Samuel Neaman Institute
For advanced studies in Science and Technology

Technion's Contribution to the Israeli Economy through its Graduates

• Amnon Frenkel • Shlomo Maital

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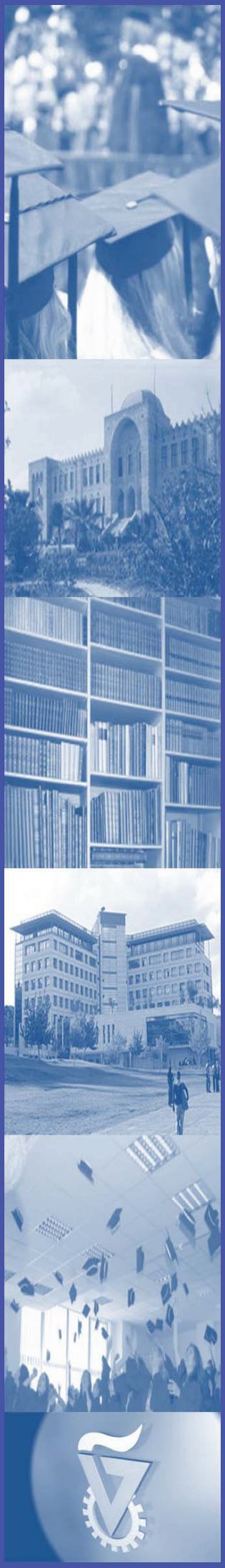
TECHNION
Israel Institute of Technology



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by

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Preface

Prof. Edward Roberts, MIT Sloan School of Management, has undertaken several studies of the impact of MIT on entrepreneurship and the economy of the United States. In his latest study (2009), done with his doctoral student Charles Eesley, based on a large-scale survey of MIT graduates, it is shown that "if the active companies founded by MIT graduates formed an independent nation, conservative estimates indicate their revenues would make that nation at least the 17th-largest economy in the world.[1]" A direct extrapolation of the survey data indicates there are 25,800 currently-active companies founded by MIT alumni/ae, employing 3.3 million people and generating annual world revenues of $2 trillion, thus comprising the 11th largest economy in the world.

Inspired by this study, and suspecting that the impact of Technion is no less dramatic, we decided to undertake a similar study. This report documents our results.

1. Introduction

The Technion, as Israel's technological university, is the premier creator of human technological capital, which is well integrated in the economy and is responsible, to a considerable degree, for its development and growth, led by high technology industries that have constituted the main growth engine of the Israeli economy in recent decades. The Technion, established in 1924, was the first technological university founded in Israel and for many years served as the only institution of its kind. As such, the Technion, as a higher education institution, has contributed to the creation of human technological capital of a high level, allowing the technological sector in Israel to develop and lead to economic growth. Yet, the Technion's contribution to the economy through its graduates has been concealed for many years.

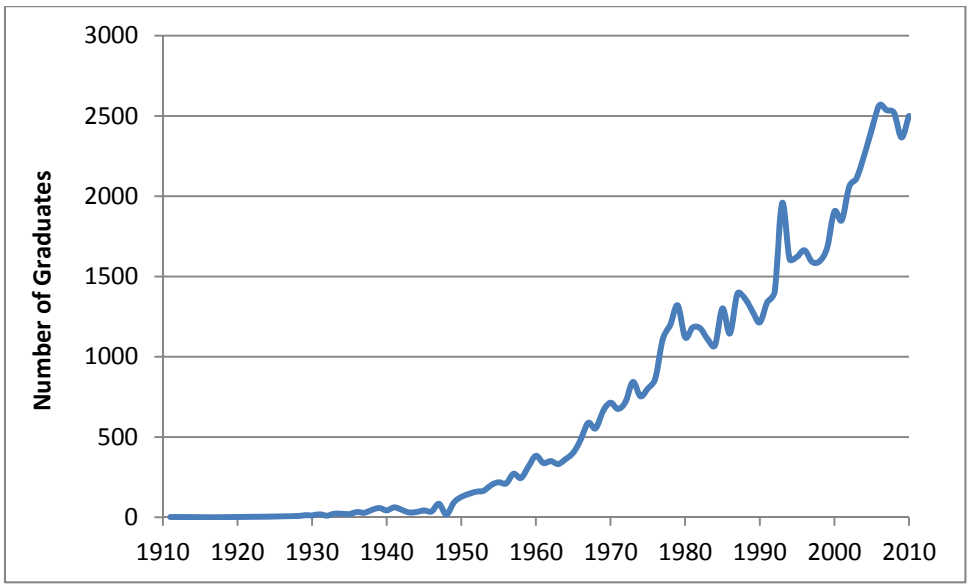
The goal of the report submitted hereby is to estimate the Technion's contribution through its graduates by examining the integration of the Technion graduates in the Israeli economy. To estimate the quantity and quality of Technion graduates who became part of the economy and their contribution to the creation of Israel's human capital, data we collected

[1] Edward B. Roberts and Charles Eesley (2009). *Entrepreneurial Impact: The Role of MIT*. MIT Sloan School of Management.

as part of the Technion Alumni survey in August-December 2010 and were then analyzed. In the survey, a questionnaire was distributed via internet among the graduates, yielding 4,052 filled questionnaires. The answers received were used to analyze the characteristics of the Technion graduates.

Since its establishment about 70,000 graduates entered the labor market in Israel and abroad.[2] Figure 1 shows the number of graduates each year (all degrees) beginning with the two first graduates in 1911 to the 2,500 graduates who graduated and received their degree in 2010.

Figure 1: The Distribution of Technion Graduates According to Graduation Year 1911-2010



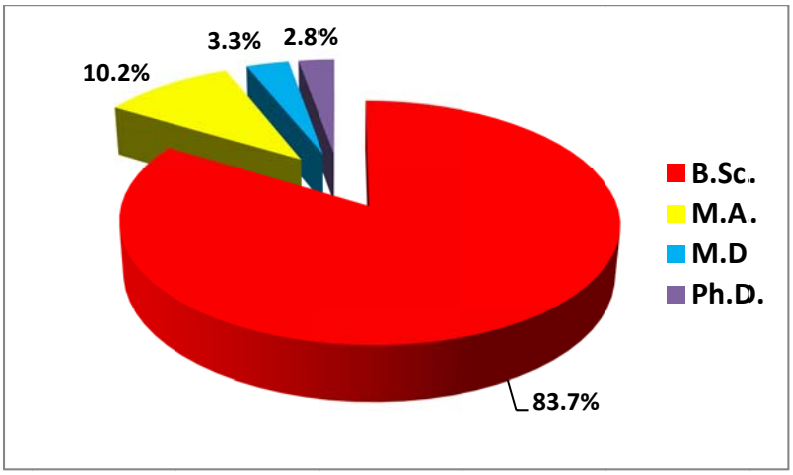
The curve indicates a fairly consistent increase in the number of graduates each year, especially since the '80s. The graduates' record was 2,656 in 2006.

About a quarter of the graduates are female and their number is steadily increasing on the time axis. The graduates' distribution according to the last degree they acquired at the Technion is presented in Figure 2. The distribution indicates that about 18.5% of the graduates studied and were awarded advanced degrees at the Technion.[3]

[2] As an illustration, the number of hired positions in the hi-tech industries today in Israel stands on 92 thousands (Statistical Yearbook for Israel, 2010).

[3] We would like to thank Mr. Moti Epstein from the Computer Center at the Technion for providing us with the data from the Technion's data bank.

Figure 2: Graduate Distribution by Type of Degree



2. The Research Method

2.1 Field Survey

The field survey was conducted using an internet questionnaire developed especially for this purpose. In order to conduct the survey among the graduates, we needed a repository URL from which to distribute the questionnaire that was constructed specifically for this purpose. The general graduates' database of the Technion could not be used, since it is updated annually only with the details of the graduates who graduated that year, but there is no follow-up over time. Also, the database contains only a handful of email addresses, updated for the date of graduation.

A large database that contains many Technion graduates' updated addresses is held by the Technion Alumni Association, which was willing to offer its assistance and help in distributing the questionnaire.[4] The database includes approximately 14,000 addresses of graduates for whom basic data were available, which allowed us to examine the representativeness of the graduates' properties in relation to the general database and the data found in the Technion Alumni Association. The distribution of the characteristics pointed to a great similarity between the two databases, and it could be assumed that the members of the Technion Alumni Association represent the Technion graduates well, as shown in the Table in Appendix 1.

[4] We would like to thank Ms. Penina Ziv, the manager of the Technion Alumni for her full cooperation and great willingness to assist us in distributing the questionnaire as well as to Ms. Noa Hacohen-Uzan, marketing manager of the Technion Alumni, for providing the required technical assistance.

The field survey was conducted during August-December 2010. In the first stage, a pilot was conducted that served for the final funneling of the questions included in the questionnaire that was distributed to the graduates. The questionnaire was distributed in two steps, the first in early September 2010, and the second in early December 2010.

The detailed questionnaire was distributed to the basic distribution list of the Technion Alumni Association, and in addition, to other address databases (not organized) which were found in the overall database of the Data Processing Department at the Technion and the Alumni Association. It is estimated that, in total, the questionnaires were sent to about 24,000 graduates. The total number of respondents was 4,337. After removing duplicate questionnaires (the questionnaire was distributed twice during the survey period) and those in which most of the questions were not answered, the graduate sample, relevant for analyzing the data, stood at 4,052 respondents,[5] constituting about 17% of the total population that received the questionnaires.

Data were collected through a Web-based questionnaire that was developed using the OPINIO software. In its first part, the questionnaire included questions about the graduates' characteristics, such as age, gender, year of graduation, academic institution, and place of residence. In the second part of the questionnaire, most questions focused on examining the graduates' contribution to the economy and especially on the integration of the graduates in the different employment sectors in the economy, on their occupation, on the positions they fulfill in the companies in which they work, on their establishing companies, and on their involvement in developing innovative technology.

2.2 The Sample Representativeness

To examine the representativeness of the sample, a comparison was made between the distribution of the sample characteristics and the distribution of graduate characteristics from the Data Processing Department, which contains about 67,000 graduates, on the following parameters: The graduates' distribution by gender, year of completion, and type of degree (achieved at the Technion). For this purpose, graduates were counted only once,

[5] Since the number of respondents to the different questions in the questionnaire is not identical, in presenting the results of the data analysis of the different issues, the number of responses on which the analysis was based will be noted for each issue. In any case, answers to most of the questions were received from at least 95% of the respondents.

according to the highest degree achieved and their distribution by faculty/department from which they graduated.

The distribution by gender shows that men are over-represented in the sample data in comparison with the total distribution of Technion graduates (Table 1). While among the Technion graduates about three-quarters were men and a quarter women, the percentage of men among the respondents to the questionnaire is higher and stands at about 83%.

