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Selected studies

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The Bank of Israel 2019 Annual Report: Selected Studies is a collection of issues that were written for the Bank of Israel Annual Report, which is published each year at the end of March. This year, due to the coronavirus crisis that broke out in Israel in February and March, the Annual Report was shortened, and some of the long-term issues that were discussed in it were taken out of the report, and are being published separately in this volume. The studies herein were mostly written before the coronavirus crisis, but to the extent necessary they were updated and adjusted to the current situation after the outbreak of the crisis.

This sections in this volume of the report were written by Shira Bozaglo, Sefi Bahar, Kobi Braude, Lior Galo, Gedalia Gillis, Maya Haran Rosen, Dima Vasilayev, Yossi Margoninsky, Uri Mishanyot, Yotam Nir, Artyom Petrosyan, Osnat Peled, Yoav Friedmann, and Gilad Shalom.

CONTENTS

Who are the Students who Aspire to be Teachers in Israel? Insights from PISA Tests[1]

- **Studies indicate a correlation between the achievements of students who aspire to be teachers in their adulthood and the achievements of their countries in international exams.**
- **In Israel, the teaching profession's status is low in an international comparison, making it difficult to attract highly skilled people to the education system. An international comparison of the achievements of students who aspire to be teachers as adults shows that in Israel these students have a lower level of achievement than most of their counterparts in OECD countries.**
- **In order to attract more quality people to the education system, efforts must be made to improve the working conditions of the teaching staff and the prestige of the teaching profession as seen by the public.**
- **Recommended steps include: Increasing the autonomy of teachers and administrators, raising the salaries of beginning teachers, and adding pay components that are based on achievement, on specialization in scarce professions and on teaching in disadvantaged schools, and working to improve teachers' physical work conditions. This is in addition to changes in the education system itself, which will make it possible to identify successful teachers according to their contribution and to incentivize them.**

Improving student achievement is a challenge facing many countries, and some policy documents have emphasized that improving the quality of the teachers is the best policy step toward achieving this goal. These statements are both from an international perspective and from an analysis adapted to Israel.[2] The importance of good teachers is again high on the agenda in view of several studies, whose main conclusion was that "smarter teachers produce smarter students".[3] Today, recruiting good teachers, especially in the StEM fields (science, technology, engineering and mathematics), is a major challenge facing many educational systems around the world.[4]

[1] Author - Sefi Bahar; Research Assistant - Yotam Nir.

[2] OECD (2018), Effective Teacher Policies: Insights from PISA, PISA, OECD Publishing. Bank of Israel Annual Report for 2017, chapter 1.

[3] E. Hanushek, M. Piopiunik and S.Wiederhold (2014). The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance (NEBR Working Paper Series). Cambridge, MA: National Bureau of Economic Research. E. C Meroni., E. Vera-Toscano and P. Costa (2015). Can low skill teachers make good students? Empirical evidence from PIAAC and PISA. Journal of Policy Modeling, 37(2), 308–323.

[4] **A. Schleicher (2012).** Building a high-quality teaching profession. Lessons from around the world. *Educational Studies* (1), 74–92. **A. Schleicher (2012,B).** *Preparing Teachers and Developing School Leaders for the 21st Century: Lessons from around the World*. OECD Publishing**. H. E. Price and K. Weatherby (2018)**. The Global Teaching Profession: How Treating Teachers as Knowledge Workers Improves the Esteem of the Teaching Profession. *School Effectiveness and School Improvement*, *29*(1), 113–149.

The question of how better teachers can be recruited has not been evaded in Israel, where student achievement is low compared to OECD countries, and teachers' "level of proficiency" in relation to the population is low compared to the corresponding ratio in OECD countries.[5] In recent years, several reforms aimed at attracting high-quality personnel to the profession were carried out, and yet there is no improvement in indicators that measure the relative quality of new teachers entering the system.[6]

In this box, we examine who the boys and girls are who aspire to be teachers and their achievements in PISA tests in Israel and in OECD countries. The relevance of the analysis relies on the relationship between students' employment expectations and their future career choices (see Box 1 for further information): Many of the students who aspire at present to be teachers are likely to be the teachers of the future.

The analysis is based on the analysis of the answers to the question "What kind of job do you expect to have when you are about 30 years old?", which is repeated in several rounds of PISA tests. This question has been effective for a number of studies that have attempted to examine the causes of the difference in the number and level of achievements of students aspiring to engage in teaching in the future among the countries participating in the PISA tests, given the differences in the characteristics of the teaching profession among the various countries—wages, work hours, the public's perception of the profession[7] and various characteristics of the individual (gender, socioeconomic background and immigration).[8]

[5] **OECD (2019)**, *PISA 2018 Results (Volume I): What Students Know and Can Do*, PISA, OECD Publishing, Paris. Teacher proficiency level – A comparison of proficiency was carried out based on the PIAAC 2015 survey at both the median level and with the distribution of the teachers' median score compared to the population score, meaning that the teachers in Israel come from a lower proficiency cross section relative to the comparison countries: Bank of Israel Annual Report for 2018, chapter 6, Figures 6.13(a) and 6.13(b).

[6] Bank of Israel Annual Report for 2018, chapter 6, figure 6.14. Central Bureau of Statistics 2019, Academic and Pre-Academic Background among Teaching Staff, August 27, 2019.

[7] Wages were calculated as the statutory wages after 15 years compared to per capita GDP; work hours were calculated according to the total hours a teacher is required to teach in that country; the prestige of the profession was measured through answers from the TALIS survey, in which teachers answered how much the teaching profession is perceived as valued in their country and using the results of the Global Teacher Status Index.

[8] **H. Park and S. Y. Byun (2015)**. Why Some Countries Attract More High-Ability Young Students to Teaching: Cross-national Comparisons of Students' Expectation of Becoming a teacher. *Comparative Education Review*, *59*(3), 523–549. **OECD (2018, B).** "Who Aspires to a Career in Teaching?", in Effective Teacher Policies: Insights from PISA, OECD Publishing, Paris **S. W. Han, F. Borgonovi and S. Guerriero (2018)**. What Motivates High School Students to Aspire to be Teachers? The Role of Salary, Working Conditions, and Societal Evaluations about Occupations in a Comparative Perspective. *American Educational Research Journal, 55*(1), 3–39. **S. Y. Tang, P. M. Wong, A. K. Wong and M. M. Cheng (2018)**. What Attracts Young People to become Teachers? A Comparative Study of Pre-service Student Teachers' Motivation to Become Teachers in Hong Kong and Macau. *Asia Pacific Education Review, 19*(3), 433–444.

Box 1 – To what extent are the aspirations of 15-year olds aligned with their future career choice

Many studies have addressed the question as to the extent to which students' aspirations regarding their future career choice, especially in the context of teaching, are a prediction of their employment as adults. Some studies have found that career expectations have a strong impact on the beginning of teaching training[1], and that youths decide on their choice of the teaching profession during their middle school studies and before graduating from school.[2] Several studies based on longitudinal surveys have found a connection between the individual's career aspirations as a youth and the actual career choice. According to these studies, aspirations regarding the occupational level (academic or professional) and the profession explain the future choice of profession better than the individual's other socioeconomic variables.[3] PISA data on student employment expectations have been used for a wide range of studies in the teaching profession and in the context of adapting youth employment expectations to the future employment world.[4]

The OECD Report (2018) presented two additional analyses that support the examination of the professional expectations of 15-year-old students with respect to the teaching profession. In the PISA teachers questionnaire, 62 percent of the young teachers stated that they chose the teaching profession during their high school studies, but the differences between countries are high (42–84 percent).[5] Another analysis presented in the report shows that the gap in scores between students who wish to be teachers and teachers of students who want to engage in another profession with similar education requirements is negative and greater in countries where the achievement in PISA tests is low and positive in countries where achievement is high.[6]

The figure shows the correlation between the achievement gap in the PISA 2006 test between students who were interested in teaching and students who were interested in pursuing another "profession" requiring an academic education[7], and the proficiency gap measured in a population of young workers engaged in those professions in PIAAC 2015. The time difference between the test dates makes it possible to examine the same population group in the countries that took part in both tests and to ascertain whether there is a connection between the gaps measured in PISA and the proficiency gaps measured in the labor

[1] **M. Aksu, C. E Demir, A. Daloglu, S. Yildirim and E. Kiraz (2010**). Who are the Future Teachers in Turkey? Characteristics of Entering Student Teachers. *International Journal of Educational Development*, *30*(1), 91–101. **P. W. Richardson and H. M. Watt (2005).** 'I've Decided to Become a Teacher': Influences on Career Change. Teaching and Teacher Education, 21(5), 475-489.

