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What are the Necessary Skills for High-Tech Workers

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For the full paper (in Hebrew) see
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Aaron Institute for Economic Policy

In the name of Aaron Dovrat z"l

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What Are the Necessary Skills for High-Tech Workers

This policy paper has been prepared at the request of the Trump Family Foundation, for the purpose of exploring the necessary professional skills for high-tech workers in Israel. In this work, we mapped the route of young adults in Israel, from high school graduation, through military service and academic studies, all the way to employment in a high-tech company. Which skills are acquired by young people during this period, and to what extent can these skills predict their future integration in technological occupations ("high-tech occupations") in general, and in the high-tech sector in particular. For the first time, we also examined the skills and characteristics of workers in "growth" occupations (the business-oriented occupations in the high-tech sector), whose relative importance is on the rise. In order to answer the research question, we examined three key aspects:

- Which occupations in high-tech companies are in increasing demand?
- What are the necessary skills for in-demand occupations?
- Which differences in professional skills arise when comparing between different occupations and different types of companies?
- What are the necessary skills that must be imparted in order to allow the high-tech sector to grow?

This paper summarizes the overall study results. For this study, we used the following information sources: workforce surveys conducted by the Central Bureau of Statistics (CBS) between 2012 and 2021, administrative CBS data for the age cohorts born between 1980 and 1989, as well as an independent survey covering over 600 high-tech workers. Based on these data, we mapped key trends in the technological employment market; developed models to assess the correlation between various skills and proficiencies on one hand, and the probability of integration into this employment market in research and development (R&D) roles or growth positions on the other hand; and compiled a list of policy recommendations, and issues for further exploration in future research.

Below are the main findings of our study:

- **Between 2017 and 2021, there had been a significant increase in the number of employees in the high-tech sector (an annual increase rate of 6.7%)** as opposed to a much smaller increase of workforce in the other economic sectors (an annual increase rate of 0.4%) and the economy as a whole (an annual increase rate of around 1.0%). **Within the high-tech sector, the annual increase rate in R&D positions and growth positions had approximated 8.5% and 5.0%, respectively.**
- The source of the increase in the number of employees in the high-tech sector is the significant rise in the number of those employed in “high-tech occupations”, which are characterized by high levels of professional technological skills, enabling engagement in knowledge-intensive activity which is done primarily in the high-tech sector. The increase rate in the number of workers employed in "high-tech occupations” was around 6.3%: around 9.1% in the high-tech sector and around 3.4% in the other economic sectors. This significant increase in the number of workers employed in “high-tech occupations” in other economic sectors means an increase in labor productivity (product per hour worked) in sectors other than high-tech.
- The increase in the number of workers employed in “high-tech occupations” is in all age groups – between 2017 and 2021, the number of workers employed in “high-tech occupations” in the 25-29, 30-34, 35-44, and 45-64 age cohorts had cumulatively increased by around 21% and around 32% and around 20% and around 35%, respectively. In the 30-34 age cohort, the share of workers employed in “high-tech occupations” reached around 19%. This phenomenon indicates that there is a process of accelaration in the growth of these occupations.
- The increase in the number of workers employed in "high-tech occupations" in turn contributes to the increase in the number and rate of employed people in the high-tech sector. Between 2017 and 2021, the percentage of people employed in the high-tech industry in the 25-29 age cohort increased from about 8% in 2017 to about 11% in 2021, in the 30-34 age cohort from about 11% in 2017 to about 14% in 2021, in the 35-44 age cohort from about 11% in 2017 to about 12% in 2021,and in the 45-64 age cohort from about 7% in 2017 to about 9% in 2021.
- While some two thirds (around 63%) of the new entrants into the high-tech sector work in R&D positions, approximately one third (around 31%) of new entrants are employed in “growth” positions: product management, user Experience, business analytics, design, marketing, sales, customer care, finances, legal, HR , and operations.