Table 1: Sample Representativeness by Gender

Gender	Technion Alumni Database	Sample
Men	75.8%	83.3%
Women	24.2%	16.7%
Total	100.0%	100.0%
N	66,813	3,851

Table 2 presents the distribution of Technion graduates by the highest degree studied at the Technion.[6] The percentage of respondents with advanced degrees (obtained from the Technion) is twice as high as the corresponding percentage among the survey population, with the bias being mainly among those with MA degree. That is, those with advanced degrees are over-represented in the sample.[7]

Table 2: Sample Representativeness by the Graduates' Type of Degree

Type of Degree	Graduate Population	Sample
B.Sc.	83.7%	66.7%
M.A.	10.2%	24.2%
Ph.D.*	6.1%	9.1%
Total	100.0%	100.0%
N	66,744	3,851

* Including 1,838 M.D. graduates that constitute 2.8% of the total graduates

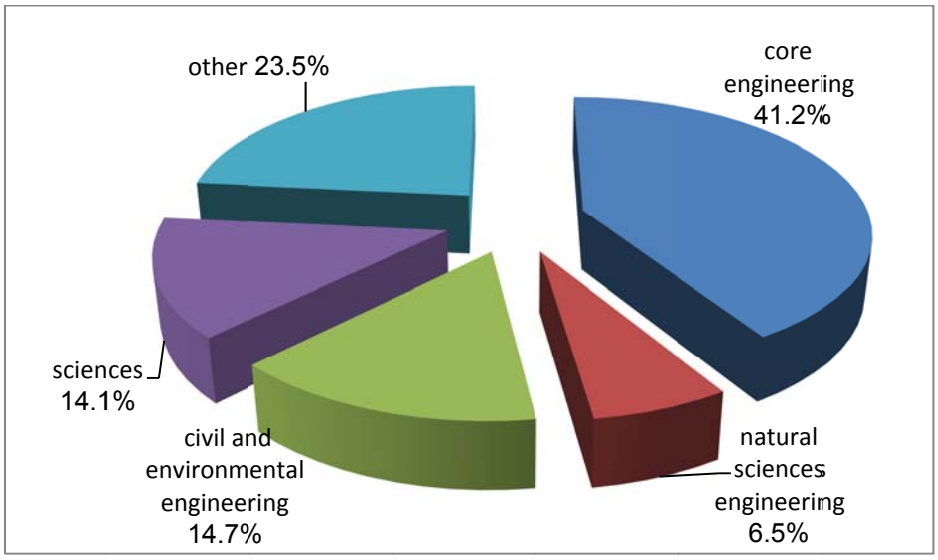
[6] The graduates were counted only once, according to the highest degree studied at the Technion.

[7] Obviously, some of the Technion graduates who filled the questionnaire continued their studies to higher degrees in other institutions. Since this information does not exist for all Technion graduates, it was not included in the data presented in Table 2, and will be presented later in this chapter, when the graduate characteristics according to the sample will be discussed.

To study the distribution of Technion graduates by the faculty in which they completed their studies, we grouped the faculties into five groups, as shown in Figure 3.

The largest group (41%) graduated from the engineering faculties, producing the skilled technical personnel for the high technology industries (which we called core engineering). These include the following faculties: Aerospace Engineering, Mechanical Engineering, Electrical Engineering, Computer Science, Biomedical Engineering, and the Iinter-unit Program for Systems Engineering.

Figure 3: Distribution of Technion Graduates by the Faculty from which They Gradated



N =66,694

The second engineering group, with only 7% of the graduates, consists of the engineering faculties related to natural sciences, which are Chemical Engineering, Biotechnological and Food Engineering, Materials Engineering and the Inter-unit Program for Polymer Engineering.

The third group of engineering faculties, in which about 15% of the Technion graduates completed their studies, consists of Agricultural Engineering, Civil Engineering, Geodetic Engineering and Structural Engineering. Over the years, these faculties, which were once separate, were merged under one roof at the Faculty of Civil and Environmental Engineering.

The fourth group consists of the scientific faculties, from which about 14% of the Technion students have graduated. These faculties include Mathematics, Physics, Chemistry, Biology, and Medicine.

Finally, the fifth group (other) consists of the faculties of Architecture and Town Planning, Education and Technology in Science and Industrial Engineering and Management, including Business Management Programs, Economics, etc.

The distribution of the sample population according to the grouping into Technion faculties where the graduates completed their advanced degree is similar to that of the general survey population, as presented in Table 3 below. Nonetheless, upward bias exists among graduates in the sample who graduated from the faculty group comprising core engineering and natural science engineering, while a downward bias is noticed among those who graduated from the civil and environmental engineering, and mainly from the science faculties in comparison with the total population.

Table 3: Sample Representativeness by Faculty Belonging

Faculty Group of Graduation	Graduate Population	Sample
Core Engineering	41.2%	57.3%
Natural Sciences Engineering	6.5%	8.1%
Civil and Environmental Engineering	14.7%	11.0%
Sciences	14.1%	8.2%
Other	23.5%	15.4%
Total	100.0%	100.0%
N	66,694	3,942

The distribution according to the time of degree completion shows a greater similarity between the distribution of the sample population and the graduate population, with a slightly higher representation in the sample for the 1980s and 1990s in comparison with a reverse situation in the '60s and '70s.

Table 4: Sample Representativeness by the Time of Degree Completion

Period of Graduation	Graduate Population	Sample
1940-1959	4.2%	3.5%
1960-1979	20.1%	29.3%
1980-1999	41.5%	35.9%
2000-2010	34.2%	31.4%
Total	100.0%	100.0%
N	67,067	3,830

In summary, the graduate sample that responded to the questionnaires is similar to the general population of Technion graduates mainly in the distribution by fields of study in which they were trained, and fairly well by year of graduation, while in the type of degree there is greater representativeness in the sample of graduates with advanced degrees than in the general population. Also, there is a higher representation of men.

2.3 Assessment Method

To assess the current contribution of Technion graduates to the economy, it was decided to consider graduates who are currently active in the job market and therefore contribute in different areas. For this purpose, we took into account the graduates who are currently of work age, i.e. up to the age of 67 years. Since the database of the graduates does not include the graduate's age, but only their year of graduation, we made a sweeping assumption that the average age for degree graduation is 26 years. Accordingly, the relevant cutting year for degree completion for the purpose of inclusion in the calculation of the estimates was set as 1968. In addition, it was necessary to take into account natural mortality over the years and therefore mortality rates were employed (CBS, 2010) on the resulting distribution of graduates by groups of years and ages. The end result indicated that the estimated amount of graduates who were at the time of the survey in the job market and whose influence on the economy today will be measured by this report is about 60 thousand graduates, constituting 87% of the total Technion graduates since its inception.

To assess the contribution of this human capital, we had to characterize the graduates by variables that will allow us to calculate approximate estimates indicating the extent of the graduates' integration in employment sectors, their income, the roles they fulfill in the

companies in which they work and their contribution as entrepreneurs. As stated, direct information about these characteristics was not found in the Technion's overall graduate database, but it was possible to learn about these properties from the answers given to the Alumni survey. These distributions served us in creating the sample's weights for the entire population, as will be described below. For maximal matching to the relevant population as mentioned above, we cut the distributions of the graduates' sample only for those who are in the parallel group of work age, i.e. up to the age of 67. These graduates constituted 85% of the total respondents to the Alumni survey.

The main difficulty we faced in applying the sample's distributions to the general population is associated with the sample's degree of representativeness. As discussed above, three key variables, which were expected to influence the estimates regarding the contribution of this human capital, were found to be biased.

The first bias was found in the distribution by the degrees that were acquired at the Technion. In the sample, the rate of graduates with second and third degree who acquired their degree from the Technion is higher than that of the overall database. The importance of this variable is related to the fact that some of the Technion graduates went on to higher studies in other institutions, a fact that has no expression in the graduates' overall database. In light of the expected relationship between degree and variables such as employment, income, job title, etc., it is necessary to evaluate the distribution of the advanced degrees acquired by Technion graduates over the years, less the bias between the sample and the total population (for degrees acquired at the Technion). To do this, we calculated in the sample the growth percentage in each of the advanced degrees among the degree holders who acquired their title at the Technion, and the total degree holders during the survey execution. Also, we took into account the rate of those with second and third degree who studied for higher degrees outside the Technion. These coefficients were employed on the distribution of the total graduates by type of degree acquired at the Technion in order to avoid the bias created in the sample.

Two other biases that influence the assessment of the graduates' integration in employment sectors, their income and the roles they fulfill, are related to the distribution by faculty/department belonging and gender. Higher rates were found among the survey

respondents in comparison with the actual distribution of the total Technion graduates, mainly in the aeronautics and space engineering and mechanical engineering faculties. On the other hand, lower rates were found among those who responded to the questionnaire in comparison with the actual distribution of the graduates from the faculty of medicine, Industrial engineering and management and architecture and town planning. With regard to gender distribution in the sample, the rate of men who answered the questionnaire was higher and stood at 86%, while according to the graduates' database, the rate of men who are Technion graduates is lower and stands at 75%. Accordingly, the slicing to the different relevant variables, derived from the sample, was applied on the graduates' actual distribution (in the overall database) by dividing the faculties and departments, and separately for men and women. The results are summarized together in order to obtain the approximated estimates while deducting the biases.

Another bias, which could be assumed to exist, is related to the natural tendency of the "more successful" to answer a questionnaire, in which they are asked about their achievements. We were unable to deal with this type of bias except to mention it as a reservation of the estimates presented. However, it seems to us that it is possible to see the entire picture obtained, indicating the great contribution of the Technion to the creation of human capital in Israel, as will be described below.

3. The characteristics of the Technion Graduates

3.1 The Education of Technion Graduates

Analyzing the graduates' database shows that the rate of Technion graduates with advanced degrees that were acquired at the Technion is 17.2%. Some of the Technion graduates continued to acquire higher degrees during their career in other institutions of higher education in Israel and overseas. The total rate of those with postgraduate degrees is shown, for those who took *any or all* of first, second and third degrees at Technion, regardless of the university at which they did their graduate studies, and is estimated at approximately 27%, a finding indicating the high level of the human capital with which these graduates provide the economy (Table 5 and Figure 4).

Table 5: The Distribution of Technion Graduates by Degree*

Degree	Acquired at the Technion[1]		Total Degree Holders[2]	
	Total	%	Total	%
First degree	50,146	82.7	43,989	72.6
Second degree	6,515	10.7	11,160	18.4
Third degree	2,129	3.5	3,642	6.0
MD	1,836	3.0	1,836	3.0
Total	60,626	100.0	60,626	100.0

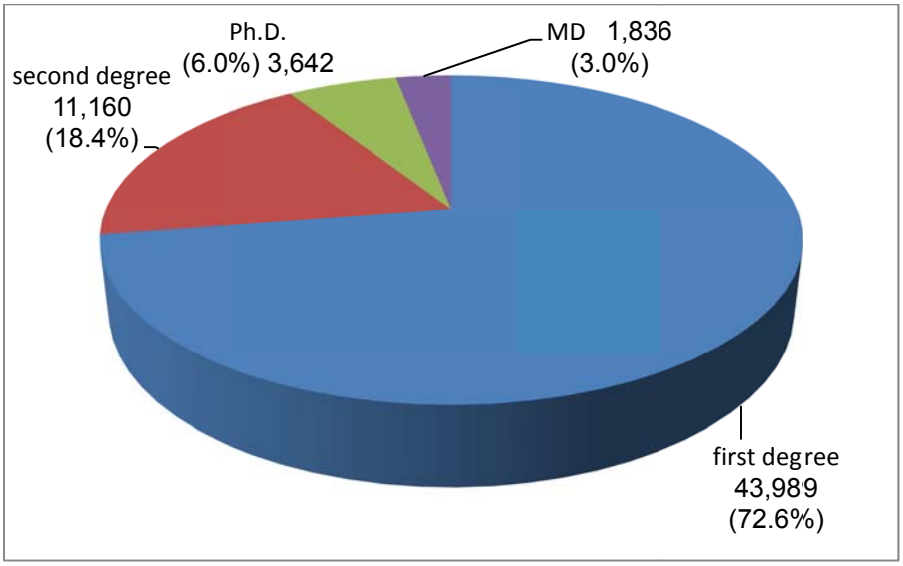
* In order to avoid redundancy, the distribution of graduates is done according to the highest degree attained.