[2] In many countries, the formal education system ends at the age of 15, and then students must choose between the professional and academic tracks. **J. Lee, S. Clery and J. Presley (2001).** *Path to Teaching*, Illinois Education Research Council, Southern Illinois University.

[3] **J. S. Ashby and I. Schoon (2010).** Career Success: The Role of Teenage Career Aspirations, Ambition Value and Gender in Predicting Adult Social Status and Earnings. *Journal of Vocational Behavior, 77(3*), 350–360**. Schoon, I., & Parsons, S. (2002)**. Teenage Aspirations for Future Careers and Occupational Outcomes. *Journal of Vocational Behavior, 60(2*), 262–288.

[4] **A. Mann, V. Denis and A. Schleicher (2020).** Dream Jobs?: Teenagers' Career Aspirations and the Future of Work.

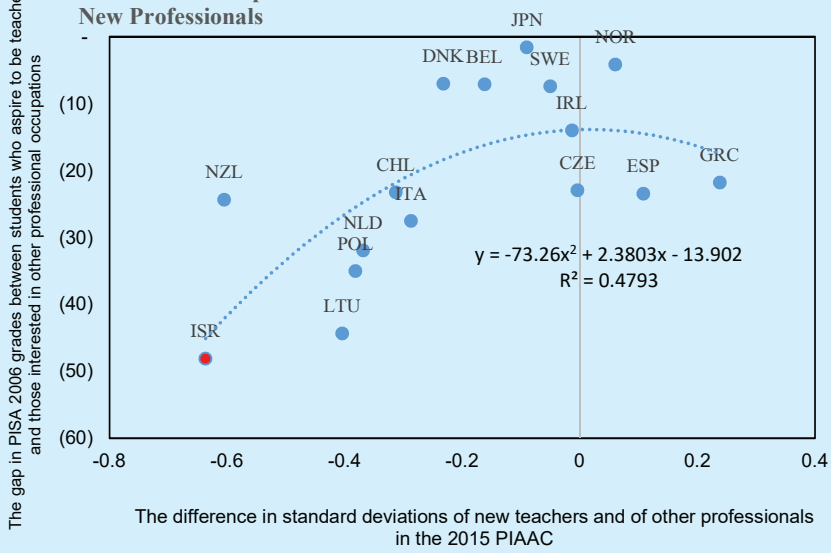
[5] Teacher questionnaires are only filled out in some countries and not in Israel, and due to the great variation between countries and the difference in the transition between the studies and the labor market in Israel, these figures do not necessarily reflect the situation in Israel.

[6] **OECD (2018).** *Effective Teacher Policies: Insights from PISA*. OECD Publishing. Figure 1.3.

[7] Professions included in the professional classification are: scientific and engineering professions, medical, business, law and ICT professions.

market. The test results indicated a high correlation (0.6) between the achievement gap in math at age 15 and the proficiency gap in solving problems between teachers and other professionals among young workers with up to 5 years of professional experience.

Figure 1
The Gap in PISA 2006 Grades between Students who Aspire to be Teachers and Those Interested in Other Professional Occupations, and the Skills Gap in the 2015 PIAAC between New Teachers and New Professionals



SOURCE: Based on 2015 PIAAC data, 2006 PISA data.

The international comparison relates to two main metrics: 1. Number of Candidates Indicator—the proportion of students who wish to be teachers among the students who answered the question.[9] 2. Candidate Quality Indicator—The achievement gap in PISA tests between students interested in teaching and students interested in pursuing another profession[10]. Using this measure of the quality of candidates neutralizes the level differences between the countries and presents the relative achievement level picture of students interested in teaching in each country. Conclusions of the studies indicated a correlation between the relative wages and the number of students aspiring

[9] Table 4.6 of the OECD 2018, B sets out the scope of responses to the question in the various rounds of testing and in the different countries. In 2006, Israel stood out with a low rate of response to the question, and in 2015 and 2018, the response rate in Israel was higher than the average in the OECD countries.

[10] In professions with an entrance threshold of an academic degree, the breakdown of the professions is according to the classification of a professional worker in ISCO 08 for the data of 2015 and 2018 and ISCO 88 for the 2006 data.

to be teachers but not necessarily between the salary and the quality of the candidates. Additionally, in some studies, there is a positive correlation between the status of teachers and the working conditions of the teaching staff (work hours, professional autonomy, etc.) and the attraction of strong students to the teaching profession.[11]

Comparing these metrics between Israel and the OECD countries[12] may provide insights into the status of the teaching profession in Israel and its trends during the period under review, during which the "Ofek Hadash" (New Horizon) and "Oz Le'Tmura" (Courage to Change) reforms were implemented in Israel with the aim of improving the attractiveness of the teaching profession and attracting high-quality people.[13]

Figure 1.1 shows that the proportion of students interested in teaching in Israel is similar to that in the OECD countries (an insignificant gap), but the dynamics over time are different. In 2006, the proportion of students who were interested in becoming teachers in other OECD countries was higher than in Israel (5.5 percent versus 4.2 percent, significant) and has been declining since then, while there has been no significant change in Israel over the period. It is possible that the reforms in the education system, which, among other things, have increased teachers' monthly wages, have contributed to stability in the proportion of students who aspire to become teachers (an increase of 0.2 percent, not significant), in contrast to the decline in the OECD countries (1.4 percent, significant). An examination of the gender difference reveals that in Israel, like in the OECD, more girls than boys aspire to be teachers (6.7 percent among girls compared to approximately 3.0 percent among boys), but in both gender groups the rate in Israel is higher than the OECD average (5.8 percent among girls and 2.7 percent among boys).

An examination of the achievement gap in all disciplines (reading, mathematics and science) between the students who wish to become teachers and those who are interested in "other professions" revealed that it is one of the highest in the OECD countries (Figures 1.2 and 1.3), at the three points in time examined (Figure 2.1). Figure 2.2 shows the difference in the gaps between 2006 and 2018. During the period, the achievement gap in Israel narrowed slightly, but not at a rate that changed its low ranking.

