages in schooling, social affairs, culture, and employment. Another advantage is access to and performance of actions online via computer and smartphone in fields such as governmental, healthcare, and education services, telecommunication, commerce, etc.

Today, computer proficiency is essential for more than 40 percent of employee posts and necessary in more than 70 percent of posts in developed countries. For those who find the new technology difficult to adopt, it is a negative factor that aggravates social and economic gaps (Melamed, 2006).

The reasons for the digital gap may originate in deficiencies in the education system, physical infrastructure that denies access to information technology, economic inequality that thwarts computer purchase and Internet connection, lack of awareness of the impact of the digital world and the need to put information technologies to broader and broader use, fear of the digital world, preconceived notions, religious motives, and so on.

If a country's wealth was once measured by the quantity of its natural resources and the capabilities of its traditional industry, today wealth also migrates to countries that know how to "generate" and sell knowledge. Today, the world's wealthiest societies are those that engage in computers, software, and products that sort, analyze, and process information. Israel, a small country not richly endowed with natural resources or sources of energy, has the potential of promoting manufacturing based on human capital and knowledge and, with the help of appropriate policies, carving 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 any measure. It has also managed to produce outstanding ICT manufacturing enterprises that compete successfully in the global market. In various indicators of the digital gap, however, Israel ranks with other countries in a "good place in the middle." To narrow the digital gaps, bolster the domestic economy, and give Israel a long-term competitive edge in the global arena, the Government of Israel needs to plan and formulate policies in these regards.