[1] Calculation based on data supplied by the Technion data processing unit.

[2] This is an estimate of the overall distribution of Technion graduates, according to the highest degree attained, regardless of which university granted the graduate degree.

The tendency to study toward a third degree is more common in the science faculties (mostly medicine) and toward a second degree in the Faculty of Architecture, Industrial engineering and management, and other disciplines.

Figure 4: The Distribution of Technion Graduates by the Type of the Most Advanced Degree They Acquired



Slicing the sample data for those with second degree (N = 1197) indicates that only 60% studied for this degree at the Technion, 29% in another higher education institution in Israel and 11% in a higher education institution abroad. Among the graduates in the sample who have earned a doctorate degree (N = 618), the percentage of those who studied for their doctorate out of the Technion is similar to those who did so for their second degree, 41%, with most of them (28%) studied abroad. 10% of those who studied for their highest degree

(MA or PhD) at the Technion, achieved their Bachelor's degree in another educational institution in Israel or abroad.

3.2 The Income of Technion Graduates

To estimate the gross monthly salary of the Technion graduates, we used the graduate sample distribution by wage groups, sliced by gender and the faculty/department from which they acquired their advanced degree. It is assumed that these variables influence the wage level. Since, as stated, the sample distribution by faculties was biased in comparison with the distribution of the general graduates, the coefficients of the sample distribution for wage groups in each faculty/department and in division for men and women were firstly employed on the actual distribution of the total graduates according to faculty/department and separate between men and women, and only then summarized in groups according to the wage groups.

The results were used to obtain a wage assessment of the Technion graduates by wage groups as shown in Table 6. In addition, we estimated the total gross monthly salary of the Technion graduates by multiplying the number of graduates in each wage group, as obtained from the previous step, by the median wage of each wage group.

The income of the Technion graduates is significantly higher in comparison with comparative data regarding the general population; as a result of the strong relationship between the level of education and income level. This is supported by the fact that most of the graduates are employed in employment sectors with high salary levels. The median income group of Technion graduates is the salary group of 20,000-25,000 NIS gross per month. This wage level is considerably higher not only relative to the average wage, which stood in January 2010 at 8,120 NIS gross per month (according to the National Insurance data), but also in comparison with the average wage of employees with 16+ years of education, which stood in 2008 at 11,602 NIS (according to the CBS' manpower survey data).

Table 6: The Distribution of Technion Graduates by Wage Groups and their Total Gross Monthly Salary

Wage Group (gross monthly salary in NIS)	No. of Graduates	Percent	Accumulated Percent	Estimated total Gross Monthly Salary (in thousands of NIS)
5000-7499	3,687	6.2	6.2	23,043.3
7500-9999	4,077	6.9	13.1	35,669.6
10000-14999	7,625	12.9	26.0	95,317.2
15000-19999	10,323	17.5	43.5	180,655.5
20000-24999	8,799	14.9	58.4	197,978.1
25000-29999	6,978	11.8	70.2	191,894.4
30000-34999	5,795	9.8	80.0	188,332.2
35000-39999	3,280	5.5	85.6	122,994.1
40000-49999	3,605	6.1	91.7	162,238.8
50000 +	4,929	8.3	100.0	271,076.9
Total	59,098	100.0		1,469,200.3

The total monthly salary of all the graduates is estimated at 1.5 billion NIS, which are approximately 6.4% of the total monthly salary in the overall economy for 2009, which stood at 22.9 billion NIS (CBS, Statistical Yearbook, 2010), although these graduates account for less than 2.5% of the jobs in the economy.

Similar to the economy at large, the men's income among the Technion graduates is higher than that of the women. While a quarter of the men earn a gross monthly salary that exceeds 35 thousand NIS, only 7% of the women were found to earn an equivalent monthly income, while the gross monthly income of about two-thirds of the women is lower than 20 thousand NIS. These differences between men and women in the sample were found to be statistically significant ($\chi^2 = 315.8$; df = 9; $\alpha = 0.00$).

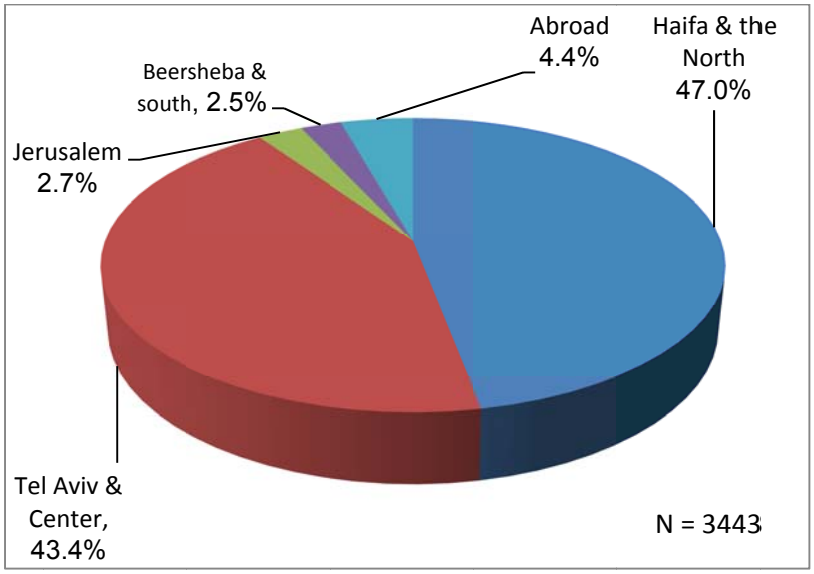
3.3 Place of Residence

The Alumni were asked in the survey about their place of residence. The findings, to the extent that they represent the Technion graduates,[8] indicate the great contribution made by the Technion to the development of Haifa and the Northern Region (Fig. 5). Nearly half of

[8] On the question regarding the place of residence there is no information in the general database of the Technion graduates, so that the representativeness of this issue could not be examined.

thegraduates, who answered the question, are living in Haifa and in Northern Israel and another 43% are living in Tel Aviv and the Center region.

Figure 5: Technion Graduates by Their Place Of Residence (%)



4. The Graduates' Integration in the Economy

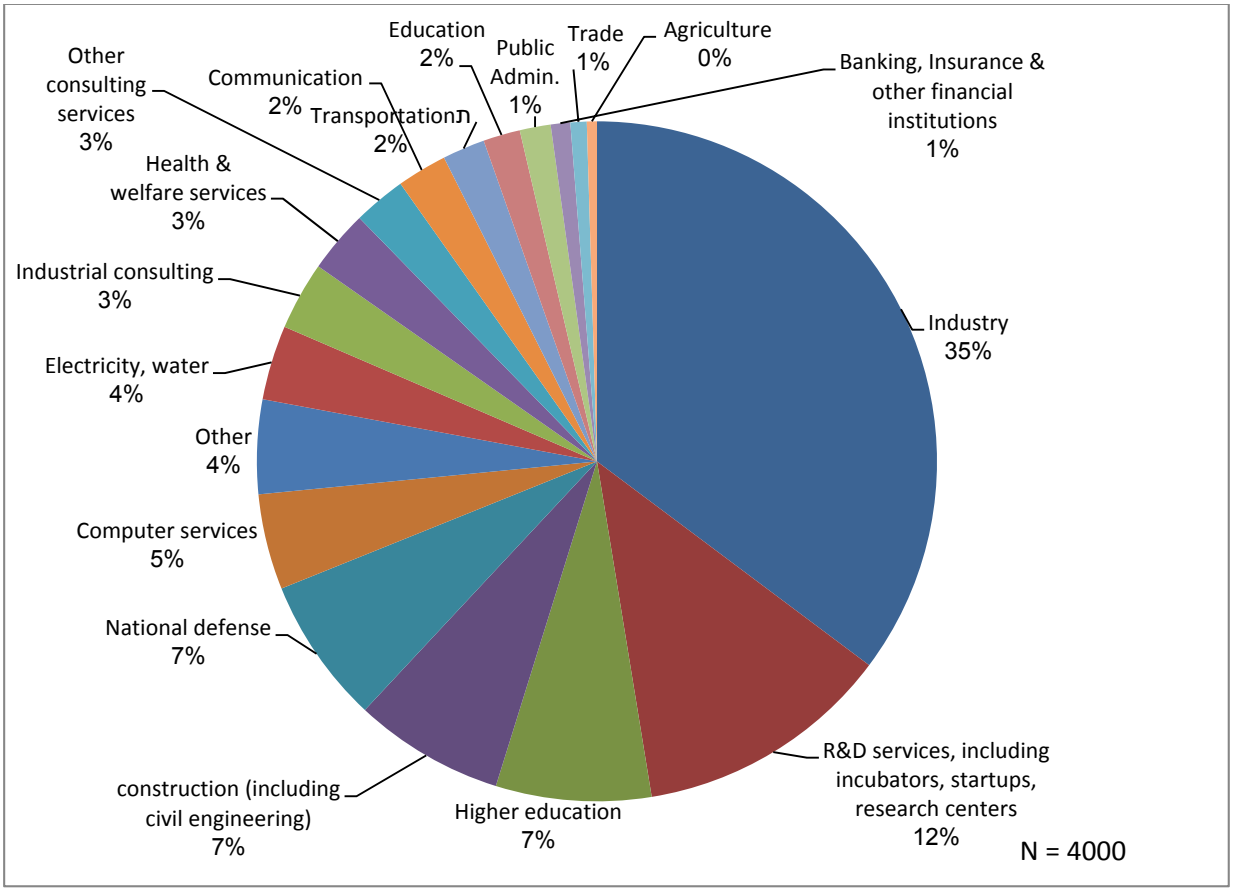
4.1 The Graduates' Employment Sectors

The distribution of Technion graduates, according to the sectors in which they are employed, shows, as expected, their prominence place in the industrial sectors, R&D services, computer services, academics and security, as can be seen from the sample data (Figure 6).