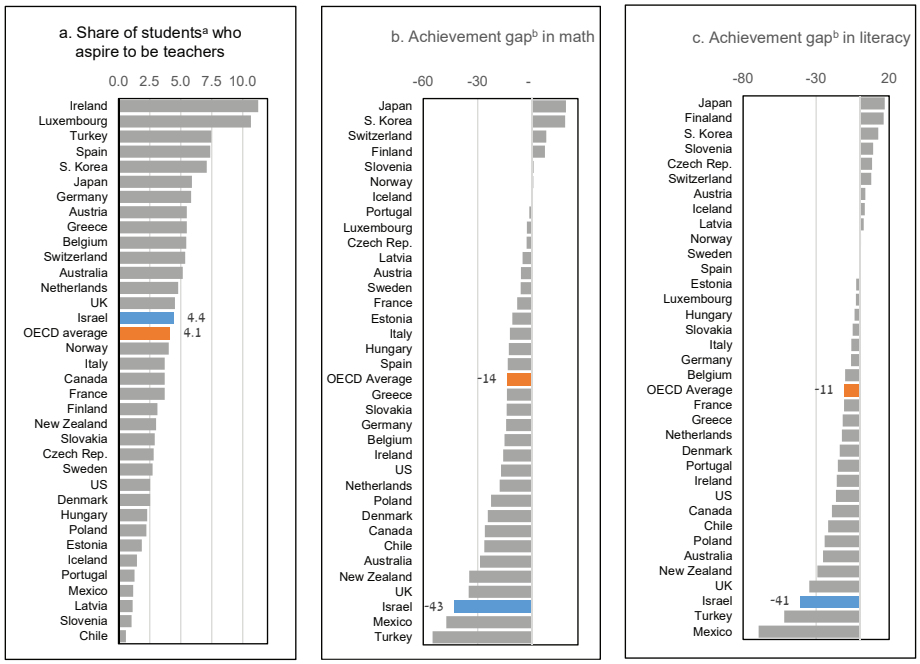
An examination of the background characteristics of students who wish to become teachers indicates that in Israel they come from a lower socioeconomic status than their counterparts in the OECD (significant). Figure 2.3 presents the difference in the proportion of students who wish to be teachers between those whose parents have an

[11] Strong students were defined as students in the top third of the achievements in that country. These students were more influenced by the public perception of the profession and the work hours. A graphical description of the relationships can be seen in OECD (2018, B) Figure 4.7, based on a sample of the OECD countries in terms of both the number of candidates and the achievements in mathematics.

[12] Because we want to examine the development of the data over time, the comparisons relate to the 35 OECD countries that took part in the three rounds of the test, even if during some of the specified period, they were not OECD members.

[13] The attraction of higher-quality people to the teaching profession can come from more talented students in the training institutions and by attracting older people in professional retraining tracks.

Figure 1
PISA 2018 Data on the Share of Students who Aspire to be Teachers and the Achievement Gaps in Math and Literacy among Students who Aspire to be Teachers and Those Who Want to Work in a Different Profession, 2019

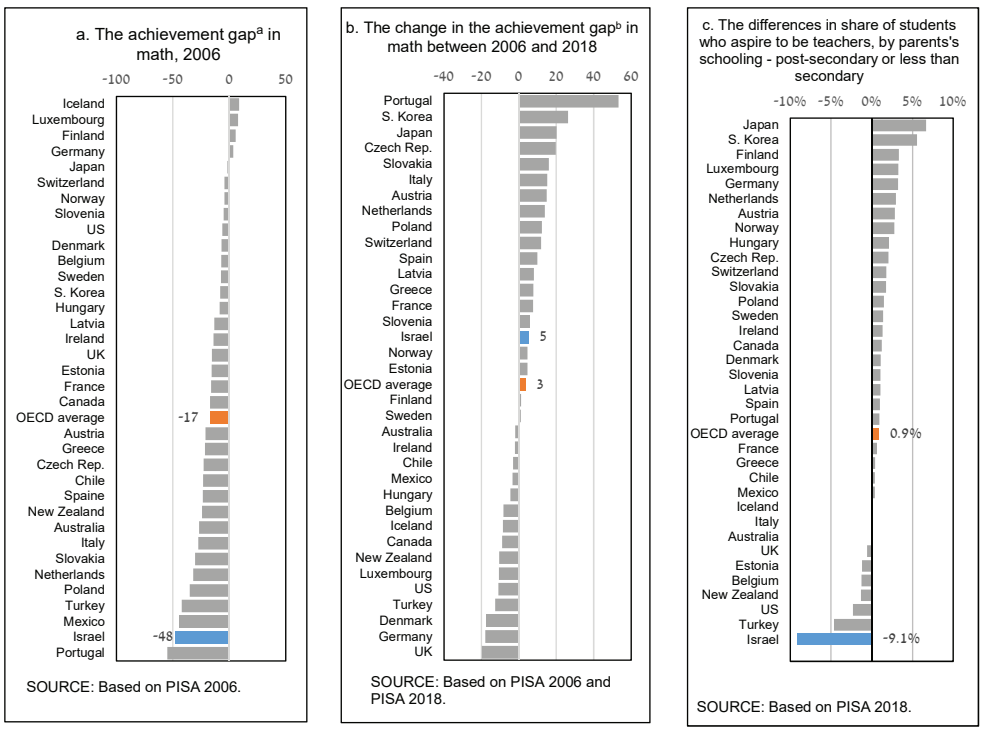


[a] Percentage of students who responded that they are interested in being teachers, relative to all respondents.
[b] The achievement gap is calculated as the difference between the grade of students who responded that they aspire to be teachers and that of students who responded that they are interested in working in a different profession requiring a Bachelors degree.

SOURCE: Based on PISA 2018.

academic education and those whose parents have a lower than high school education. This comparison enables us to see for which students the teaching profession is perceived to be more attractive. The figure shows that in most OECD countries, the teaching profession is seen as more attractive among students of parents with an academic education (4.2 percent compared to 3.3 percent, a significant gap), while in Israel the teaching profession is perceived as more attractive among students of parents with less than a high school education (12.4 percent compared to 3.3 percent among those with an academic education, a significant gap).

Figure 2
The achievement gap in math between students who aspire to be teachers and those who aspire to other professions, at various points in time, and schooling data of parents of students who aspire to be teachers



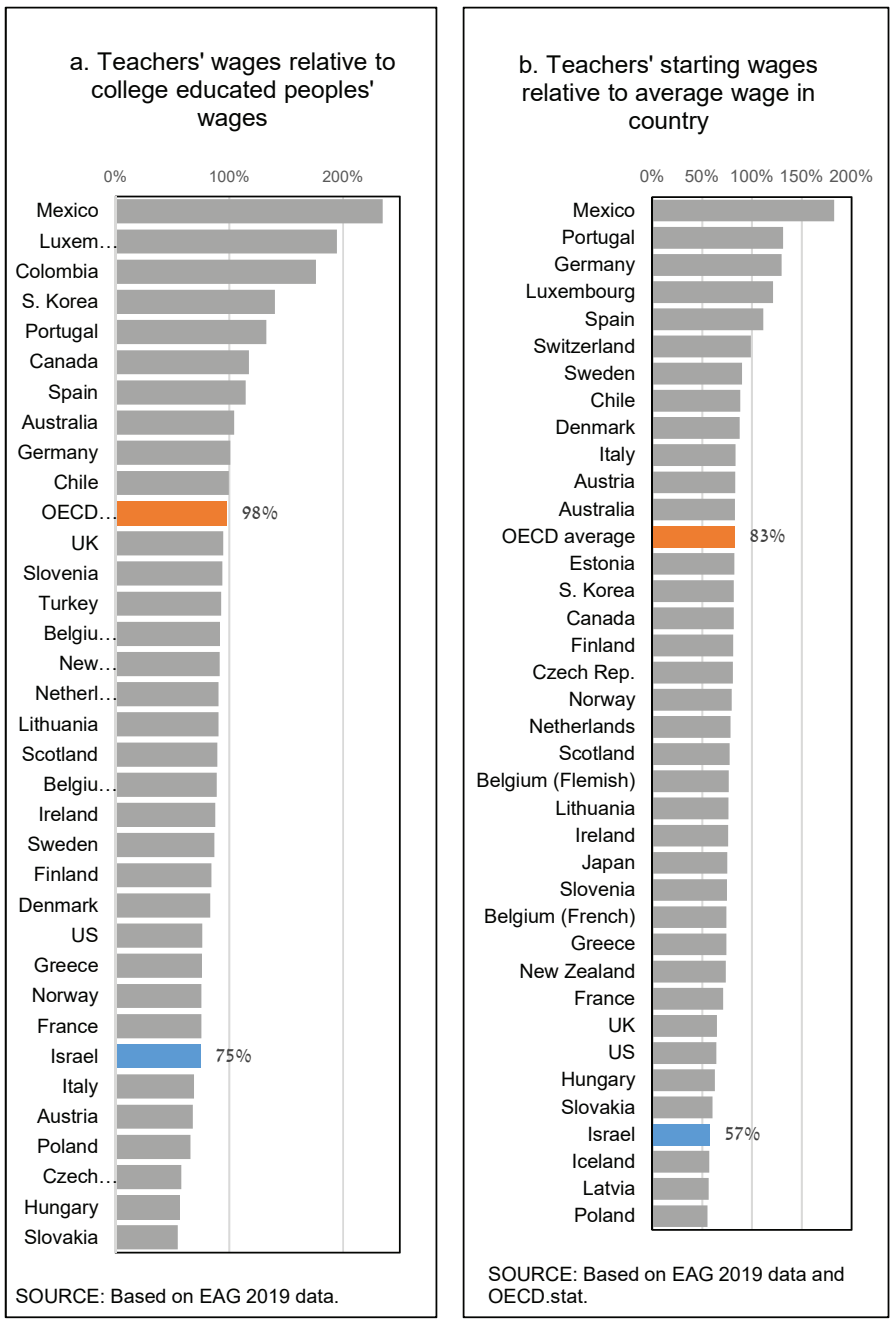
[a] The achievement gap is calculated as the difference between the grade of students who responded that they aspire to be teachers and that of students who responded that they are interested in working in a different profession requiring a Bachelors degree..
[b] Calculated as the difference in math achievement gaps between 2006 and 2018.
[c] Calculated as the difference in the share of those who aspired to be teachers and whose parents have a college education and those who aspire to be teachers and whose parents' education is less than secondary.