- Due to the positive trends in the numbers of employees in "high-tech occupations" and the high-tech sector, **the number of employees with "high-tech proficiencies"[1] reached around 555,500 in 2021, and the relative share of these employees out of all employees across the economy reached around 17.6%.[2]**
- In international comparison, Eurpean countries have ambitious plans, with clearly defined targets, to increase the number of employees in "ICT occupations", which, if successful, would significantly reduce the disparity between those countries and Israel. In order to maintain the advantage which Israel currently enjoys in the number of workers employed in "high-tech occupations", our recommendation is to set a target for the share of **employees with "high-tech proficiencies" in general, and the share of employees in "high-tech occupations" in particular**, for the year 2035.
- Our study has clearly identified the high threshold for entry into the industry, with an emphasis on the importance of an academic degree as a precondition to integration into the high-tech industry – around 85%-90% of high-tech employees have an academic degree.

Our study found a strong correlation between studying mathematics, physics, and computer science at an expanded level of 5 study units, as well as English at native-speaker level, and employment in the high-tech sector. Therefore, we have created a definition for **"high-tech matriculation"** – matriculation composition which includes: mathematics and English at a level of 5 study units, along with physics or computer science at a level of 5 study units.

- The number of graduates with "high-tech matriculation" (which is highly correlated with employment in R&D, product management, and business analytics positions) is increasing, however it is possible that the share of graduates with high-tech matriculation is not sufficiently high to support the target share of workers employed in "high-tech occupations", which would enable Israel to maintain its advantage over European countries.

[1] Employees who belong to the combined group of employees in "high-tech occupations" and the high-tech sector.

[2] Excluding employees in Occupation Class 216 – architects, planners, surveyors, and designers – the number of employees in the combined group of employees in high-tech occupations and the high-tech sector in 2021 stood at around 519,000, and the relative share of these employees out of all employees across the economy reached around 16.5%.

- There is very high correlation between studying for "high-tech matriculation" and studying for a "high-tech degree"[3] in academia.
- There is low correlation between "high-tech matriculation" and integration in growth occupations, however there is high correlation for English matriculation at a level of 5 study units – this finding suggests that is is possible to work in high-tech sector even without "high-tech matriculation" (although not in R&D roles), and that extensive English language knowledge is the basic proficiency for these occupations.
- There is very high correlation between the extremely low rate of "high-tech matriculation" in the Haredi (ultra-Orthodox) society, and the extremely low employment of this population group in the high-tech sector. In Arab society, the rate of a "high-tech degree" graduates with "high-tech matriculation" is very low compared to the Jewish population.
- There is high correlation between "PISA skills"[4] and the necessary abilities for high-tech workers – in both technological occupations and growth occupations.
- We assign great importance to informal education such as youth movements, regular group sport activities, extracurricular STEM courses, and musical training, which provide the majority of "PISA skills" – **a very high proportion (around 76%) of high-tech employees, in both R&D and growth positions, had participated in extracurricular activities** (STEM courses, sports, and youth movements).

It should be noted that since 2012 there has been an increase in the number of graduates who have taken 5 study units in mathematics, physics, computer science, English, and "high-tech matriculation", hence the trajectory is positive and is expected to contribute to an increase in the share of high-tech employees, over the next 5 years at least.

[3] "High-tech degree" – a BA degree in one of the following subjects: computer science, mathematics & computer science, management information systems, electrical engineering, electronics engineering, computer engineering & computer science, computer & electrical engineering, communication systems engineering, and data systems engineering.

[4] For the purposes of this study, "PISA skills" include four clusters of skills: **values cluster**: social responsibility; **cognitive skills cluster**: problem solving, professional knowledge, analytical skills, programming, English language, information usage, digital literacy; **social skills cluster**: interpersonal communication, teamwork; **personal skills cluster**: task orientation, critical thinking, creative thinking, flexibility, self-learning, leadership.