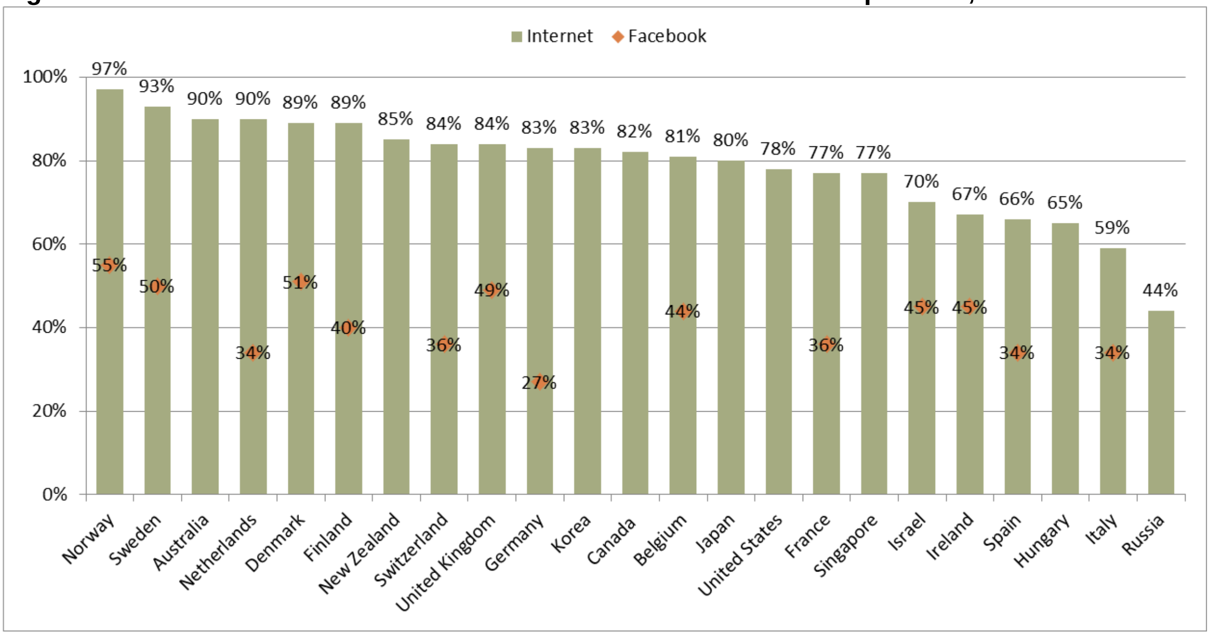
8.1 Communication and Internet access

Previous reports in this series examined the Israeli public's overall potential in applying and using information technologies by means of two separate indicators: households that have computer access and households that have Internet access. Given the tremendous advance of technology today, a computer without Internet access is meaningless; Internet access, too, is attained not only via desktop computers but also by laptops, smartphones, and tablets, making it possible not only in homes and workplaces but also on the way to work (trains, buses, and airports), while waiting (for the doctor, at the bank, in traffic jams, etc.), and at places of entertainment and leisure. Therefore, Figure 8.1 shows the share of Internet subscribers and Facebook accounts among the population as indicators for use in testing the integration of technology in Israel and comparing it with that of other countries. We would expect Israel, considered a start-up and high-tech powerhouse, to place among the world's leading countries in the Internet access indicator. Such is not the case: Israel ranks in the lower third; 70 percent of its population has Internet access, low by the standards of similarly populous countries such as Norway (97 percent), Sweden (93 percent), the Netherlands (90 percent), and Belgium (82 percent). One may explain this humble proportion by noting that various population groups in Israel do not use computers or the Internet. Some 32 percent of non-Internet users trace their avoidance to religious motives and 58 percent say that they neither need or take an interest in the Internet.

The second indicator shown in Figure 8.1 is the number of Facebook accounts relative to population. Facebook is the world's largest online social networking site, available in more than seventy languages. Facebook users can choose whether to participate in one social network or another on the site, parsed by school, work, geographic area, or any other parameter. These networks help users to communicate with other users who belong to other networks of similar nature. Facebook does not charge subscription and use fees; the company derives its income from advertisements on the side of the screen that are tailored to the user's profile.[53]

One would expect Facebook subscribers to be more technologically involved and to use computers and the Internet more. In Israel, 45 percent of the population has Facebook accounts; in this respect, Israel resembles other leading countries and is in fifth place after Norway, Denmark, Sweden, and the UK.

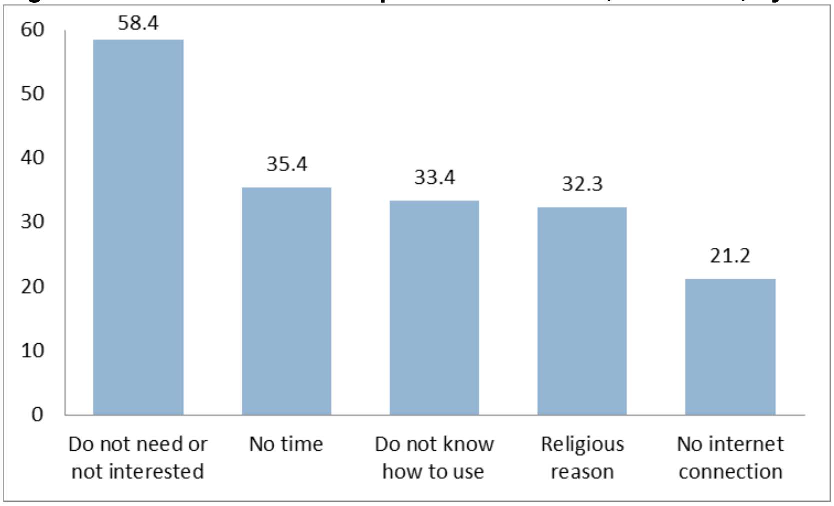
Figure 8.1: Internet Users and Facebook Subscribers as Share of Population, 2011



Sources: Internet world stats Site. Retrieved July 9, 2012 from http://www.internetworldstats.com/stats4.htm
Definitions of Internet and Facebook users: http://www.internetworldstats.com/surfing.htm

[53] Wikipedia, "Facebook," http://he.wikipedia.org/wiki/%D7%A4%D7%99%D7%99%D7%A1%D7%91%D7%95%D7%A7#cite_note-6.

Figure 8.2: Non-Users of Computer and Internet, Abed 20+, by Reason



Sources: CBS, from the Social Survey 2010, Table 33. - aged 20 and older who do not use computers and the Internet, by reason and by Selected Characteristics, 2010

8.2 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, accessible, 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 to stay touch with citizens and provide better and more accessible service.

E-government is immensely important in several ways:

- enhances 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;
- improves 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;
- promotes 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 developed immensely 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 almost every year since then. Many countries participate in it (192 countries did so in 2008), including Israel. Its purpose is to yield a comparative estimate of member states' ability to use ICT to improve government services by providing citizens with online access to them. Thus, the survey is a tool that may be used to compare and monitor governments' progress in delivering e-government services.[54]