Another test examined the effect of the student's background characteristics on the desire to be a teacher at age 30 using a probability model (Logit) estimated for each of the OECD countries.[14] It was found that in Israel, a student's desire to be a teacher at 30 is more affected by socioeconomic status than in most OECD countries: In Israel, an increase in socioeconomic level significantly reduces the likelihood that a student will want to become a teacher, while in most OECD countries this effect was not found. This result remained the same at the three points in time examined.

One possible explanation for the great difference between Israel and the OECD countries in the socioeconomic status of those who aspire to be teachers is the variation among the population groups in Israel in relation to the teaching profession. The probability model estimation of Israeli data only, with a dummy variable for students in the State-Religious, State-Arab and Ultra-Orthodox education systems,

[14] The regression model is the reproduction of Table 4.8 from "Effective Teacher Policies: Insights from PISA" for the years 2006, 2015 and 2018. The variables included are: sex, immigration, mother tongue different from test language, socioeconomic indicator, mathematics score, reading score, whether one parent is a teacher and the school's socioeconomic average.

Figure 3
Data on salary of teachers in various stages of their career



revealed that the probability of students in these systems wanting to be teachers is significantly greater than students in the State-Hebrew system.

Table 1 shows the proportion of students who aspire to become teachers in the two major education systems (State-Hebrew and State-Arab). The proportion of teachers in the working-age population is approximately 2.5 percent in Israel.[15] The table shows that most of the students who aspire to be teachers in Israel come from the State-Arab education system (42 percent of those who responded that they want to be teachers, well above their proportion in the study population – approximately 23 percent). This education system already has an excess supply of teachers (approximately 10,000 qualified teachers who are not employed, and every year the number of new qualified teachers exceeds the number of those employed), which results in low prospects for employment. The table shows that most of the students who aspire to be teachers in Israel come from the State-Arab education system (42 percent of those who responded that they want to be teachers, well above their proportion in the study population – approximately 23 percent).

Table 1
Percentage of students who aspire to be teachers, by education system, over time

Education system	2006	2015	2018
State-Hebrew	0.9%	1.0%	0.9%
State-Arab	9.0%	**10.9%**	**8.7%**
Total Israel	4.2%	**4.9%**	**4.4%**

A statistically significant difference is shown in bold. The analysis does not include State-Religious or ultra-Orthodox school systems due to a small number of observations and large variance in the share of respondents between periods.

After reviewing the characteristics of the students who aspire to become teachers in Israel, we will try to relate the findings to the transformations that have occurred in the teaching profession in Israel and to previous studies on the subject. The lack of improvement in the relative quality of students wishing to become teachers (Figure 2.2), despite the implementation of the reforms, is consistent with findings from previous studies (Han et al., 2018), which have shown that a increase in the relative wages mainly affects the desire of the weaker students to enter the profession, while strong students are mainly influenced by the prestige of the profession and by employment conditions.[16] The main reforms in Israel raised the monthly salaries of the teaching staff, but increased the number of working hours, so that the hourly

[15] The Number of Teaching Employees by Supervision: Central Bureau of Statistics, 2019 Statistical Yearbook, Table 4.33.

[16] Strong students were defined as students in the top third of the achievements in that country, and weak students were defined as students in the bottom third of the achievements in that country.

wages of the teachers hardly changed. Comparing the wages of teachers with those of all Bachelor's degree graduates between Israel and the OECD countries shows that even after the reforms, the wages in Israel are lower than in the comparison countries (Figure 3.1).[17] According to research by Hanushek and others (Hanushek et al., 2014) in countries where teachers' wages are high relative to those of other Bachelor's degree graduates, the teachers' skills are higher, as are the students' achievements in PISA tests.

Another factor that correlates with the attraction of good applicants to the teaching profession is the starting wage.[18] Figure 3.2 shows a comparison of full-time starting wages in relation to the country's average starting wages and Israel's low ranking in this indicator. Israel's low position does not change even when the comparison focuses on the wages of academics aged 25–35: In Israel, teachers' salaries are approximately 68 percent of that of the comparison group, while the average in the other countries is approximately 87 percent.[19] In addition, in Israel, approximately 60 percent of beginning teachers are employed in a part-time position, compared to approximately 25 percent of beginning teachers in the 30 OECD countries that participated in TALIS 2018—a gap that is expected to increase pay gap between new teachers in Israel.[20]

Another reason that is found in the literature as attracting high-quality people to the teaching profession is the status of the teacher as perceived by the public. In Israel, the status of the teaching profession is low. Evidence of this can be found in the Global Teacher Status Index survey, a large-scale international survey that follows the teaching profession in 35 countries. In 2018, Israel's position according to this poll was the next to last, following the 2013 poll in which it was ranked last.[21] Similar results were also obtained in a survey that examined the attractiveness of the profession in Israel in relation to a series of professions.[22]

One of the explanations for the low status of the teaching profession in Israel is the great demand for teachers along with their relatively low wages. The low level of the actual wages is also influenced by the high proportion of part-time teachers

[17] Comparison of the statutory wage for a teacher with 15 years of seniority in a full-time position to the average salary of employees with an academic education. Education at a Glance 2019, Indicator D3, Table D3.2b.

[18] **McKinsey (2007).** "On the Causes of the Success of the World's Best Education Systems", *Hed Hachinuch Publications,* translated from English Y. Farkash.

[19] This comparison was made in conjunction with the 2015 PIAAC data for 19 OECD countries, which included wage data, Bank of Israel processing.

[20] Source: TALIS 2018 individual data, Bank of Israel processing. Part-time employment is less than 90 percent of the position. Due to a low number of observations for teachers who began teaching in Israel that year, a beginning teacher was defined as a teacher whose seniority in teaching is up to one year.

[21] The survey was conducted among 1,000 respondents and included questions on many topics; including: status of the profession as seen by the public, what do people think are teachers' wages and work hours, what are the proper wages for teachers as seen by the public, does the public trust the teachers as an educator, how many parents will encourage their children to become teachers, students' assessment of teachers and more. Using the PCA method, the various answers were weighted into one index, which is meant to represent the attractiveness of the teaching profession in an international comparison.