The high productivity in the high-tech sector has triggered an economic discussion on the question of whether the strategy in Israel should focus on attempting to expand the high-tech sector as much as possible. Thus, for example, there have been calls to set a target of increasing the relative share of high-tech employees to 15% of all employees across the economy. We believe this is not the correct target.[5] The high productivity of the high-tech sector also contributes to the advancement of other sectors (the banking sector is a clear example), while also increasing the supply of workers with appropriate skills for integration in "high-tech occupations", extending to other sectors as well. **Therefore, in our view, the correct goal would be to raise the population's educational attainment and quality, as well as skill levels, in a manner which would facilitate integration into "high-tech occupations" not just within the high-tech sectors, but also in other sectors, in order to enhance labor productivity and innovation across the economy as a whole.**

Accordingly, our key recommendations are as follows:

1. Utilizing the index of **employees with "high-tech proficiencies" (divided between emloyees in R&D positions / growth positions)** as a leading national index for a policy of enhancing digital literacy capabilities throughout the economy, and supporting the high-tech sector specifically. Setting a national target for the share of **employees with "high-tech proficiencies"**, and deriving from it targets for the educaton system, the higher education system, and a vocational training scheme.

Recommendations for the education system:

2. Systematically impart "PISA skills": self-learning ability, teamwork ability, ability to solve complex problems.
3. Increase access to STEM/programming courses (including informal education frameworks), with an emphasis on Arab society.
4. Set a formal definition of "high-tech matriculation" as a national index in high schools. Increase the share of graduates with "high-tech matriculation" from 9% to 15% within 5 years.

[5] The Israeli high-tech sector is already very large in international comparison, and it is not clear how much further it could be expanded, partly because of the restraining factor of the currency exchange rate, since the products of this sector are almost entirely export-oriented.

5. Set a national target for the share of high school students who graduate with English matriculation at a level of 5 study units, and are able to hold a conversation, present a topic, and engage in debate, in order to expand the groundwork for integration in growth positions. Drastically revise English language studies, so that graduates at a level of 5 study units will be able to hold a conversation, present a topic, and engage in debate in this language.

Recommendations for the higher education system:

6. Set a national target for the share of academics with a "high-tech degree" from higher education institutions. Increase the share of academic graduates with a "high-tech degree".
7. Enhance the integration of academics in the high-tech sector by adapting study programs to the requirements of the labor market, for example:
    - Adding courses in: data science, coding literacy, user experience.
    - Adding tracks of study which focus on: product management, business intelligence, business analytics.
    - Tuition in English language to enhance proficiencies: speaking, writing, presentation.
8. Develop training courses (on top of academic education) for missing "high-tech proficiencies", and lifelong learning of occupations which are affected by technological changes.
9. Incorporate internship and practical training in the course of undergraduate studies, to acquire professional experience and match the high-tech proficiencies being taught to those required by high-tech companies.
10. Ensure ongoing access to data, to track progress towards the aforementioned targets.

1. Summary and conclusions

This study was conducted at the request of the Trump Family Foundation, which sought to determine the necessary professional skills for high-tech workers, by occupation. In order to answer our research question, we examined three key aspects:

- Which occupations in high-tech companies are in increasing demand?
- What are the necessary skills for in-demand occupations?
- Which differences in professional skills arise when comparing between different occupations and different types of companies?
- What are the necessary skills that must be imparted in order to allow the high-tech sector to grow?

This paper summarizes the main findings revealed in the first stage of research. The full results of this study will be published at the end of August 2022.

For this study, we use the following data sources: workforce surveys conducted by the Central Bureau of Statistics (CBS) between 2012 and 2021, administrative CBS data for the age cohorts born between 1980 and 1989, as well as an independent survey we conducted among 606 high-tech workers.