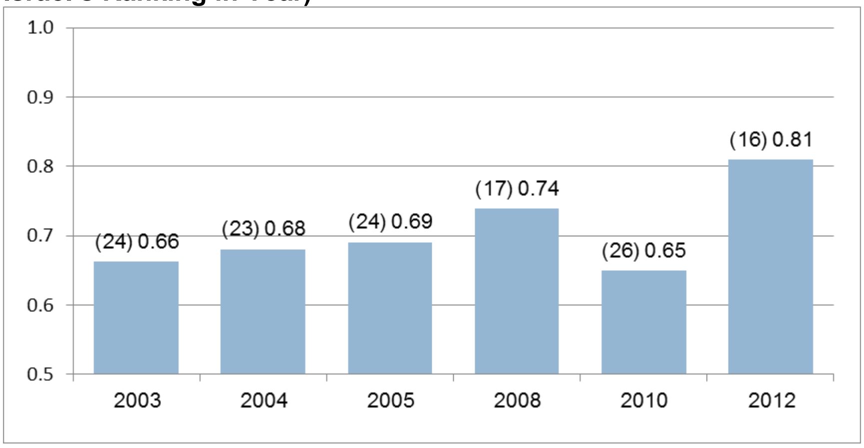
8.2.1 The UN E-Government Readiness Index

To make countries comparable, the UN has developed a comprehensive tool called the E-Government Readiness Index. It is a composite of four indices:

- Web measure index— based on a five- phase model (growth, reinforcement, interaction, activity, accessible government). The index examines which online tools and applications the government supplies its citizens;
- telecommunication infrastructure index—examines countries' existing infrastructure on the basis of the number of Internet users, personal computers, telephone landlines, mobile-phone lines, and broadband connections, normalized to 100 persons;
- human-capital index—the adult literacy rate and the percent of participants in primary, post-primary, and higher education systems;
- on-line participation index—composed of three categories: online information, online advice, and online decision-making. The index reviews twenty-one government services as to the extent of their online capacity, accessibility, and citizen involvement.

In the 2012 Readiness Index, Israel ranked sixteenth among 192 participating countries with a relative score of 81 percent—an improvement relative to its performance in 2005, when it ranked twenty-fourth and achieved a relative score of 69.03 percent.

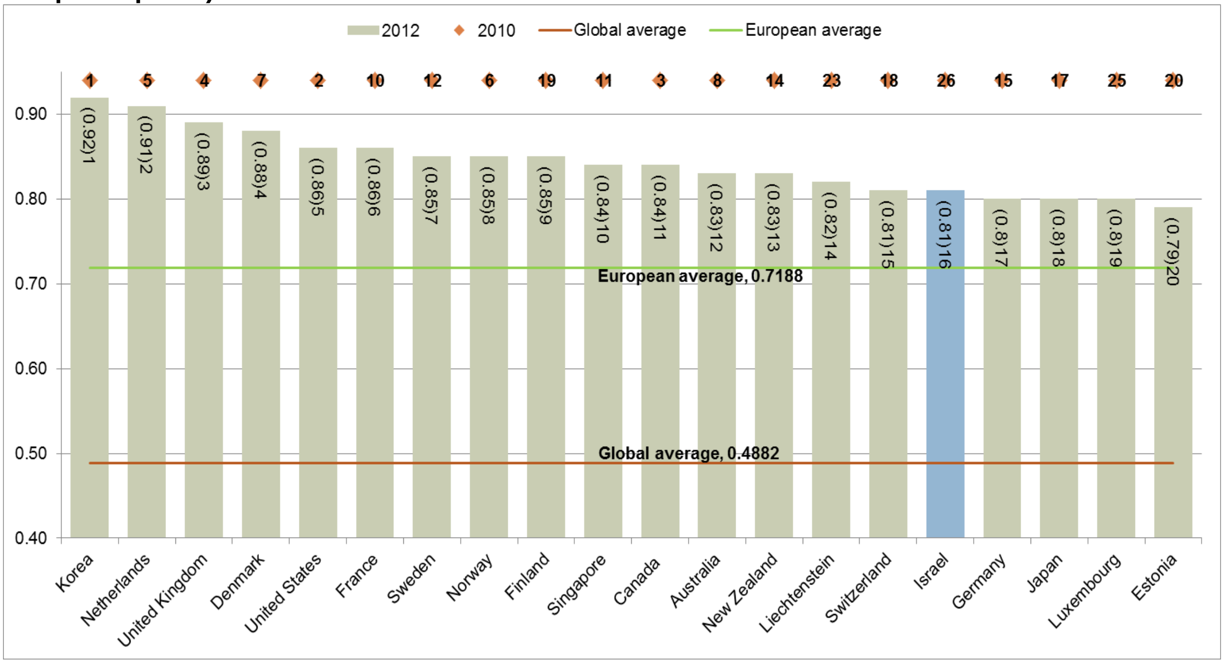
Figure 8.3: The UN E-Government Readiness Index, Israel, 2003–2012 (In Parentheses: Israel's Ranking in Year)



Source: UN

[54] Source: Israel Government Services and Information Portal, "E-Government Report 2012–2009, E-Government Summary."