[22] **J. Gilat, and N. Wongrowitz (2018).** The Status of Teachers in Israeli Society Today. *Pages*, 11–27.68.

compared to the average position rate in the OECD[23]. The shortage of teachers results in a lowering of the conditions for employment and the recruitment of less qualified staff, thereby eroding the status of the teacher, which can lead to negative feedback and long-term harm to the status of the teacher. According to the State Comptroller's Report (2019), the shortage of teachers has continued for almost a decade, and in some stages of education there is, according to the comptroller, a "loose connection" between the teacher's training and the profession he teaches.[24] Reinforcement of these findings can also be found in PISA 2018 data, which show that in Israel, the rate of unqualified teachers is higher than in most OECD countries.[25]

The findings presented in this box illustrate the need for attracting quality people to the teaching profession. Recommendations of this kind have been expressed in a number of public committees that have dealt with the education system in Israel (the Guri Committee, 1960; the Etzioni Commission, 1979; the Dovrat Committee, 2005), in many policy documents by leading education researchers[26], and more recently in a special report by the Bank of Israel Research Department dealing with productivity in the economy.[27] The Productivity Report included a series of practical recommendations for improving the quality of the teaching, including recommendations for increasing the autonomy of teachers and administrators, raising the salaries of beginning teachers and adding pay components that are based on achievement, on specialization in scarce professions and on teaching in disadvantaged schools, and improving the teachers' physical work conditions. This is in addition to changes in the education system itself, which will make it possible to identify successful teachers according to their contribution and to incentivize them.

[23] According to TALIS 2018 data, approximately 70 percent of teachers in Israel are employed full-time, compared with approximately 84 percent in the 30 OECD countries that took part in the survey. The gap in position rates is expected to lead to an upward bias in Israel's data. The position rate gap also leads to the bias of the "actual wage" figure published by the OECD, as it is calculated only on a full-time teacher basis, which leads to a bias due to the high correlation between position rates and seniority rates in Israel, with the average seniority of a full-time teacher in Israel being 17.15 compared to approx. 15.4 in the OECD countries.

[24] **State Comptroller (2019).** Annual Report 96b, Ministry of Education, Teaching Personnel – Planning, Training and Placement.

[25] **OECD (2019).** PISA (2018). Results (Volume II): Where All Students Can Succeed, PISA, OECD Publishing, Paris. Table II.B1.5.3 Fully certified teachers, by school characteristics.

[26] "Fateful Search: Israeli Society is Seeking Good Teachers", *A Collection of Articles,* edited by Drora Kfir, Mofet Institute 2011. M. Ben-Peretz (2009). Position paper on the topic: The Teacher's Status: *New Directions*, Haifa University. N. Blass (2009). Improving the Attractiveness of the Teaching Profession, A Review Commissioned as Background Material for the Work of the Expert Team "Who will Learn when Teachers are Lacking".

[27] Special Report of the Research Division: Raising the Standard of Living in Israel by Increasing Labor Productivity, August 2019.

Achievement Gaps between Hebrew-Speaking and Arabic-Speaking Students[1]

- **Comparison of achievements between schools in a similar socioeconomic cross-section indicates that the achievements of Arabic-speaking schools are greater than the achievements of Hebrew-speaking schools in a similar socioeconomic cross-section. These findings support the hypothesis that the achievement gaps between the Hebrew-speaking education system and the Arabic-speaking system are mainly due to the difference in the socioeconomic composition between the two groups.**
- **The results of the study show that the claim of inefficiency in the Arabic-speaking education system in relation to the Hebrew-speaking system is not supported by the data when the comparison is focused on schools in a similar socioeconomic cross-section.**

This box deals with the achievement gaps between students in the State-Arab education system and students in the Hebrew speaking education systems.[2] The achievement gaps exist from primary education (according to the Meitzav exams) and widen throughout the advancing stages of education. In high school, the achievements of Arabic-speaking students are lower than those of their Hebrew-speaking counterparts, which is reflected in higher dropout rates and in a lower proportion of those eligible for a matriculation certificate (Figures 1-A and 1-B). The scores in the PISA 2018 tests showed that the achievement gap between the groups in the various disciplines has widened in recent years, mainly as a result of the weakening of the Arabic-speaking students' achievements (Figures 1-C and 1-D).[3] In contrast, Blass (2020)[4] found that although the achievement gaps are considerable, in recent years they have actually narrowed (as seen in Meitzav exams, completion of studies, matriculation eligibility, and the commencement of studies at an institution of higher education), in particular when comparing individuals whose parents' education is the same. Researchers from the National Authority for Measurement and Evaluation (RAMA, 2017) found a large achievement gap in mathematics in favor of Hebrew speakers, but this is greatly diminished when considering the socioeconomic background of the individuals. They note that the reason for the widened gap in the PISA tests is that the tests examine math literacy and not necessarily knowledge of the specific material studied.

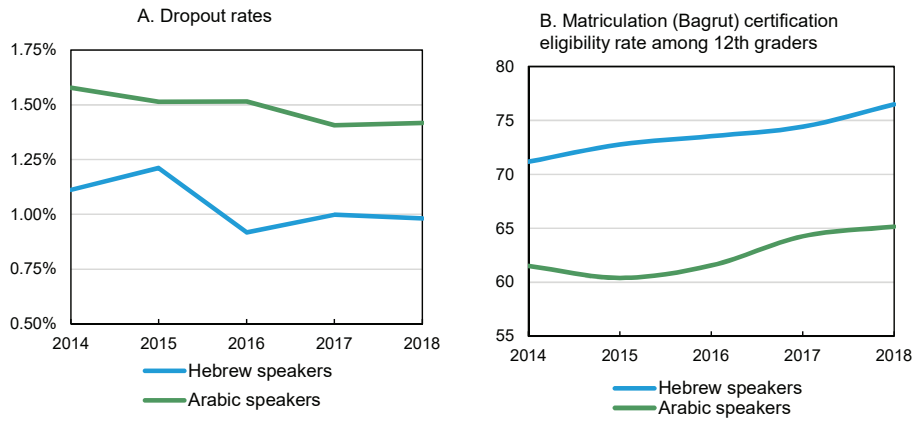
[1] Author - Sefi Bahar; Research Assistant - Uri Mishnayot.

[2] The education system in Israel is divided into four main systems (State-Hebrew, State-Arab, State-Religious and Ultra-Orthodox), serving population groups that differ from each other in their language of study, religious level and curriculum.

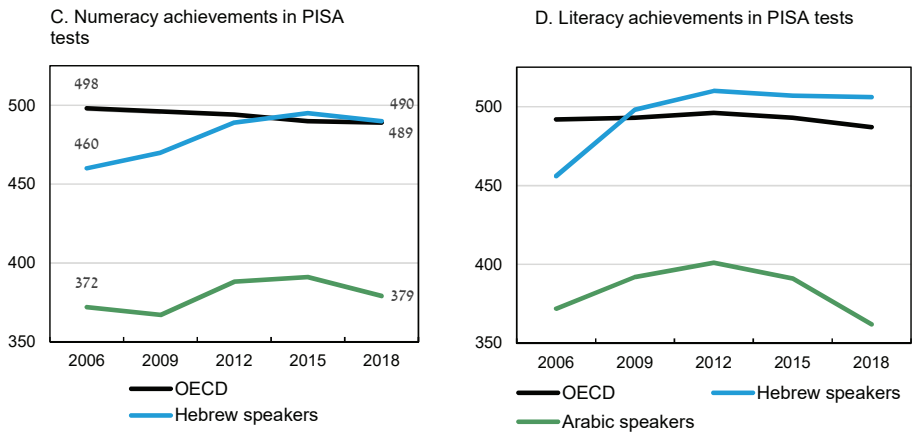
[3] National Authority for Measurement and Evaluation (RAMA) (2019). Pisa 2018: Literacy among 15-year-old Students in Ramat Gan: National Authority for Measurement and Evaluation in Education.