Employees throughout the labor market may be divided into two main groups: those who are employed in "high-tech occupations", and those employed in occupations which are not defined as "high-tech". Employees in "high-tech occupations" are characterized by high levels of professional technological skills, which facilitate engagement in knowledge-intensive activity.[6] In 2021, around 452,000 workers (14.4% of all employees) were employed in "high-tech occupations", and around 2,696,000 workers (85.6% of all employees) were employed in non-high-tech occupations.

[6] A full list of high-tech occupations, as defined by the CBS, is provided in Appendix A.

Out of the 452,000 workers in "high-tech occupations", around 246,000 (54%) were employed in the "high-tech"[7] economic sector,[8] which is comprised of a group of firms involved in: medicine development and manufacturing, computer manufacturing, electronic and optical equipment manufacturing, aerospace manufacturing, data processing, data storage, website building, computing services, research and development. **High-tech firms are knowledge- and innovation-intensive, as reflected in the high ratio between R&D expenditure and output (R&D intensity), which exceeds 6% at an industry-wide level.**[9] The 246,000 workers employed in "high-tech occupations" within the high-tech sector are employed in: research & development (R&D) roles, product management and business intelligence roles, and positions for practical engineers and technicians in digital fields, and they constitute the majority of the workforce in the high-tech sector, with a relative share of around 70% out of the entire workforce in the high-tech sector, which encompasses around 352,000 workers.

Out of 246,000 workers employed in "high-tech occupations" within the high-tech sector, around 179,000 **work in R&D positions,**[10] **representing around 51% of the workforce in the high-tech sector.** Accordingly, the number and proportion of those employed in other occupations within the high-tech sector – **"growth positions": "product"** (product management, business analytics, user experience, design), **"marketing and sales"** (marketing, sales, customer care), **"**General and Administrative (G&A)**"** (HR, legal, finance, operations) – stand at around 173,000 and around 49%, respectively.

Between 2017 and 2021, the number of workers employed in "high-tech occupations" across the economy as a whole had increased by around 98,000. **This increase is manifested in the integration of workers employed in "high-tech occupations" across all age groups, but is particularly pronounced in the younger age groups.** Thus, in the 30-34 age cohort, the number of workers employed in "high-tech occupations" reached around 19%.

[7] See Appendix B for a list of the subsectors constituting the high-tech sector.

[8] An economic sector is defined as a group of firms which share the same or similar business activity. The inclusion of a firm in an economic sector is determined according to the nature of its business activity. The nature of a firm's business activity is determined according to the activity which provides it with the highest added value (added value is the value of gross output minus the value of intermediate inputs). See: CBS, Standard Industrial Classification of All Economic Activities 2011 (Updated Edition), https://www.cbs.gov.il/en/publications/Pages/2015/Standard-Industrial-Classification-of-All-Economic-Activities-2011-Updated-edition.aspx. See also Appendix B.

[9] See Appendix C, which presents R&D intensity by economic sector as of 2018, with a distinction between sectors in which the intensity exceeds 6% and other sectors.

[10] **R&D roles:**
Service managers in information technology sectors (133), practitioners in the fields of physical and Earth sciences (211), practitioners in the field of life sciences (213), electrical and electronics engineers (215), software developers and application analysts (251).

Out of the around 98,000 employees in "high-tech occupations" which were added between 2017 and 2021, around 74% joined the high-tech sector, and around 26% joined other economic sectors. Accordingly, the number of high-tech sector employees increased by around 80,000, from around 272,000 in 2017 to around 352,000 in 2021.[11] In December 2021, the number of employees in the high-tech sector had climbed as high as 390,000, representing around 12% of all employees in primary working age (25-64).[12] The annual increase rate in the number of employees in the high-tech sector during this period stood at around 6.7%, and was significantly higher than the increase rate in the other economic sectors, which was around 0.4%. **The annual increase rate in the high-tech sector, for R&D positions and growth positions, approximated 8.5% and 5.0%, respectively.** The increase in the integration of younger workers in "high-tech occupations" had a considerable contribution to the significant increase in the number of employees in the high-tech sectors.