Estimating the distribution of Technion graduates by major sectors of employment was calculated on the basis of the distribution of the sample data (Figure 6). This distribution was employed according to faculty/department and gender belonging, in order to neutralize the bias found between the sample and the actual distribution of the graduates on these characteristics. The estimates obtained indicated, as expected, to the prominence of Technion graduates in the industry, R&D services, computer services, communications and universities, which employed approximately 58% of the graduates. In all these branches the percentage of graduates is significantly higher than the comparative percentage of those employed in the economy, as shown below. Moreover, if we take into account that the

graduates serve in senior positions in light of their skills, as will be presented in a separate chapter in this report, than their unique contribution is much higher in comparison with the national distribution of the employees.

Figure 6: Technion Graduates by Employment Sectors (%)



Referring to the division by faculty/department (Table 7), Technion graduates are all the more conspicuous, as could be expected, among the graduates from the core engineering group and from faculties and departments related to natural sciences, in which more than 75% of the graduates employed in these sectors have studied. The rate is lower among graduates from the science faculties and those in the "other" group (particularly graduates of industrial engineering and management), where less than 50% of graduates are employed in those branches. The department with the lowest rate of 26% is, as expected, among the graduates of civil and environmental engineering. Most of the employees in these branches are graduates from agricultural engineering.

About half the 34 thousand Technion graduates, who are working in above five employment branches, are employed in the industry branch and more than a fifth are employed in R&D

services. This rate is marked especially in the first two groups of the engineering faculties and departments that are defined as core and in those related to natural sciences, with over 80% of the graduates from these two departments/faculties are employed in the two employment sectors (Table 7). In the communication industry, graduates of the core engineering faculties and industrial engineering and management are more prominent and in the universities, the rate of graduates from the science faculties is prominent, reaching a third of graduates employed in these five branches of employment.

Table 7: Technion Graduates by Belonging to Selected Employment Sectors and the Faculty Group from which They Graduated

Employment sector		Core Engineering[1]	Natural Science Engineering[2]	Civil and Environ. Engineering	Science[3]	Other[4]	Total
Industry	Total	10,290	2,068	978	1,381	2,716	17,433
	Percent	54.7	72.6	48.5	33.2	42.5	50.9
R&D Services	Total	4,809	360	328	1,073	968	7,538
	Percent	25.5	12.7	16.3	25.8	15.2	22.0
Computer Services	Total	1,527	20	250	252	1,396	3,444
	Percent	8.1	0.7	12.4	6.0	21.9	10.1
Communications	Total	955	26	75	110	295	1,461
	Percent	5.1	0.9	3.7	2.6	4.6	4.3
Universities	Total	1,244	374	386	1,349	1,012	4,366
	Percent	6.6	13.1	19.1	32.4	15.8	12.8
Total	Total	18,825	2,848	2,018	4,164	6,387	34,242
	Percent	100.0	100.0	100.0	100.0	100.0	100.0
Percent of Total Graduates		77.9	75.9	25.8	47.3	44.0	57.9

[1] Faculty of Aerospace Engineering, Faculty of Mechanical Engineering, Faculty of Electrical Engineering, Computer Science, Faculty of Biomedical Engineering, and the inter-unit Program for Systems Engineering

[2] Faculty of Chemical Engineering, Faculty of Biotechnological and Food Engineering, Materials Engineering and the Inter-unit Program for Polymer Engineering.

[3] Faculty of Mathematics, Faculty of Physics, Faculty of Chemistry, Faculty of Biology and Faculty of Medicine.

[4] Faculty of Architecture and Town Planning, Education and Technology in Science and faculty of Industrial Engineering and Management, including Business Management Programs, Economics, etc.

Table 8 shows the graduates' distribution in these branches of employment in relation to the distribution of jobs in the entire economy. These five branches of employment employed in 2009 nearly 600 thousand employees in Israel (CBS, Statistical Yearbook for Israel 2010), which are about a fifth of all the workers employed in Israel in that year (2.78 million). Of all the workers in these branches, the Technion graduates constitute about 6%,

however among the Technion graduates the rate of graduates employed in these branches is almost three times higher than their rate in the general economy, reaching approximately 58%.

Table 8: The Weight of Technion Graduates in Selected Branches of Employment

Branch of Employment	Technion Graduates	Percent of Total Graduates	Total Employees 2009	Percent of Total Employees	Percent of Technion Graduates of the Total Employees in That Branch
Industry	17,433	29.5	407,700	14.6	4.3
R&D Services	7,538	12.8	26,380	0.9	28.6
Computer Services	3,444	5.8	83,080	3.0	4.1
Communications	1,461	2.5	45,930	1.6	3.2
Universities	4,366	7.4	29,200	1.0	15.0
Total	34,242	57.9	592,290	21.3	5.8

The most dominant branch out of these five branches of employment is, as noted, the industry sector. In this sector, in which the percentage of workers employed stands at 14.6%, the Technion graduates constitute 4.3% of all the workers employed in the sector and about 30% of the total Technion graduates. However, it should be noted that the industry branch is highly heterogeneous in terms of personnel level, and in it the Technion graduates constitute the thinner layer of skilled personnel. This can be seen from the significant weight of the Technion graduates in those branches in which the rate of high-quality personnel is high, such as the branch of R&D services and the universities. In the sector of R&D services, the weight of Technion graduates is approaching 30% Of the total workers employed in this sector, in comparison to less than one percent of the total employees working in this sector. Therefore, there is no doubt that the contribution of the Technion graduates to Israel's position as an international R&D lab is highly significant. The rate of Technion graduates who are employed in the universities is impressive and stands at 15% in comparison with one percent of the total employees in the economy. In the other two branches of employment, communications and computer services, the rate of Technion graduates is also prominent in comparison with their rate in the general economy.

The weight of Technion graduates in these employment sectors increases over the years. The sample data indicate that among the graduates who completed their studies in the past 20 years, 38.8% are employed in the industry and 15.8% in R&D services. These data highlight the contribution of Technion graduates to these branches, constituting the spearhead in the development of technological innovation.

It is common today to divide the industry sector, in the world and in Israel, which employs the largest group of graduates, into four categories according to the technological intensity of the branch, as follows:

High-technology Industries - high-tech industries (pharmaceuticals for human and veterinary use; office and accounting machinery and computers; electronic components; communications equipment; Industrial control and supervision and medical and scientific equipment and aircraft).

Medium-high Technology Industries - chemicals and chemical products (excluding pharmaceuticals), petroleum refining and petroleum products and nuclear fuel; machinery and equipment; electric motors and equipment for electric distribution and transport (excluding aircraft).

Medium-low Technology Industries - mining and quarrying; plastic and rubber products, mineral non-metal products, precious and non-ferrous metals; iron and steel products and metal products.

Low Technology Industries - food products; alcoholic and soft beverages and tobacco; textiles, clothing and shoes; leather and leather products; paper and printing paper products and wood products and furniture.

The great contribution of the Technion graduates to economic growth stems from their relative high weight among the employees in the high-tech industries. The importance of this group of industries is great, since although they contain only about a quarter of the jobs in the industry sector and 3.2% of the jobs in the economy as a whole, these industries contribute to 51% of the industrial export and 39.5% of the gross added value of the industry (CBS, Israel Statistic Yearbook 2010).

The contribution of the Technion to the manpower in this group is significant. From the total Technion graduates employed in industry 75% were employed in high-tech industries, or about 13 thousand employees (Table 9). In these industries, which constitute about 27% of the total jobs in the industry[9], the Technion graduates constitute about 14%. That is, the rate among Technion graduates who are employed in high-technology industries is 2.8 times the rate of the total employees working in the high-technology industry (Figure 7).

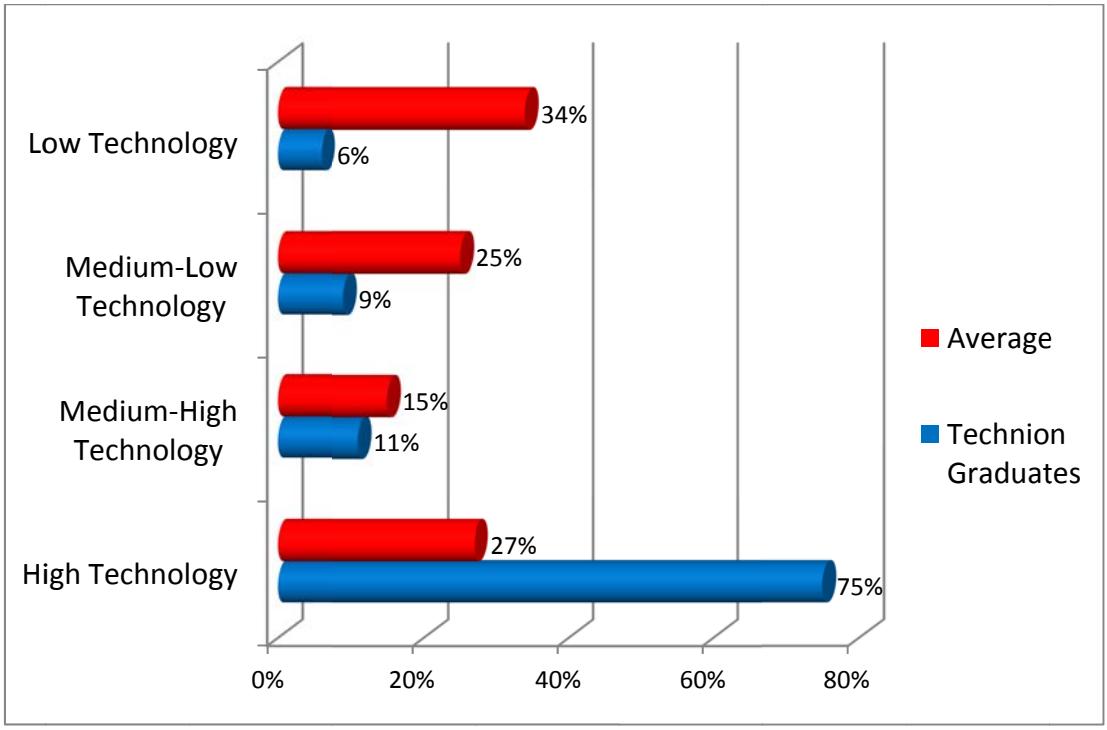
These findings are important because the branches of high technology serve as the "locomotive" of the Israeli economy. An international comparison indicates that Israel is in the first place among the Western countries in the percent of employees in the high-tech industries that stood in 2007 at 26.3% of those employed in the industry (in the second place is Ireland with 19%) and 6.7% employees in the high-tech services sector, or in total, 9.3% of all those employed in Israel. There is no doubt therefore that the contribution of Technion graduates to the forefront of technological employment is significant, with 75% of the graduates who are employed in manufacturing industries belong to the high-tech industries, 2.8 times the average rate of the entire economy (CBS, 2010)

Table 9: The Weight of Technion Graduates in Industry Sectors by Technological Intensity

Branch of Employment	Technion Graduates	Percent of Total Graduates	Total Jobs In the Economy	Percent of Total Jobs	Percent of Technion Graduates of the Total Jobs in the Industry
High-tech	13,071	75.0	92,424	26.8	14.1
Medium-high Technology	1,915	11.0	51,510	14.9	3.7
Medium-Low Technology	1,478	8.5	85,465	24.8	1.7
Low Technology	971	5.6	115,829	33.6	0.8
Total Industry	17,434	100.0	345,228	100.0	5.1

[9] The CBS's data regarding the distribution in industries by technological intensity is stated in the number of jobs, not the number of employees. Therefore, on this item, calculating the rate of employees is based on the total jobs. In total, in the industry, the ratio between the number of employees and jobs is 1.2.