[4] N. Blass (2020). Achievements and gaps in the Israeli education system: A Snapshot. Taub Center.

Figure 1
Achievement Gaps between Hebrew and Arabic Speaking Stuedents in PISA and Various Upper School Indices



SOURCE: Based on Ministry of Education, the Educational picture: Upper secondary school.



SOURCE: Based on RAMA 2019.

One of the hypotheses about the source of the sectoral achievement gaps is that they stem from the inefficiency of the Arabic-speaking education system (in adapting the curriculum and allocating resources).[5] This approach questions the benefit of increasing the investment in Arab state education, arguing that increasing resources to date has not led to a narrowing of the gaps. However, this argument ignores the differences between the socioeconomic groups, a background characteristic that has been found in many studies to be correlated with low educational achievement.[6]

[5] These issues were mentioned in the remarks of the Minister of Education and the Director General of the Ministry regarding the establishment of a special examination team following the widening of the gaps in the PISA 2018 exams.

[6] OECD (2018), *Equity in Education: Breaking Down Barriers to Social Mobility*, PISA, OECD Publishing, Paris - A literature review on the effects of background characteristics on student success is presented.

A further examination of the sectoral gaps, conducted by the Chief Economist at the Ministry of Finance[7], showed that the probability of success of Arabic-speaking boys was lower than that of their Hebrew-speaking counterparts in all the variables examined (admittance to matriculation exams, eligibility for matriculation certificate, matriculation certificate that includes 5 points (the highest level) in mathematics and in English), even after considering the eighth grade achievements and the different background characteristics of the students. Among girls, the findings were mixed. According to the study's authors, "barriers and failures in high school" have a major impact on the gaps between the groups.

The unique contribution of this box to the discussion of the sectoral achievement gap in Israel is in the comparison of this gap—for the first time—among schools where the concentrations of socioeconomically disadvantaged students are similar. According to research evidence, the school environment has a strong impact on the student's achievement[8], and this is in addition to the influence of his or her personal characteristics (peer effect). Because most Arab students belong to a low socioeconomic level, their very concentration in schools with a high rate of students with low socioeconomic characteristics may explain a large part of the sectoral gaps in achievement. Comparing the (measurable) achievements of schools with the same nurture indices (see below) may therefore contribute to understanding whether the sectoral achievement gaps reflect the ineffectiveness of the Arabic-speaking education system compared to its Hebrew-speaking counterpart or, in particular, the socioeconomic level of the students.

The comparison will be made using the data of the Ministry of Education's School Nurture Index. The nurture index measures "educational deprivation" and is calculated for each student based on the following components[9]:

- Education of the higher educated parent (40 percent)
- Family per capita income (20 percent)
- School peripherality (20 percent)
- Combination of immigration and distressed country (20 percent)

The index score is divided into deciles. Decile 10 contains the students who need the highest level of nurture (i.e., those whose background characteristics are the lowest) and Decile 1 contains the students who do not need additional nurturing (i.e., those with the strongest background characteristics). This box has used the highest level of detail published by the Ministry of Education—the nurture decile at the school level. In early education (elementary and middle school) the nurture index is an operational tool for differential resource allocation ("nurture basket").[10] The differential resource

[7] Chief Economist Division, 2019, Weekly Economic Review - "On the Gaps between Arab and Jewish Students in Matriculation Achievements" April 29, 2019.

[8] OECD (2018). *Equity in Education: Breaking Down Barriers to Social Mobility*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264073234-en.

[9] Ministry of Education website - https://edu.gov.il/sites/Shaar/Pages/madad_tipuach.aspx

[10] In high schools, there is no differential budgeting.

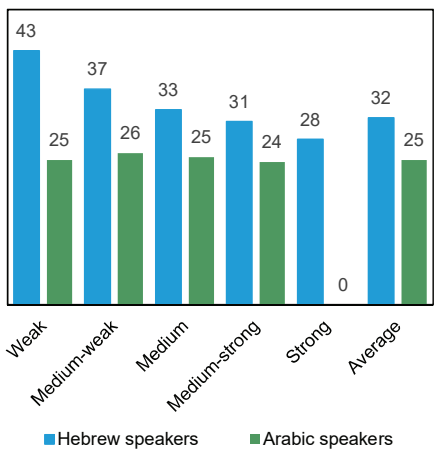
allocation is mainly expressed in the number of hours, negligible in relation to the number of students in the class and not present in the teachers' wages.

In Israel, most students in the high deciles of the nurture index are Arabic-speaking students. These students receive a significantly lower allocation of resources compared to Jewish students who are in a similar nurture decile, and the resource allocation gaps continue throughout the educational stages. The largest budgeting gaps are in the high schools[11]. Figure 2-A presents the distribution of students in high schools by sector and quintiles, and shows that the quintile containing the strongest students (Deciles 1 and 2) does not have Arabic-speaking students. Most of the Arabic-speaking students (63 percent) are concentrated in Deciles 9 and 10, which have almost no Hebrew-speaking students (6 percent). Figure 2-B shows the budgeting for a student in high school, according to the grouping of the nurture index quintiles.[12] Although there is no formal differential allocation of resources according to this component in high schools, there is a positive correlation between the nurture decile and the expenditure per student with regard to Hebrew speakers (0.412), but not regarding Arabic speakers.

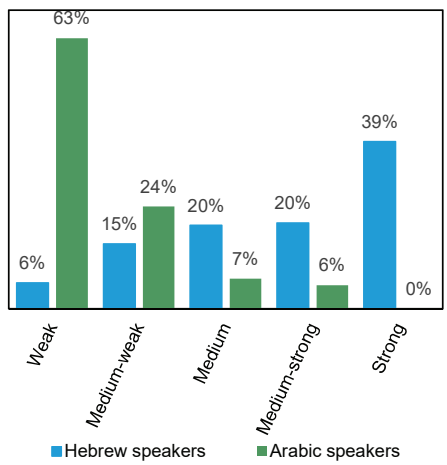
According to the Ministry of Education, most of the budgeting gap in high schools

Figure 2

B. Average Cost per Secondary School Student, by Sector and Nurture Quintile, NIS thousands



A. Distribution of Secondary School Students,



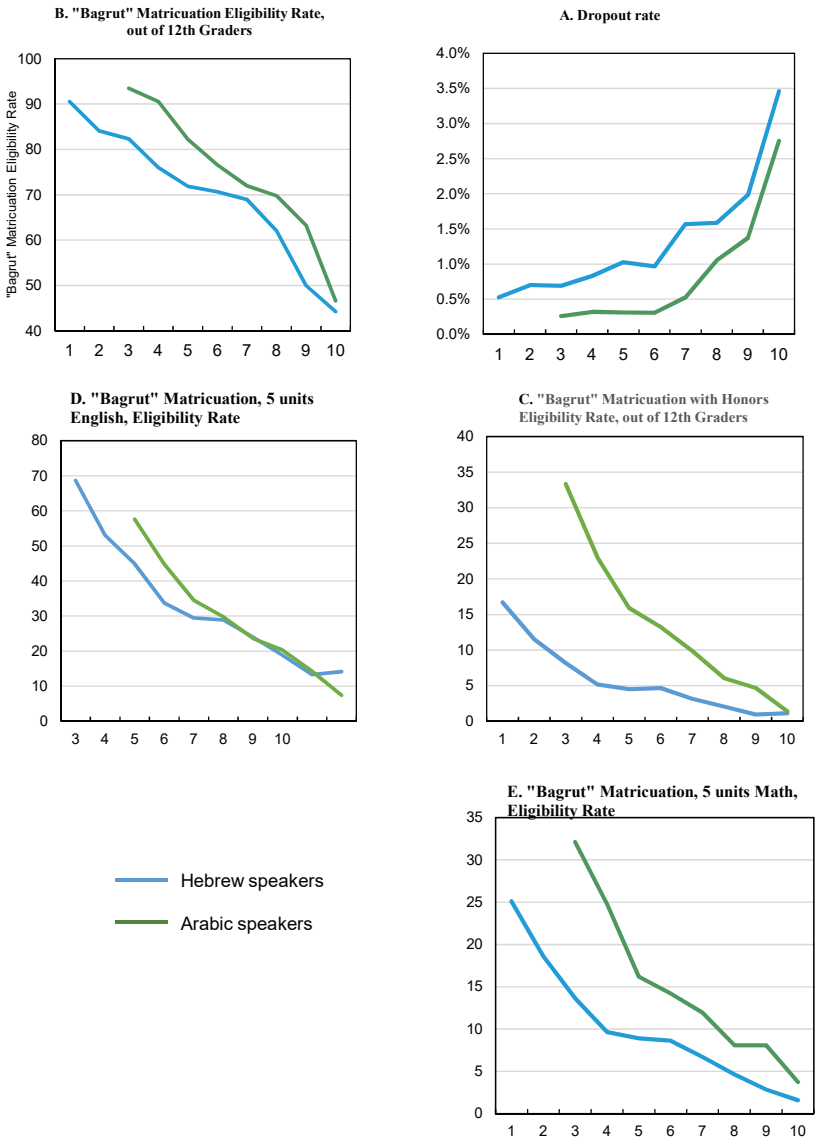
SOURCE: Transparency in Education findings.