Out of the 80,000 additional employees in the high-tech sector, **around 75,000 (approximately 94%) joined the high-tech services sector**, of whom around 61,000 joined the computing sector and around 14,000 joined the R&D sector.

In order to discern which occupations in the high-tech sectors have particularly grown in demand, we differentiated between occupations involved in research and development **(research and development positions)**, **and growth positions**, and analyzed the additional workforce joining the high-tech sector according to these occupations.

An analysis of new entrants into the high-tech services sectors shows that between 2017 and 2021, around 75,000 workers had joined the high-tech services sectors, consisting of: 61% in research and development positions, 20% in product management positions, and 9% in sales and marketing positions. In 2021, the relative share of those employed in research and development positions, in marketing and sales, and in practical engineer and technician positions, remained similar to their share in 2017, while the share of those employed in product management and business intelligence positions increased significantly to around 10%. **Out of all new entrants into the high-tech services sector, around 91% are academically qualified;**[13] among new entrants in research and development positions, around 95% are academically qualified; all new entrants in product management positions are academically qualified; among new entrants in sales and marketing positions, around 97% are academically

[11] The increase in the number of employees from December 2017 to December 2021 is even higher, and stands at around 105,000 employees.

[12] Around 10% of all employees aged 15 and above.

[13] The percentage of workers with academic degrees in high-tech occupations within the high-tech sector stands at around 90% on average, in both the high-tech services and high-tech manufacturing sectors.

qualified; among new entrants in finances, legal, and operations positions, around 53% are academically qualified.

An analysis of new entrants into the high-tech manufacturing sectors shows that between 2017 and 2021, around 5,000 workers had joined the high-tech manufacturing sectors, consisting of: around 3,600 in research and development positions, around 1,000 in product management positions, and around 1,600 in sales and marketing positions. During this period, the number of manufacturing positions had decreased by around 5,500. In 2021, the relative share of those employed in research and development positions, and product management positions, had increased to approximately 24% and 17%, respectively, while the share of those employed in manufacturing positions had decreased by around 10 percentage points, to around 13%. **In the high-tech manufacturing sectors, as well, around 90% of new entrants are academically qualified.**

Hence, while some two thirds (around 65%) of the new entrants in the high-tech sectors work in R&D positions, around a third (around 31%) of new entrants in the high-tech sectors are employed in "growth" positions.

In recent years, there has been rising awareness to the importance of imparting skills which facilitate optimal, high-quality integration in military service, academia, and employment. The skills in question include: problem solving, interpersonal communication, teamwork, critical thinking, creative thinking, task orientation, self-learning, and so forth ("PISA skills"). **Our survey results indicate the great importance of "PISA skills" for employment in the high-tech sector.** A very high proportion of high-tech employees assigns importance to skills such as: responsibility (around 94%), problem solving (around 93%), interpersonal communication (around 87%), teamwork (around 86%), task orientation (around 84%), critical thinking (around 83%), creative thinking (around 81%), flexibility (around 80%), self-learning (around 78%).

Informal education – such as youth movements, regular sport activities, extracurricular STEM courses, musical training – provides the majority of "PISA skills", and plays a highly significant role in empowering high school students prior to their decision whether to pursue studies for high-tech matriculation, a high-tech degree, and future integration into the high-tech sector. **A very high proportion (around 76%) of high-tech employees, in both R&D and growth positions, had participated in extracurricular activities;** around 20% had been involved in extracurricular STEM courses (26% of high-tech employees in R&D positions, around 11% of high-tech employees in growth positions).