Figure 7: A Comparison of the Distribution of Technion Graduates and the Average in the Economy who are Employed in Industrial Sectors by Technological Intensity (%)

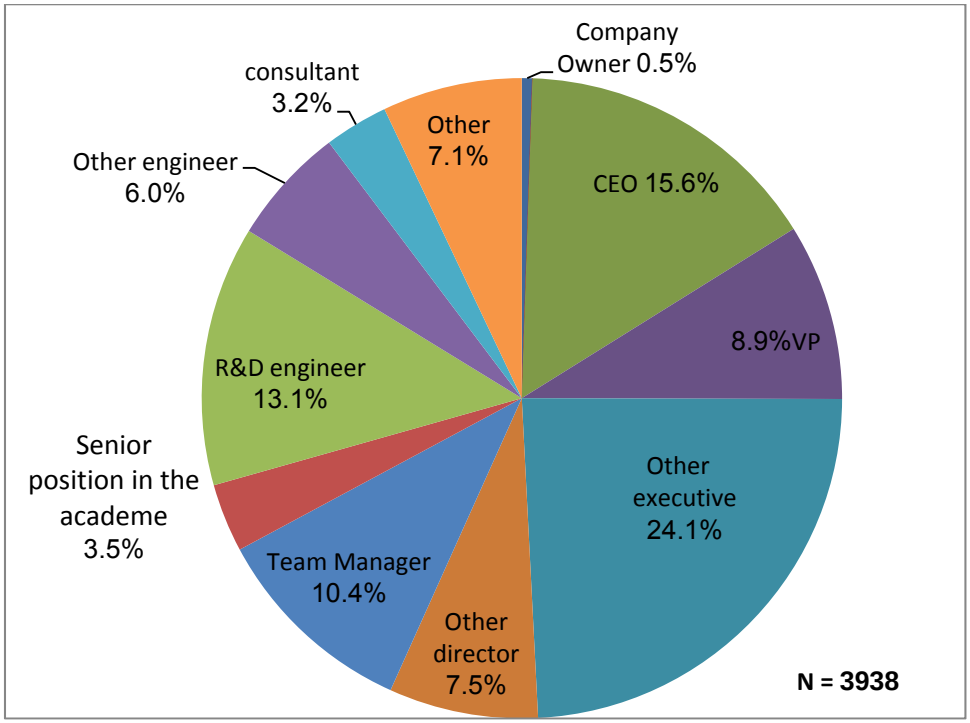


4.2 Technion Graduates Fulfilling Senior Positions in the Economy

The sample data provided us with information about the alumni, who responded to the questionnaire, about the type of role that they fulfill or fulfilled in the past in the companies in which they have worked/are working. This information is very important since it points to the importance of Technion graduates in the occupational array of the Israeli economy. The findings testify that most of the graduates fulfilled various management roles (Figure 8).

To extract the estimates on the rate of graduates in the various types of roles, we divided the major roles according to the faculty/department from which they graduated and by gender and employed the rates on the actual distribution of graduates by gender and faculty, as derived from the general database. This correction of bias in the sample was based on the fact that significant statistical differences were found in slicing the sample of role holders by the faculties from which they graduated. Figure 9 shows the approximate estimate of Technion graduates by the senior role they fulfill in the economy.

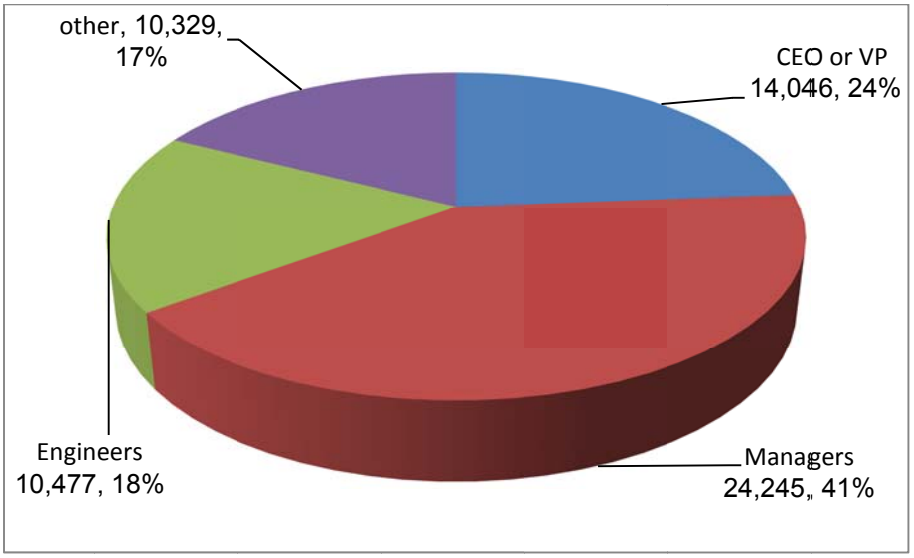
Figure 8: Distribution of Technion Graduates by the Type of Top Job They Fulfilled or Currently Fulfill (%)



Legend:

- **CEO** - CEO, general manager of government services, a company director and general manager in the business sector.
- **VP** - VP/production manager, VP/director of research and development, VP/director of computing services, deputy head of division/department, a senior partner in a company.
- **Other executive** - director of financial services and taxation, finance manager and control, department head, director of research and development, director of laboratory, plant manager, director of community services and medical director of an educational institution, deputy managing director/director of an educational institution, deputy director, deputy department head, chief/division manager, section chief.
- **Other director** - quality assurance manager, supply manager, office manager, development manager, project manager, marketing manager.
- **Team Manager** - development team leader, team manager.
- **Other Engineer** - quality assurance engineer, company engineer, production engineer, systems engineer, city engineer, project engineer, chief engineer, software engineer.
- **Other** - an architect, a position at an educational institution, an economist, a programmer, a job in academe, a student, a senior IDF officer, a minister, doctor, etc.

Figure 9: The Distribution of Technion Graduates by the Senior Role They Fulfill in the Economy



As can be seen, Technion graduates occupy senior positions in the economy and most of them are fulfilling a variety of management roles. A quarter of them are acting as CEOs and vice presidents, 41% fulfill other management positions, and only 18% work in engineering positions. Analyzing the sample data shows that the role is related to the employee's seniority and that most of the graduates who start their career as an engineer move over the years into management positions. This is supported by the age distribution of the different role holders. The average age of the CEOs and vice presidents group is 59 years, while the average age of the other directors is 53 years, and the engineers are 42 years old (these differences were statistically significant on a variance test one way ANOVA, at 99.9%).

The senior positions fulfilled by Technion graduates reward them with high-level wages. As indicated by the analysis of the sample data, when we examined the median wage level (by wage group) between the various functionaries, according to their division into four major categories, statistically significant differences emerged: the group that includes company owners, CEOs and vice presidents is at the top with the median salary of this salary group being 30,000-35,000 NIS gross per month; below them is the managers group with a median salary of 20,000-25,000 NIS gross per month, and in third place are the engineers and other professionals with a median of 15,000-20,000 NIS gross per month. The differences

between the groups of functionaries and the wage groups were statistically significant (χ^2 = 868.6; df = 27, α = 0.000).

A significant difference in fulfilling senior positions was found between the men and women graduates of the Technion as seen from Table 10. While 27% of the male Technion graduates serve as CEO's and VP's of the companies in which they work, only 13% of women graduates serve in these senior positions (half than the men). However, in the role of 'managers', the rate of men and women fulfilling this position is identical.

Table 10: The Distribution of Technion Graduates by the Senior Position They Fulfill in the Economy and by Gender

Senior Position	Technion Graduates		Men		Women	
	Total	Percent	Total	Percent	Total	Percent
CEOs and VPs	14,046	23.8	12,143	27.4	1,903	12.9
Managers	24,245	41.0	18,148	41.0	6,097	41.2
Engineers	10,477	17.7	8,111	18.3	2,366	16.0
Other	10,329	17.5	5,908	13.3	4,421	29.9
Total	59,098	100.0	44,310	100.0	14,788	100.0

4.3 The Graduates' Contribution to Technological Entrepreneurships and Innovativeness in the Economy

Entrepreneurship plays a key role in advancing the economy. In the Alumni survey, we tried to estimate the scope of entrepreneurship. The data received enabled us to examine the rate of graduates that established new companies as an indication of the existence of entrepreneurship. Employing the rates received by slicing according to faculties/ departments and gender on the distribution of the total graduates who are now in working age, shows that approximately 23% or 13.5 thousand graduates were among those who established and founded new companies in the economy. The rate was higher, as expected, among men than among women, although also among the women it was found that about 15% of them established a new company during their career.

A significant expression of Israeli entrepreneurship is reflected in the establishment of startup companies in technology, making a significant contribution to the growth of the

Israeli economy. Israel is known as a country with the highest rate of startup companies in international comparisons, relative to its size. This fact puts it at the forefront of technological knowledge in the world and contributes greatly to the development of technological innovation. Exports of services from startup companies in Israel in 2010 stood at 2.2 billion NIS (CBS, National Accounts.) The percent of jobs in startup companies, computerization and R&D of all jobs in the economy is around 6% (CBS, Statistical Abstract of Israel, 2010).

The sample data, in this context, allowed us to assess the involvement of Technion graduates in Israeli startup companies. Employing the coefficients on the total graduate population, currently in working age, revealed that 10,882 of the graduates (18.4%) work or have worked in startup companies, of whom 83% were men and 17% were women, three times the rate of the entire economy. Of them, about 2,600 (24%) served as CEOs, approximately 1,600 (15%) as VPs and about 1,450 (about 13%) as R&D managers.

The existence of technological innovation is directly related to the development of new products or improving existing processes. While innovation of processes is intended to reduce production costs, the innovation of product development and improvement is aimed at increasing the sales market. Moreover, technological innovation associated with the development of new products and its support by the government leads to the economy's rapid growth in the long run. To examine the contribution of the Technion through its graduates to this issue, we asked the respondents to specify their involvement in the development and improvement of new products, new processes, and developing new business models. The data indicate great involvement of Technion graduates in the development of technological innovation, especially the innovation of new products. Using the distributions obtained in the graduate sample in this context, while neutralizing the biases of faculty and gender distributions, we were able to estimate the scope of the graduates who were involved in these processes. The results indicate that of the total graduates, about half of them, 29,800 graduates, were involved in some innovative development, mainly in developing new products and/or new processes.