Figure 8.4: The UN E-Government Readiness Index, 2012 (20 leading countries among 192 participants)



Source: UN

The leading countries in 2012 were South Korea, the Netherlands, the UK, Denmark, and the United States. Israel was in sixteenth place, besting countries such as Germany and Japan. In a regional comparison among West Asian countries, Israel was the leader.

8.2.2 <u>Four Indices: Web Measure, Telecommunication Infrastructure, Human-Capital, and On-Line Participation</u>

The table below compares Israel with the leading twenty countries in the components of the E-Government Readiness Index. According to the 2012 survey, Israel ranked thirteenth in the Web measure index, fourteenth in human capital, thirteenth in telecommunication infrastructure, and sixth in on-line participation.

Table 8.1: Israel in the E-Government Readiness Index, by Index Components

		E-government readiness	Web measure	Human capital	Telecom infrastructure	On-line participation
1.	S. Korea	0.93	1.00	0.95	0.84	1.00
2.	Netherlands	0.91	0.96	0.94	0.83	1.00
3.	UK	0.90	0.97	0.90	0.81	0.92
4.	Denmark	0.89	0.86	0.95	0.86	0.55
5.	U.S.	0.87	1.00	0.92	0.69	0.92
6.	France	0.86	0.88	0.92	0.79	0.58
7.	Sweden	0.86	0.84	0.91	0.82	0.68
8.	Norway	0.86	0.86	0.93	0.79	0.68
9.	Finland	0.85	0.88	0.95	0.72	0.74
10.	Singapore	0.85	1.00	0.85	0.69	0.95
11.	Canada	0.84	0.89	0.92	0.72	0.68
12.	Australia	0.84	0.86	1.00	0.65	0.76
13.	New Zealand	0.84	0.78	1.00	0.73	0.58
14.	Liechtenstein	0.83	0.59	0.89	1.00	0.24
15.	Switzerland	0.81	0.67	0.89	0.88	0.34
16.	Israel	0.81	0.85	0.89	0.69	0.89
17.	Germany	0.81	0.75	0.90	0.78	0.76
18.	Japan	0.80	0.86	0.90	0.65	0.74
19.	Luxembourg	0.80	0.70	0.84	0.86	0.39
20.	Estonia	0.80	0.82	0.91	0.66	0.76

Source: UN

8.3 Public Attitudes toward Science and Technology

In the technology and telecommunication era, the public's attitudes are a topic of much value. This section examines the status of science and technology (S&T) in the eyes of the Israeli public and asks questions such as: How important are 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 will tell us whether the Israel public thinks that government policies on the advancement of and investment in these fields are adequate and whether it understands and appreciates the meaning and underlying values of scientific information.

Below are main findings from a survey commissioned by the National Council for Research and Development and performed by Dahaf Institute in 2009 on Israeli public perceptions and attitudes toward issues related to the status of science and technology. We presented a summary of the results in the previous edition of this Report. At the end of 2011, Dahaf Institute repeated the survey and examined changes relative to the previous one. Below are the main findings and comparisons from the latter survey, which was based on a sample of 528 persons who represent the adult population of Israel.

1. **Perceptions of the need for S&T-related knowledge in daily life; interest in and knowledge of various fields and personal knowledge**
   a. *Perceptions of the need for S&T-related knowledge in daily life*
   57 percent of respondents said that S&T knowledge is either vital (28

percent) or necessary (29 percent) for them in daily life (down from 66 percent in 2009; almost all the decrease was confined to the Arab sector).

b. *Level of interest in various fields*

   The leading topics by level of respondents' interest are health (80 percent expressed an interest), environmental quality (60 percent), computers and Internet (60 percent), and water issues (44 percent). As expected, the level of interest in a given topic was found related to the level of knowledge concerning it.