The matriculation qualifications of employees in the high-tech sector are exceptionally high, across all occupations. Around 53% of high-tech employees had taken 5 study units in mathematics, around 39% had taken 5 study units in physics, and around 36% had taken 5 study units in computer science. **Around 42% of high-tech workers have "high-tech matriculation" – matriculation composition which includes: mathematics at a level of 5 study units, English at a level of 5 study units, or physics or computer science at a level of 5 study units.** This percentage stands at around 58% among workers in R&D positions, and around 24% among those in "growth" positions. "**PISA skills" and informal education have a strong positive correlation with studies for mathematics matriculation at a level of 5 study units / "high-tech matriculation".**

Studying for "high-tech matriculation" in high school is positively correlated with integration into academic studies:[14] studying for "high-tech matriculation" increases the probability that an employee in a high-tech company will have an academic degree by around 9 percentage points, and the probability that an employee in a high-tech company will have a "high-tech degree" by around 41 percentage points (when taking into account the effects of gender and age). Accordingly, **around 85% of employees in the high-tech sector have an academic degree, and around 40% of employees in the high-tech sector have a "high-tech degree"** (the share of academics with a "high-tech degree" among those employed in R&D positions reaches as high as around 61%). Among employees in growth positions, the share of academics with a "high-tech degree" ranges between around 14% and around 19%. It is important to note that **among academically qualified high-tech employees in growth positions, around 84% have a first degree which is not a "high-tech degree"** (compared to around 25% among academically qualified high-tech employees in R&D positions).

Although the skills required for R&D positions are somewhat different than those required for growth positions, it can be asserted that in a comprehensive view, excellence is required across all positions in the high-tech sector, with an emphasis on high-tech matriculation, a high-tech degree in R&D positions or a relevant academic degree in growth positions, and even a master's degree.

[14] Studies for "high-tech matriculation" in high school are positively correlated with integration into technological units in the army. Appendix K-2 presents the positive correlation between "high-tech matriculation" studies and integration into technological units in the army, and the results of an LPM regression estimating the probability of serving in a technological unit in the army.

In light of the findings of this study, we recommend proceeding with the development of **human capital with "high-tech proficiencies"** for engagement in knowledge-intensive positions across the economy as a whole, and in the high-tech sectors in particular. To achieve this goal, we recommend:

Recommendations for the education system:

1. Systematically impart "PISA skills": self-learning ability, teamwork ability, ability to solve complex problems.
2. Increase access to STEM/programming courses (including informal education frameworks), with an emphasis on Arab society.
3. Increase the share of graduates with "high-tech matriculation" from 9% to 15% within 5 years.
4. Drastically revise English language studies, so that graduates at a level of 5 study units will be able to hold a conversation, present a topic, and engage in debate in this language.

Recommendations for the higher education system:

5. Increase the share of academic graduates with a "high-tech degree".
6. Enhance the integration of academics in the high-tech sector through:
    - Adding courses in: data science, coding literacy, user experience.
    - Adding tracks of study which focus on: product management, business intelligence, business analytics.
    - Tuition in English language to enhance proficiencies: speaking, writing, presentation.
7. Develop training courses (on top of academic education) for missing "high-tech proficiencies", and lifelong learning of occupations which are affected by technological changes.
8. Incorporate internship and practical training in the course of undergraduate studies, to acquire professional experience and match the high-tech proficiencies being taught to those required by high-tech companies.

Recommendations with regard to measurement:

9. Utilizing the index of employees with “high-tech proficiencies” (preferably divided between R&D positions / “growth” positions) as a leading national index for a policy of enhancing digital literacy capabilities and promoting innovation throughout the economy, and increasing employment in the high-tech sector specifically.
10. Setting national targets for:
    - The share of employees with “high-tech proficiencies”.
    - The share of academics who graduate with a “high-tech degree” in higher education institutions.
    - The share of high school students who complete “high-tech matriculation”.
    - The share of high school students who graduate with an English matriculation at a level of 5 study units and are able to hold a conversation, present a topic, and engage in debate.
11. Ensure ongoing access to data, to track progress towards the aforementioned targets.