Another measure used in various studies as an indication of the existence and level of technological innovation in a country is the number of patents registered in the country

during a year. In this context, recent data on international patent registration indicate that Israel is ranked 13th in terms of the number of international patent applications and in the fourth place relative to its size.[10]

In this context, too, the contribution of the Technion through its graduates is significant. The survey findings show that 24% of the Technion graduates in the sample filed a patent application and/or registered a patent. The distribution of the presenters and patent registers by faculty group points, as expected, to a relation mainly to the faculties which belong to the core engineering group. Of them, it should be noted that most patent applications and patent registrations are made by graduates from the Faculty of Electrical Engineering and Mechanical Engineering.

The number of applications filed by Technion graduates was 3,775. This figure was calculated from the responses received from only 71% of those who indicated that they filed a patent application. Accordingly, the average patent applications per graduate of those who submitted requests stand at 5.5 requests, and the median at two applications. The number of patents registered by Technion graduates in the sample is 2,607, or an average of 4.9 patents per graduate who registered a patent.

5. Estimating the Value of the Human Capital Produced by the Technion and the Return on Investment to the Economy

A very wide range of careful studies by economists have shown beyond reasonable doubt that the social rate of return (return to society as a whole), and indeed the private rate of return (the return to the owner of the human capital alone) are both in high double digits, in every country where such studies have been carried out.

And history itself has verified the result. Influenced by Karl Marx, who wrote that countries grow wealthy by amassing physical and financial capital, the Soviet Union built enormous capital-intensive industries and factories larger than those in the West. However the result was economic failure. In the West, influenced by the research of Nobel Laureates Theodore Schultz (U. of Chicago), Gary Becker (U. of Chicago) and Robert Solow (M.I.T.), it is widely recognized that the path to economic growth and wealth lies through human, not physical,

[10] In: The Justice Department site – Patent Department. URL: http://www.justice.gov.il/MOJHeb/RashamHapatentim

capital – the skills, energy, knowledge and motivation of creative people, working in a system that enables them the freedom to innovate and implement their innovations.

Israel, the Start-Up Nation, is also rightly regarded as a Human Capital Nation. According to an S. Neaman Institute study, among the 34 OECD (Organization for Economic Cooperation and Development) nations, some 44 per cent of Israel's working-age population has secondary or more schooling (in 2007), one of the highest rates in the OECD. About half of Israeli 12th-graders qualify for high school matriculation and 44 per cent pass university entrance requirements (Getz et al., 2007).

In 2008/9, some 8,700 students completed undergraduate degrees in science and engineering; more than half of them studied engineering and architecture, about a fifth studied math, statistics and computer science; 15 per cent, biological sciences, and 7 per cent, in physical sciences (CBS, 2010). At the same time, the senior teaching and research staff in all the higher education institutions included in these years 4,722 members,[11] in comparison with 5,137 in 1999/0, i.e., a decrease of 8% during the last decade (CBS, 2010). Faculty members are aging. Some 46 percent of senior university academic staff is 55 or older, far higher than the proportion 55 and older in other developed nations (Planning and Budgeting Committee Report in: Getz et al., 2007).

Much of Israel's human capital is employed in innovation. In 2008 Some 54,620 posts exist in R&D in the business sector in Israel, which were 12.2% of the total employees in this sector, a significantly higher rate than the median in developed countries which stood in this year at 4% only (CBS, 2011, publication no.1425). Israel, therefore, directly makes a living from its human capital (For a brief discussion of what human capital is, see the Box below).

[11] Based on the equivalent of a monthly average of full-time jobs.

Human Capital: Karl Marx Vs. Theodore Schultz

Why are some nations wealthy while others are poor? This issue has preoccupied economists and political leaders for centuries. One answer was supplied by Karl Marx. Countries grow wealthy, he wrote, because they save and accumulate vast amounts of physical capital (machinery, factories, etc.), which drives industry. Another, competing answer was supplied by Professors Theodore Schultz, Prof. Jacob Mincer and Prof. Gary Becker. Countries grow wealthy, they argued, mainly because they build human capital -- the stock of competences, knowledge and skills that together create the ability to generate economic value. Both physical and human capital generate a stream of future benefits (income, or output) that can be summed and valued. Hence the rate of return on investment in both physical and human capital can be calculated, measured as the ratio between the value of human capital and the value of the resources invested to create it. A variety of studies show that the return on investment in human capital is significantly larger than the return to investment in physical capital (Becker, 1964, 1993).

In this context, it would be appropriate to quote one of the experts on measuring the output of human capital, Jack Phillips, who claimed that (*http://www.trainingreference.co.uk/training_roi/roi9.htm*):

> Research has consistently supported the fact that human capital is an undervalued investment opportunity. Past research illustrates that physical and financial capital investment returns are substantially smaller than the value of intangibles like human capital. Phillips states: *"one may see ROI in excess of 800% and the Tennessee Valley Authority … typically sees average ROI percentages around 1000%. An ROI analysis done by a world-class corporate university was 5,612%!"*.

There is a paradox, rather bitter for many who grasp the key role played by Israel's human capital, that as the importance of Israel's universities in supplying new and excellent human capital grows, their government funding has been slashed. Following the 2001/2 economic crisis, in the wake of the dot.com bubble, austerity measures were implemented to reduce Israel's budget deficit, and university funding, including R&D, was cut. The budgetary data of the Ministry of Finance show that the budget for a student in the higher education system has been reduced in real terms during 1996-2008 by 34.2% (Bar, 2011). These cuts lasted nearly a decade, and only recently have been reversed.

This myopic and self-destructive policy stands in sharp contrast to the following finding: "Increasing R&D per student in Israel's research universities [to the level in Sweden that found to be the leads among the OECD countries] will cost $ 375 m. a year, and will result in

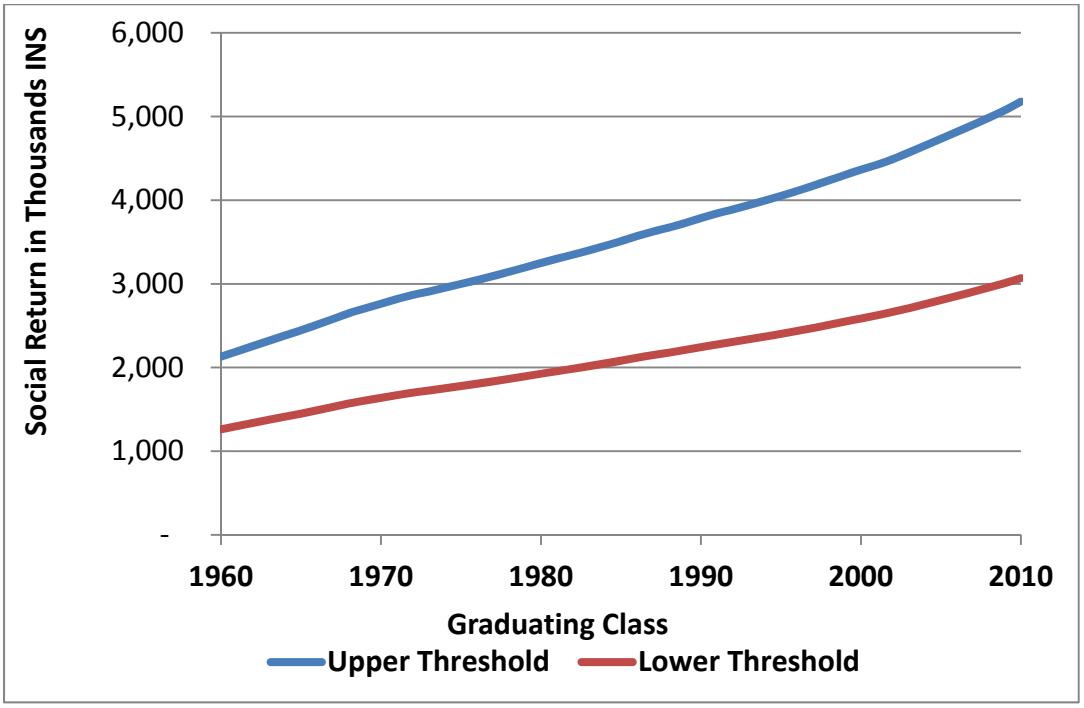
an increase of $ 600 m. a year in GDP" (Frenkel and Leck, 2006). The findings of Frenkel and Leck imply a 60 per cent risk-free rate of return on investment in university R&D in the OECD countries. No investment known to man can compete with this staggering rate of return. Why then has Israel, for a decade, reduced its proportional investment in this 60% ROI asset rather than increased it?

It is now widely accepted that the principal driver of wealth and economic growth is human capital, working, of course, in concert with physical capital, especially infrastructure. It is also clear that Israel's global competitiveness, a key element in the sustained success of its economy, is crucially dependent on this human capital. The latest World Competitiveness Yearbook (IMD, 2011) shows Israel ranks 17th in the world in competitiveness. A key reason for this high ranking is Israel's "scientific infrastructure", which ranks fourth in the world!, and Israel's technological infrastructure, which ranks fifth.

The experts who evaluated Israel's competitiveness were asked to list the key factors that made Israel's economy "attractive". In order of importance, the top four (of 15) were: *high educational level; dynamism of the economy; strong R&D network; and skilled workforce*. The remaining factors were ranked, by the experts, as far less important. It is noteworthy that all four of these top 'attractiveness' factors are directly related to the quality and quantity of human capital. This is why it is so important to try to estimate and quantify the value of the human capital generated by Technion, and given that, to estimate the rate of social return on the investment of resources in Technion, in order to create that human capital.

The results are shown in Table 2A (Appendix 2) and in Figure 10 below. We present the main findings in this chapter, and then outline the method used to calculate them in Appendix 2. We have limited the calculation to graduating classes beginning in 1960, because reliable wage and GDP data was not available for earlier years and because this period embraces 65,361 graduates, who comprise 97 per cent of all those who ever graduated from Technion.

Figure 10: The Annual Social Return Per Graduate in Thousands of NIS in 2005 Prices, by Graduation Cohorts, 1960-2010 (Lower And Upper Limit)



The main findings emerging from the calculation are as follows:

- **The calculation we conducted (see Appendix 2 in this report) shows that Investment in creating human capital at the Technion generates an annual social rate of return of between 97 and 197 per cent, at least, or in absolute terms, between $35 b. and $60 b. during some 50 years of graduating classes. The annual social return of human capital created by the graduating class of 2010 is estimated in the range of 1.759-2.968 billion dollars, the summed net present value of the additional output created by Technion-originating human capital, that will accrue over the working lifetimes of the 2,500 Class of 2010.**

- **Technion's operating budget is NIS 1.1 billion. Of that, it is estimated by senior Technion management that about NIS 900 million goes toward undergraduate education. In dollars, this amounts to $265 million. Suppose that this sum is invested each year, in the 2,500 undergraduates, for four years, amounting to a total investment of about one billion dollars.**

- **What was the social output this investment generated, in terms of the discounted 'cash flow' of added GDP these grads produced, relative to what they would have produced had they not gained a Technion degree? The answer, given in Table 2A in Appendix 2 , and approximated, as mentioned above, in the range of 1.759-2.968 billion dollars worth of human capital, generated by**

resources worth 1.0 billion dollars, or 76%-197% (1.76/1.0-1x100; 2.97/1.0-1x100).