2. Use of information sources and level of credibility attributed to them

a. *Frequency of use of various information sources:* mass media are the adult population's most frequently used source of information. Among the respondents, 72 percent "often" or "quite often" use the Internet to obtain information, 68 percent use television, 59 percent consult people in their surroundings, and only one-fourth use libraries, museums, and scientific periodicals.

b. *Level of credibility attributed to various sources of information:* the information source awarded the highest average level of credibility, on a 1–10 scale with 10 as the most reliable, is libraries (7.86); the lowest is clerics (4.92).

3. Perceived implications of scientific discoveries and technological innovations

a. *Perceived implications of scientific discoveries and technological innovations*

   Familiarity with the following fields was examined: cellular communication, computers, technological services and accessories (including the Internet) for leisure purposes; social use of e-networks; Internet and email for work purposes, motor vehicles, medicine and pharmacy, and agriculture. As expected, the respondents distinguished between the implications of scientific discoveries and technological innovations for quality of life and their implications for environmental quality. In respect of environmental quality, too, the balance in regard to most topics examined was positive. Notably, when the balance of effects on environmental quality was negative, the gap between those claiming detriment and those claiming a contribution to improvement is wide. When the balance was positive, however, the gap between those making these contrasting claims was usually small.

b. *In the respondents' opinion, do technological achievements create social* *alienation?*

About half (51 percent) of the respondents, much as in the 2009 survey, think the technological achievements contribute to all population strata. One-fourth (25 percent) think that the achievements contribute only to those who engage in technology; most of these respondents (21 percent of all respondents) think that this specific group's advantage abets alienation between them and others. As shown below, a relation was found between perceptions of the implications of scientific achievements and the perception of a contribution of international R&D centers operating in Israel.

4. Prestige and appreciation of various groups of occupations and their contribution to national strength

a. *Prestige and preference of occupations*

The survey data show that physicians and scientists are held in the highest prestige, attaining average appreciation scores of 8–9 on the 10-rung scale, far above the occupation below them, engineering. Teachers rank fourth among the seventeen occupations, between engineers (above) and army officers (below). A strange but unsurprising finding is the low level of prestige attributed to Members of the Knesset. Presumably this assessment reflects not the level of prestige of this occupation but rather, as other studies have found, low regard to MKs in view of various attributes (e.g., honesty, good faith, avoidance of personal interests in their work, etc.).

b. *Assessment of various occupations' contribution to national strength*

The contribution of physicians and senior scientists to national strength is highly valued (averages of 8.73 and 8.67 on the 1–10 scale, respectively). Senior technologists and engineers (8.08) and high-ranking military personnel (7.82) are also perceived as contributing to national strength. The contribution to national strength of intellectuals and cultural personalities (7.36) is less appreciated but surpasses that of senior business people (6.81). At the bottom of the scale are leading entertainers, whose contribution to national strength is valued at 5.81 on average.

5. Importance of investing in research and development

a. *Attitudes toward the need to invest in research*

A large majority of the public (92 percent) are either sure (69 percent) or think (23 percent) that the state should invest in academic research. A large majority (71 percent) are also either sure (34 percent) or think (37 percent) that the state should invest in commercial firms' applied research. These data illuminate the immense importance attributed to research in higher-education institutes and the priority given to such research over industrial research.

The domains that he respondents termed “very important” or “important” for long-term infrastructure investment, in declining order of percent, are education (98 percent), research at higher-education institutes (88 percent), transport infrastructure (87 percent), industrial research and development (85 percent), military infrastructure (79 percent), financial infrastructure (65 percent), and communication infrastructure (69 percent).

b. *Assessment of actual investments*

Most of the public (74 percent) think the state invests too little in academic research, as against 9 percent who think it invests too much. About half (51 percent) think the state invests too little in commercial firms’ applied research; 10 percent think the state invests too much in this.

c. *Total state investment in S&T development*

Nearly half of the respondents (48 percent) think Israel invests less than most developed countries (17 percent—much less; 31 percent—slightly less), about one-fourth (23 percent) think Israel invests as most developed countries do, and 14 percent believe Israel invests more than most developed countries do (11 percent—slightly more; 3 percent—much more).

d. Appreciation of the contribution of R&D investments

About three-fourths of the respondents (76 percent) think R&D investments contribute to national strength “a lot” (45 percent) or “somewhat” (31 percent).

6. Attitudes toward narrowing disparities in education

Most respondents (83 percent) are either sure (54 percent) or think (29 percent) that investing in the education of weak population groups will contribute to social justice. Also, two-thirds (67 percent) are either sure (38 percent) or think (29 percent) that affirmative action in education and overinvestment in weak population groups are justified.