is due to unique additions for students in the State-Religious education system (many hours, extra Jewish studies, etc.), from the disproportionate allocation of high-quality special classes among Hebrew speakers (Gifted students, MABAR, ETGAR, HILA, TOB, etc.), and differences in teacher characteristics that affect wages (such as

[11] Ministry of Education (2019), Key Findings of the Education Budget Transparency System – 2019.
[12] The group ranges from Deciles 9-10, "weak" to Deciles 1-2, "strong".

seniority and Master's degree).[13] Another explanation for the gaps lies in differences in the courses of study, in particular the high representation of Hebrew speakers in the scientific technology fields, characterized by high costs.[14]

Figure 3
Distribution by Sector and Nurture Deciles in Several Outcome Indices in Secondary School, 2014–18, "Transparency in Education" Findings



SOURCE: Based on Ministry of Education, the Educational picture: Upper secondary school.

[13] Ministry of Education (2019), Key Findings of the Education Budget Transparency System – 2019.

[14] Hadas Fox, Guy Yanai, and Nachum Blass (2018) Techno-Vocational Education: Trends and Developments in the Years 2006–17, Taub Center for Social Policy Research In Israel.

Despite the low allocation of resources, in almost all deciles of the nurture index (Figure 3), the average achievement of Arabic-speaking school students exceeds that of the Hebrew-speakers. In some of the variables, the achievements of students in Deciles 3 and 4 of the Arabic-speaking schools (approximately 9 percent of the institutions) are even greater than in Deciles 1 and 2 of the Hebrew-speaking schools (approximately 28 percent of the institutions).

Similar results were also obtained by using an econometric model that compares the achievements in high schools with the same nurture index from different sectors. The database is taken from the "Transparency in Education" website, which gives access to extensive information on the educational institutions operating in Israel regarding the academic years 2014–2018.[15] To examine the sectoral achievement gaps, we estimated the following model:

$$Y_{s,t} = \alpha + \beta_1 Arab + \beta_2 Madad_{s,t} + \beta_3 x'_{s,t} + \delta Year_t + \varepsilon_s$$

Where is the outcome variable of school s in year t. The outcome variables examined are: the students' dropout rate; the percentage of 12th grade students eligible for matriculation; the percentage of 12th grade students eligible for an outstanding matriculation certificate[16]; the percentage of those eligible for a matriculation certificate that includes 5 units of English or mathematics.[17] is a dummy variable that receives the value 1 for an Arabic-speaking school (Arabs, Druze and Bedouins) and 0 otherwise. is a set of dummy variables that represents the nurture index to which the school belongs. is a vector of background variables that describe the characteristics of the school: the median seniority of the teachers, the median seniority of the teachers squared, the percentage of teachers with a Master's degree, the percentage of students eligible for study adjustments in the matriculation exams and the percentage of invalidated tests. is a set of dummy variables for the relevant school year.

The dummy variable for an Arabic-speaking school represents the achievement gap between an Arabic-speaking school and a Hebrew-speaking school when considering the school's other characteristics. Its estimates are presented in Table 1, where each row represents a different outcome variable, and each column has a different specification of the model (inclusion of nurture indices, school characteristics) or a different study population (exclusion of the ultra-Orthodox). Column 1 shows that when the school characteristics are not taken into account, the achievements of Arabic-speaking students are significantly lower than their Hebrew-speaking counterparts (except for the eligibility rates for an outstanding matriculation certificate). Column 2

[15] https://shkifut.education.gov.il/national

[16] An outstanding matriculation certificate is a matriculation that includes 5 units of English and at least 4 units of mathematics, with an average grade of at least 90 and includes excellence in the program for personal development and social-community involvement. "Transparency in Education" website.

[17] Outcome variables were calculated according to the Ministry of Education's definition. For further details on the calculation method, see the "Transparency in Education" website.

shows the estimations when considering the impact of the nurturing indicator, that is, comparing students who are in schools with similar socioeconomic status. The results in this column are reversed: and the achievements of the Arabic-speaking students are significantly greater than those of their Hebrew-speaking counterparts who have the same nurture index.

A possible explanation for the discrepancies between the similar groups in terms of the nurture index is the relative weakness of students in schools under ultra-Orthodox supervision. This is despite the fact that the ultra-Orthodox schools included in this study are only those who teach for the matriculation exams, like the other groups. In Column 3, we excluded the ultra-Orthodox schools, and there is still a significant gap in favor of the Arabic speakers in most of the outcome variables, except for the rate of eligibility for a matriculation certificate with 5 units of English (an insignificant gap in favor of the Hebrew speakers).

Table 1 Estimation results, differences between Arabic speakers and Hebrew speakers

	1	2	3	4	5
Dropout rate	0.38**	-0.90***	-0.68***	-1.02***	-0.67***
Eligibility rate: Bagrut matriculation,	-9.93***	10.42***	0.83***	19.39***	16.74***
Eligibility rate: Bagrut matriculation with honors	0.01	6.78***	6.81***	8.36***	8.69***
Eligibility rate: Bagrut matriculation, 5 units English	-18.15***	2.72*	-0.80	6.90***	3.22*
Eligibility rate: Bagrut matriculation, 5 units Math	-2.22***	6.63***	4.58***	7.70***	6.88***
Nurture index	X	V	V	V	V
School characteristics	X	X	X	V	V
Ultra-Orthodox	V	V	X	V	X

In Column 4, we added a set of variables that control for the school characteristics, due to the significant differences between the groups in a number of background variables that are not reflected in the nurture index, and may be correlated with the outcome variables examined: The gaps in the median teaching seniority (-3.7 years in the Arab sector), in the percentage of teachers with a Master's degree (-6 percent), in the percentage of students with study adjustments (-23 percent) and the higher rate of invalidated tests (1.4 percent) may influence the various outcome variables.[18] The inclusion of these variables led as expected to an increase in the gaps estimated in all outcome variables examined; these remained significant even after the exclusion of the ultra-Orthodox schools, but their estimated scope was reduced (Column 5).

The findings presented in Table 1 reinforce the hypothesis that the achievement gaps between the Hebrew-speaking education system and the Arabic-speaking system are mainly due to the difference in the socioeconomic composition between the two

[18] The gaps presented are in comparison to the Jewish population, with the exclusion of the Ultra-Orthodox. When the Ultra-Orthodox are included, some of the gaps are narrowed, but still remain significant.

groups. This means that the claim of ineffectiveness in the Arabic-speaking education system in relation to the Hebrew-speaking system is not supported by the data when the comparison is focused on schools in a similar socioeconomic cross-section.