- **This figure is generated by assumptions that provide the lowest of the lower bounds for human capital and ROI. It does not include the added productivity of Technion engineering graduates, relative to general undergraduate degree holders, nor does it include Technion's human capital value created by startups, entrepreneurship, innovation, and initial public offerings of stock. The true figure could be as much as double the 76-197 per cent rate of return.**

- **It should be noted that this is not a highly risky investment, but a risk-free one – because while the earnings potential of a single graduate may be uncertain, the earnings potential of 2,500, by the law of large numbers, is not uncertain, because the variance of their added GDP is very small.**

In summary let this be clear. No financial investment, other than a rare strike-it-rich stroke of good fortune, such as buying Microsoft stock the year it went public, can come close to the rates of return that human capital investment generates, and specifically, investment in Technion-generated human capital. Israel's Ministry of Finance applies very rigid criteria to the various ministries' requests for funding, and its experts, who generally have Master's degrees in Economics, carefully evaluate investment projects to ensure they are financially worthwhile. It is difficult to understand, then, why Israel's seven universities have for years been seriously underfunded, why their Faculties have been allowed to age, why the looming shortage of engineers has been allowed to happen, and why the colleges have been favored at the expense of the universities, treated as cost centers that place a burden on the public fiscal, rather than profit centers whose human capital accounts for most of the growth and progress, and wealth, Israel's economy has amassed for the past 63 years.

6. Estimating the Overall Economic Contribution of Technion Graduates

In the final part of our report, we provide cautious estimates that provide some partial indication of the extent of the economic contribution generated by Technion graduates to the Israeli economy. These economic estimates are based on estimates widely accepted, regarding the economic contribution stemming from high-tech engineers. We do not aspire or claim to estimate, in a rigorous, scientific manner, the overall economic contribution, because such an estimate, for some 67,000 Technion graduates over the years, would be

exceedingly difficult to construct. Indirectly, we presented, in the previous chapter, the value of graduates' economic contribution by computing the very high social rate of return generated by the investment in their human capital.

Here our objective is to present initial and cautious estimates that provide some indication, in general terms, of the extent of the contribution from graduates' human capital, to the economy. For this, we made use of some estimates and calculations provided by Yehuda Zisapel, founder of the RAD group and Chair of the Israel Electronics and Software Industries Association, with regard to the estimated contribution of an engineer employed in Israel's high-tech industries.12 It is worth noting that a high proportion of engineers employed in Israel's high-tech industries are Technion graduates.

Zisapel estimates, therefore, that the contribution of an engineer to high-tech industry, to the economy, is shown by the following:

Employment: "Each engineer in high-tech generates employment for six other workers, who support high-tech in some fashion, who are not engineers, and who earn on average wages of NIS 15,000 monthly", almost double that of the economy average wage.

Value added and output: "Every engineer in high-tech produces output (value added) of one million dollars". This estimate seems, on the face of it, very high. However, we note that a relatively small number of engineers in Israel's high-tech industries generated, in 2010, total exports of $20 b. (source: Israel Central Bureau of Statistics, 2011), and in addition, some $12 b. of additional exports for medium-high tech industries – in other words, a total of $32 b. in exports.

Tax Revenues: The tax revenues generated by engineers are often ignored, in computing the value of human capital investment. However, these revenues are substantial. Zisapel's research shows that the average monthly salary of an electrical engineer in the industry is NIS 23,000. Additional employment created by the activities of this engineer, within the same firm (administrative and technical staff), create an additional monthly NIS 30,000 in salaries. Additional employment generated by the engineer, outside his or her company, add an additional monthly NIS 45,000 in salaries.

[12] Cited in Guy Grimland, "Investing in high-tech is more profitable for Israel than investing in oil and gas", The Marker, 5 December 2012.

Hence, the total annual taxes and social insurance payments generated by employing an additional electrical engineer are: a) directly, NIS 110,000, assuming a 40 per cent tax rate on the engineer's salary, b) indirectly, NIS 108,000, from revenues on within-firm additional employment, assuming a 30 percent tax rate, and c) indirectly, NIS 163,000, from outside-the-firm additional employment, assuming a 30 per cent tax rate.

The grand total is: NIS 381,000 annually per engineer. This is an underestimate, because it does not include, for example, capital gains taxes on 'exits' (sale of startup firms creating large capital gains that are subject to tax), and corporate taxes paid on the profits generated by the engineer. When annual corporate taxes of some NIS 72,000 per engineer, and annual capital gains taxes of approximately NIS 150,000 are added, the grand total of additional revenues pouring into the public coffers, per additional engineer, exceeds NIS 600,000. [Zisapel assumes, based on careful research, that six of every 1,000 electrical engineers will establish startup companies that perform either an initial public offering of shares, which creates capital gains, or an 'exit', which also generates capital gains].

In order to estimate the general contribution of Technion graduates to the Israeli economy, we used the estimates above, and applied them to the affiliation of the 60,000 graduates according to the various industries employing them, as shown in the previous chapters.

The main findings emerging from the calculation are as follows:

- **Technion engineers employed in high-tech produce overall annual output of some 13 b. dollars. If we add to that Technion graduates employed in computer services, communications and R&D, and assuming their output is 2/3 that of a high-tech engineer, 13 the annual output of these Technion graduates reaches an additional 8 b. dollars. In other words, the overall annual direct economic contribution of Technion engineering graduates, to these industrial branches, amounts to 21 b. dollars, or about 20 per cent of the total annual output of these industries (including computer services, communications and R&D).**

[13] This is the overall ratio of output, for these two industries, per employed person.

- **With regard to the employment of Technion graduates working in high-tech, the employment 'multiplier' indicates they generate some 78,000 jobs, which pay wages that are substantially higher than the economy-wide average.**

- **The annual contribution of Technion graduates to public tax revenues is estimated at NIS 15.2 b., or 12 per cent of the overall total tax revenues from direct and indirect taxes.**

All these estimates are based on Technion graduates employed in high-tech and in supporting services, comprising 43 per cent of all the Technion graduates. This means that the total economic contribution of all Technion graduates, not just those working in or linked to high-tech, is far greater.

Summary

This report presented the Technion's contribution to the economy through its graduates. Since its establishment, about 67,000 people have graduated from this institution and were integrated into the life of the economy and society in Israel. To estimate the quantity and quality of Technion graduates who were integrated in the economy and their contribution to the human capital in the state, we used the data collected as part of the graduate survey that was conducted in the months August to December 2010. As part of the survey, an online questionnaire was distributed among the graduates, to which 4,055 responded.

Applying the distributions of the sample of Technion graduates to all the Technion graduates was made through a method that allowed us to neutralize the biases found between the sample and the distribution of the total graduates in the databank of the Data Processing Department at the Technion, in the properties of faculty/department division, degree holders and gender. In the estimate made, we considered the graduate population that is currently in working age, in order to assess their current influence on the labor market.

The assessment results indicate the graduates' high-level, with approximately 27% of them holding advanced degrees, some of which were acquired at the Technion and others in other institutions of higher education in Israel and overseas. The integration of the Technion graduates in the various economic branches is impressive, particularly in employment and jobs where the pay level is high. Estimates indicate that the median income of Technion graduates is in the wage group of 20-25 thousand NIS gross per month and is significantly higher in relation to the average wage in the economy (approximately 8 thousand NIS gross per month), but also in relation to the salary of wage-earners with higher education of 16+ years of study. One-fifth of Technion graduates (about 12,000 alumni) earn more than 35 thousand NIS per month gross.

Technion graduates are integrated in leading employment sectors in the economy. In the five branches of employment that include the industry, R&D services, computer services, communications and universities, the assessment of employees who are Technion graduates is of about 34 thousand employees, with the rate of Technion graduates employed in them is three times higher than the general rate in the economy. The rate of

Technion graduates is especially marked among the workers employed in high-tech industries, which is estimated by about 13 thousand graduates. These constitute 75% of the total Technion graduates and 14% of the total jobs in these branches.

About fourteen thousand graduates (24%) serve in the most senior managerial roles (CEOs and VPs) in the companies in which they work. The Technion graduates make also a unique contribution to the development of startups in the economy, a unique feature of the technological culture of Israel. More than 10 thousand graduates work or have worked in startups and 39% of them serve in senior management (CEO or Deputy Directors). Many graduates (about 30 thousand) were also involved in the innovative development of products and/or processes.

Israel is known worldwide as a country with the highest rate of startups that are a platform for creating technological innovative ideas on an international scale. Even in this context, Technion graduates make a very significant contribution. About 18% of the graduates are working or have worked in startups, three times the average rate in the economy, which also has no parallel in the entire developed world. Evidence of the great involvement of the Technion graduates in the development of technological innovation can be seen in the high proportion of graduates involved in the development of new products and/or new processes. This is also reflected in the large number of patent applications and registered patents of Technion graduates, in which about a quarter of the graduates are involved.

By using the data we collected we performed an assessment of the social rate of return from Investment in creating human capital at the Technion which is estimated in absolute terms, at the range between 35-60 billion dollars. The cost of training one cohort of Technion graduates amounting to a total investment of about one billion dollars .In comparison, the social output this investment generated, in terms of the discounted 'cash flow' of added GDP these grads produced, relative to what they would have produced had they not gained a Technion degree is estimated by 1.76-2.97 billion dollars. These findings indicate that the government's investment in the training of Technion graduates actually proves itself, since the resulting yield from this investment is estimated by 76%-197%, which is a very high return considering the fact that this is a no-risk investment and the fact that this assessment is an underestimation.

Finally, we cannot fully summarize without an overall estimate of Technion graduates' GDP contribution to the Israeli economy, even if such an estimate is done with caution and without firm, scientific data. The results show that the annual output of Technion graduates in high-tech industries and computer services, communications and Research & Development is estimated at a minimum of $21 b., or some 20 per cent of the annual output of these industries overall. Technion engineers also contribute to generating some 78,000 jobs that support high-tech industries, jobs that pay relative high wages. Technion graduates' contributions also find expression in the taxes they pay, some NIS 16.6 b. or about $4.4 b., in direct and indirect taxes, or some 13 per cent of the state revenue from direct and indirect taxes.

The estimates that have been evaluated in this report point to the unique contribution of the Technion to the economy through its graduates. The large amount of human capital that is created between the walls of this institution over the decades since its establishment and the high quality of its graduates, which is reflected in the various variables that were introduced in the report, testify to the integration of the graduates and their leading position in the growth branches of the Israeli economy.

List of Sources

Bar, A. (2010), *Analysis of the Higher Education Budgetary Proposal for the Fiscal Year 2011-2012*, The Knesset, Research and Information Center, the Budget Control Department, Jerusalem.

Getz, D., Buchnik, Z., Zalmanovic, B., Tekhauko M. and S. Frenkel (2007), *Technological and Scientific Personnel in Israel*, Samuel Neaman Institute, the Technion, Haifa.