7. Appreciation of national scientific and technological achievements

a. *Concern about national achievements*

A large majority of respondents (88 percent) are concerned about national achievements.

b. *Appreciation of scientific achievements*

The state receives a score of 7.90 on the 1–10 scale for scientific and technological achievements. A large majority of respondents (79 percent) also say that relative to its size, Israel's achievements either resemble (28 percent) or surpass (51 percent) those of most other developed countries.

c. *Identification with winning the Nobel Prize*
The highest achievement of Israeli science—a large majority of respondents (82 percent) heard that a Israeli researcher at the Technion (Prof. Dan Shechtman) won the Nobel Prize last summer. Seventy-two percent of the sample felt pride on this account.

8. Perceived implications of various factors for national S&T achievements

a. *Contribution of a high concentration of R&D in scientific technologies to national achievements*
Most respondents (58 percent) think that diversifying expertise across various fields would contribute more to national achievements than acute concentration of research and development in scientific technologies.

b. *Contribution of globalization to Israel's S&T achievements*
Most respondents (66 percent) think globalization either contributes greatly (24 percent) or somewhat (42 percent) to Israel's S&T achievements.

c. *Perceived implications of the brain drain phenomenon and assessments of national efforts to bring scientists home*
Two-thirds of the respondents (66 percent) think brain drain is taking place on a large scale. A large majority (95 percent) who hold this view consider it harmful to the country. Some 69 percent of respondents think the state has not done enough to prevent it.

9. Bibliography

- Central Bureau of Statistics, *Business Research and Development 2009,* Jerusalem, 2012.
- Central Bureau of Statistics, *Higher Education in Israel, 2008/2009,* Publication 1475, Jerusalem, 2012.
- Central Bureau of Statistics, *National Expenditure on Civilian Research and Development 1989–2010,* Publication 1473, Jerusalem, 2012.
- Central Bureau of Statistics, *Standard Industrial Classification of all Economic Activities, 1993,* Technical Publication 63, Jerusalem,1993.
- Central Bureau of Statistics, *Statistical Abstract of Israel,* 1996-2012, http://www.cbs.gov.il
- Getz, D., Leck E., & Hefetz, A. (2013). *R&D Outputs in Israel – A Comparative Analysis of PCT Applications and Distinct Israeli Inventions.* Samuel Neaman Institute for Advanced Studies in Science and *Technology*, Technion-Israel Institute of Technology, Haifa (in Hebrew).
- Getz, D., Gordon, A., Lavid, N., Even-Zohar, Y.,Eyal, I., Barzani, E.,
- *Outputs in Israel: International Comparison of Scientific Publications, 1990-2011.* Samuel Neaman Institute for Advanced Studies in Science and *Technology*, Technion-Israel Institute of Technology, Haifa (in Hebrew).
- European Commission, *Innovation Union Scoreboard 2011*, Research and Innovation Union Scoreboard, 2012
- *Frascati Manual, Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris, 2002.
- Israel Government Services and Information Portal, *E-Government Report 2012–2009, E-Government Summary,* http://www.gov.il/FirstGov/BottomNav/MemshalZamin/Report/E-Gov-Report2009.
- IVC Research Center.

- Ministry of Education, National Authority for Measurement and Evaluation in Education, International Test Data, http://cms.education.gov.il/http://cms.education.gov.il/EducationCMS/Units/Rama/MivchanimBenLeumiyim/
- Ministry of Industry, Trade, and Labor, Bureau of the Chief Scientist, *R&D Support Program, 2011–2012,* 2013.
- National Council for Research and Development, *Report for 2010 and 2011,* July 2012.
- OECD, *Education at a Glance*, 2003–2012.
- UNESCO Institute of Statistics Data Centre.
- OECD (2012), *Main Science and Technology Indicators*, OECD Science, Technology and R&D Statistics (database). doi: 10.1787/data-00182-en OECD.
- OECD, *Manual on the Measurement of Human Resources Devoted to S&T, "Canberra Manual,"* Paris, 1995.
- OECD Stat
- United States Patent and Trademark Office: http://www.uspto.gov/index.html
- Institute of International Education http://www.iie.org/
- US NSF—National Science Foundation S&E Indicators 2010, http://www.nsf.gov/

Samuel Neaman Institute For National Policy Research
TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY
Tel: 972 4 829 2329 Fax: 972 4 823 1889
Technion City, Haifa 32000, Israel
w w w . n e a m a n . o r g . i l