Central Bureau of Statistics (2010), The development of the hi-tech field in Israel during 1995-2007, Publication No. 1389, Table 20.
http://www.cbs.gov.il/webpub/pub/text_page.html?publ=73&CYear=2007&CMonth=1

Central Bureau of Statistics (2010), Israel Statistic Yearbook 2011.
http://www.cbs.gov.il/reader/shnatonhnew_site.htm

Central Bureau of Statistics (2010), National Expenditure on Civil Research and Development 1989-2009, Publication No. 1435.
http://www.cbs.gov.il/webpub/pub/text_page.html?publ=36&CYear=2009&CMonth=1

Becker, G.S. (1964), Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, New York: National Bureau of Economic Research.

Becker, G.S. (1993), Nobel Lecture: The Economic Way of Looking at Behavior, *Journal of Political Economy*, 101(3): 385-409.

Phillips, J. (2011), Part 9 - ROI in Human Capital vs. Non-Human Capital ROI.
http://www.trainingreference.co.uk/training_roi/roi9.htm

Frenkel and Leck, E. (2006) "Investments in Higher Education and the Economic Performance of OECD Member Countries. Paper presented to The 46th Congress of the European Regional Science Association, Volos, Greece, 23-27 August 30th – September 3rd, 2006.

IMD World Competitiveness Yearbook (2011), Lausanne, June 2011.

Appendices

Appendix 1: The Distribution of Technion graduates and Technion Alumni Organization by Major Characteristics

Variable	Groups	Total Technion Graduates	Members of the Technion Alumni Organization
Academic degree	First degree	86%	83%
	Second degree	11%	13%
	Third degree	3%	4%
	Total	100%	100%
	N	63,413	16,450
Year of graduating advanced degree	1940-1959	4%	5%
	1960-1979	20%	22%
	1980-1999	41%	33%
	2000-2010	34%	40%
	Total	100%	100%
	N	67,067	13,193
The faculty from which they graduated	Core Engineering[1]	41%	48%
	Natural Science Engineering[2]	7%	9%
	Civil and Environ. Engineering	15%	11%
	Science[3]	14%	13%
	Other[4]	23%	20%
	Total	100%	100%
	N	66,661	16,342

[1] Faculty of Aerospace Engineering, Faculty of Mechanical Engineering, Faculty of Electrical Engineering, Computer Science, Faculty of Biomedical Engineering, and the inter-unit Program for Systems Engineering

[2] Faculty of Chemical Engineering, Faculty of Biotechnological and Food Engineering, Materials Engineering and the Inter-unit Program for Polymer Engineering.

[3] Faculty of Mathematics, Faculty of Physics, Faculty of Chemistry, Faculty of Biology and Faculty of Medicine.

[4] Faculty of Architecture and Town Planning, Education and Technology in Science and faculty of Industrial Engineering and Management, including Business Management Programs, Economics, etc.

Appendix 2: A Methodology for Estimating Human Capital Value of Technion Graduates

The model used to estimate the value of the human capital of the Technion graduates HC_j is presented in equation no. 1:

$$[1] \qquad HC_j = \sum_{t=j}^{j+45} \frac{(\Delta GDP_t)}{(1+R)^{t-j}}$$

Where:

HC_j = the value of the human capital created by Technion in year j, through its graduating class, expresses a) as absolute value, and b) later, as a rate of return

j = year of graduation (j = 1960-2010)

t = calendar year (t = 1960-2010)

N_j = number of graduates in year j

ΔGDP_t = value of added GDP accruing to Technion graduate in the year t

R = rate of deduction

The model assumptions:

A. College graduate average wage is higher than the average wage in the economy, 2001-2008; so it is assumed this holds for Technion graduates as well.

B. It is assumed that the addition to GDP generated by a Technion degree is proportional to the difference between the average wage accruing to a worker with an undergraduate college degree, and the average wage in the economy.

C. To calculate the difference we have been extra careful, paralleling the average salary of a Technion graduate to the pay of an academic worker with 16+ years of education. The CBS data indicate that the average salary of academics is higher by 46% than the average salary and higher by 78% of the average salary in the general economy for all workers with an education up to 16 years of study. We assume that this range reflects the lower threshold and the upper threshold of the wage difference in the economy in favor Technion graduates. However, it should be noted that comparing the wage receive by an academic with 16 years of study to the wage of a Technion graduate is a significant underestimation, since engineers and graduates from scientific faculties earn above the average wage of university graduates in the social sciences and humanities and of college graduates.

D. The model takes into consideration that the number of work years of the graduates will be 45 years, assuming the continued trend of increased life expectancy in the future. Thus, calculating the ΔGDP_t in the model (the additional GDP generated by a

Technion degree) was estimated with the multiplier of 0.46-0.78 in GDP per worker during 1960-2055.

E. An annual increase of 2% in GDP per worker was assumed for workers during 2010-2055.

F. R is the social rate of discount, assumed to be 5 per cent.

Explanation: the human capital created for one Technion graduate, graduating in year 'j', is the net present value of the additional GDP that the Technion degree has created, summed over the 45-year period of active working life, from year '0' through year 45.

Thus:

[2a] $\Delta\ WAGE_t = 0.46 \times GDP_{t,}$

or

[2b] $\Delta\ WAGE_t = 0.78 \times GDP_t$

When GDP_t is the respective weight in GDP per capita in year t and $\Delta\ WAGE_t$ is the difference between the wage earned by a worker with an undergraduate degree (equivalent to the wage of a worker with 16+ years of education), and the average wage in the economy, or the average wage of worker with an education up to 16 years of study which, according to the income data, is estimated by 46%-78% (that is, a Technion graduate with a B.Sc. degree provides at least an addition of 46%-78% to the economy's productivity relative to a worker without equivalent academic degree).

Thus, the total human capital for cohort j is then

[3] $N_j * HC_j$

Where N_j is the number of graduates for year 'j' and HC_j is the annual social return from investment in creating a single graduate in year 'j'.

This calculation was performed for the 50 years of graduation, 1960-2010. The results are presented in Table 2A.

Table 2A: Social return from investment(HC) created by the Technion Graduates During 1960-2010 (data are shown in NIS in 2005 prices)

year	No. of graduates	Social return (HC) per graduate in thousands of NIS		Total social return if HC in thousands of NIS		Social return (HC) per graduate in thousands of $		Total social return if HC in thousands of $	
		Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
1960	383	1,262	2,130	483,497	815,638	290	488	110,894	187,073
1961	338	1,300	2,194	439,509	741,432	298	503	100,805	170,053
1962	350	1,338	2,257	468,225	789,875	307	518	107,391	181,164
1963	332	1,376	2,321	456,688	770,413	315	532	104,745	176,700
1964	363	1,413	2,384	512,890	865,222	324	547	117,635	198,445
1965	402	1,450	2,446	582,949	983,410	333	561	133,704	225,553
1966	484	1,488	2,510	720,132	1,214,831	341	576	165,168	278,631
1967	588	1,529	2,580	899,115	1,516,768	351	592	206,219	347,883
1968	554	1,571	2,650	870,349	1,468,241	360	608	199,621	336,753
1969	662	1,604	2,707	1,062,104	1,791,723	368	621	243,602	410,946
1970	714	1,638	2,763	1,169,316	1,972,586	376	634	268,192	452,428
1971	675	1,671	2,819	1,127,847	1,902,629	383	646	258,681	436,383
1972	718	1,700	2,868	1,220,765	2,059,377	390	658	279,992	472,334
1973	843	1,725	2,909	1,453,766	2,452,441	396	667	333,433	562,486
1974	754	1,752	2,955	1,320,686	2,227,940	402	678	302,910	510,996
1975	802	1,779	3,000	1,426,375	2,406,233	408	688	327,150	551,888
1976	864	1,805	3,045	1,559,368	2,630,585	414	698	357,653	603,345
1977	1,110	1,833	3,092	2,034,454	3,432,035	420	709	466,618	787,164
1978	1,198	1,864	3,144	2,232,493	3,766,118	427	721	512,040	863,789
1979	1,320	1,895	3,196	2,500,972	4,219,031	435	733	573,617	967,668
1980	1,122	1,927	3,250	2,161,562	3,646,460	442	745	495,771	836,344
1981	1,182	1,957	3,301	2,312,707	3,901,436	449	757	530,437	894,825
1982	1,178	1,985	3,349	2,338,595	3,945,108	455	768	536,375	904,841
1983	1,111	2,016	3,401	2,239,722	3,778,314	462	780	513,698	866,586
1984	1,072	2,047	3,453	2,194,057	3,701,279	469	792	503,224	848,917
1985	1,301	2,081	3,511	2,707,913	4,568,132	477	805	621,081	1,047,737
1986	145	2,117	3,570	306,893	517,715	485	819	70,388	118,742
1987	1,392	2,149	3,625	2,991,085	5,045,831	493	831	686,029	1,157,301
1988	1,364	2,178	3,674	2,970,369	5,010,884	499	843	681,277	1,149,285
1989	1,286	2,209	3,727	2,840,906	4,792,485	507	855	651,584	1,099,194
1990	1,214	2,245	3,787	2,725,387	4,597,609	515	869	625,089	1,054,497
1991	1,340	2,277	3,841	3,051,307	5,147,422	522	881	699,841	1,180,601
1992	1,405	2,306	3,890	3,239,472	5,464,849	529	892	742,998	1,253,406
1993	1,957	2,337	3,942	4,572,813	7,714,136	536	904	1,048,810	1,769,297
1994	1,609	2,368	3,995	3,810,568	6,428,263	543	916	873,984	1,474,372
1995	1,623	2,401	4,051	3,896,972	6,574,022	551	929	893,801	1,507,803
1996	1,663	2,436	4,110	4,051,514	6,834,728	559	943	929,246	1,567,598
1997	1,592	2,473	4,172	3,936,931	6,641,431	567	957	902,966	1,523,264
1998	1,594	2,512	4,237	4,003,466	6,753,672	576	972	918,226	1,549,007
1999	1,673	2,549	4,301	4,265,286	7,195,352	585	986	978,277	1,650,310
2000	1,904	2,588	4,366	4,927,190	8,311,955	594	1,001	1,130,089	1,906,412
2001	1,851	2,622	4,423	4,852,935	8,186,691	601	1,014	1,113,059	1,877,681
2002	2,061	2,663	4,492	5,487,804	9,257,687	611	1,030	1,258,671	2,123,323
2003	2,113	2,709	4,570	5,724,445	9,656,890	621	1,048	1,312,946	2,214,883
2004	2,255	2,758	4,652	6,218,980	10,491,150	633	1,067	1,426,372	2,406,227
2005	2,413	2,806	4,734	6,771,289	11,422,871	644	1,086	1,553,048	2,619,925
2006	2,565	2,855	4,816	7,323,402	12,354,261	655	1,105	1,679,679	2,833,546
2007	2,536	2,905	4,900	7,366,885	12,427,615	666	1,124	1,689,653	2,850,370
2008	2,520	2,955	4,986	7,447,564	12,563,716	678	1,143	1,708,157	2,881,586
2009	2,366	3,009	5,076	7,118,965	12,009,384	690	1,164	1,632,790	2,754,446
2010	2,500	3,069	5,177	7,672,595	12,943,335	704	1,187	1,759,770	2,968,655
Total	65,361			154,071,079	259,911,213			35,337,406	59,612,663

12/008

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