Table 2
Estimation results, differences between Arabic speakers and Hebrew speakers, limited sample of nurture deciles

	1	2	3	4	5	6	7	8
Dropout rate	-0.61***	-0.63***	-0.65***	-0.65***	-0.68***	-0.73***	-0.62***	-0.60***
Eligibility rate: Bagrut matriculation,	8.80***	8.72***	7.43***	7.50***	5.94**	5.82*	11.16***	10.46***
Eligibility rate: Bagrut matriculation with honors	8.01***	8.00***	9.74***	8.68***	6.81***	6.32***	17.37***	17.20***
Eligibility rate: Bagrut matriculation, 5 units English	0.45	0.13	1.48	1.05	-0.80	-0.34	7.09**	6.77**
Eligibility rate: Bagrut matriculation, 5 units Math	6.25***	6.23***	6.83***	5.91***	4.58***	4.34***	11.69***	11.41***
Nurture indices	2-9	3-9	3-8	4-8	5-8	6-8	3-5	1-5
Percent of secondary school that are Hebrew speake	82%	68%	61%	50%	41%	32%	30%	58%
Percent of secondary school that are Arabic speakers	65%	65%	41%	35%	32%	29%	12%	12%

*The row was calculated relative to the number of schools included in the estimation out of total schools in the relevant population.

In order to address the widespread distribution of the groups between the nurture indices and the lack of overlap between the Hebrew-speaking schools and the Arabic-speaking schools in the number of schools included in the nurture indices, especially the extreme ones (Figure 2-A), we conducted a number of estimations on a small sample of nurture deciles in which both groups are significantly represented. Table 2 shows the estimate of "Arabic speaker", and the difference between the columns is the nurture deciles that were included in the estimation. In the bottom two rows, the percentage of schools included in the estimation for each group is noted: 30–82 percent of all Hebrew-speaking high schools and 12–65 percent of all Arabic-speaking high schools. From the estimation results presented in Columns 1–6, which include the weakest students in both groups, it can be seen that the achievements of Arabic-speaking students are better than those of their Hebrew-speaking counterparts in all variables, except for the eligibility for a matriculation certificate with 5 units of English studies.[19]

In Columns 7 and 8, we examined the gaps between the strong students in both groups; in Column 7, there is an overlap between the schools in the different nurture deciles and in Column 8 we also included Deciles 1 and 2, which do not have Arabic-speaking schools. The results show that the achievement gaps in favor of the Arabic-speakers are maintained and even widened when the students with relatively strong background characteristics in both groups are compared.

The results presented in this study relate only to high school students. This is important to remember, because there is a gap between the two groups in the study rates (the number of students from the number of children in the age group) and it may bias the results in favor of the Arabic-speaking schools, due to the dropping out

[19] A possible explanation for the achievement gaps in English is that the English language is the third language for Arabic-speaking students and the second language for Hebrew speakers.

of the weak students before high school. The gap in the study rate between the groups in high school is approximately 3 percent[20], a rate that is lower than in most of the estimates obtained in Tables 1 and 2. Therefore, despite the gap in study rates, the findings presented in the box remain the same.

The Research Department's Productivity Report points to the importance of closing the achievement gap between Hebrew-speaking and Arabic-speaking students, and its implicit contribution to the future growth of the economy. The above findings show that the results achieved by the State-Arab education system are better than those achieved by the state education in the Jewish sector, at least in schools where there is an overlap in the nurture indices. Given the low resources allocated to them, the State-Arab education's use of resources seems to be effective. Therefore, a more balanced allocation of resources can help accelerate the narrowing of gaps in student achievements and skills. Detailed recommendations in this regard are included in the Productivity Report, and include increasing the progressiveness of instruction hours and creating progressive teacher wages. This is to attract quality teachers to schools where the improvement of achievement is an educational challenge of primary importance. Steps to reduce budgetary gaps to the detriment of the Arab education have been taken within the five-year plan in Arab society. (For further information, see box below).

We should qualify our statement and say that in interpreting the findings of the analysis presented above regarding the Arabic-speaking schools in the higher nurture deciles (the weakest schools), the absence of a comparison group sufficiently similar in the Hebrew education system should be taken into consideration. Approximately 35 percent of Arabic-speaking schools are in Decile 10, including most Bedouin schools (75 percent). Because of the important role of the local authorities in the education system in general and in high schools in particular, combined with the many differences between the localities in the Arab society, it is not obvious that the education system in these localities is just as effective as the system in the stronger localities. However, it is argued that the above findings have weakened the opposing argument that the achievements indicate an ineffective utilization of the relatively scarce resources allocated to the Arab education system.

[20] Nachum Blass (2020) – See Note 3.

Government Activity under Resolution 922 in the Field of Education

Resolution 922 deals with the government's activity for economic development in the minority population in the years 2016–20, with the aim of "reducing the social and economic gaps in the minority sectors in Israel". The Resolution is implemented through a five-year plan, which involves the cooperation of 15 government ministries and local authorities in five main areas: physical infrastructure, employment and economics, education and higher education, empowering local authorities and society and community. Implementation of the five-year plan requires meeting many challenges, which has resulted in a low budget execution rate (at the authority level) – approximately an actual 33 percent of the allocation; the education field stands out favorably at a higher rate of implementation (budget execution of approximately 70 percent).

The Ministry of Education has defined a number of outcome targets that it intends to achieve in the program by 2021, including:

- Increasing the professional level of teachers in the Arab education system.
- Improving student achievements:
  - Reduction of dropout rate to 3 percent.
  - Increasing matriculation certificate eligibility rates to 73 percent of 12th grade students.
  - Increasing the eligibility rates for a quality matriculation certificate to 62.5 percent of those who qualify for a matriculation certificate.
- Increasing the number of children and youth participating in informal education activities.
- The steps taken by the Ministry of Education to achieve these goals are:
- Teacher training – In Arab society, there is an excess supply of teaching staff (more than 10,000 qualified teachers waiting for a position). The problem is exacerbated, as every year the annual amount of training exceeds the annual demand of the Arabic-speaking education system. As a result, employment rates and extent of employment among employed persons are low, leading to difficulties integrating into the education system and even to lowering the quality of applicants. In order to meet the challenge, the Ministry of Education, within Resolution 922, has taken a number of steps related to the training of the teaching staff throughout the career stages:
  - Applicants to Teaching Colleges – Increasing the admission requirements for teaching colleges, adding tests of the knowledge of Arabic and Hebrew, expanding the program for excellence.
  - Teaching students –
    - Programs for improving proficiencies in Arabic and in Hebrew. (These are intended, among other things, to help absorb Arabic-speaking teachers into the Hebrew-speaking system, and over 1,000 have already succeeded in being integrated.
    - Expanding the amount of participants in quality practical training programs ("Academia-Kita", PDS).
    - Developing courses on identity and culture, establishing units for social involvement, and opening courses to strengthen the students' academic proficiencies.
  - Improving the absorption mechanism in the system (absorption and internship)

        - Integrating quality metrics into teacher placement procedures in Arab society – A tool that is intended to help sort candidates based on achievements in the training program.
        - "Getting out in the field" in the internship workshops in "incubators" in schools and localities with the aim of adapting the training to the unique needs of the place.
    - Professional development throughout the career –
        - Workshops for developing pedagogical leadership in the school (empowerment of the mid-levels); developing professional study communities – a proactive model of teachers studying various disciplines; strengthening the PISGA centers (teaching staff development) by allocating additional resources and programs to accompany the centers' staff.
    - Additional steps –
        - Strengthening the teaching-support resource through the establishment of a volunteer system (retirees and students); improving teaching staff evaluation processes by accompanying administrators and training them to conduct assessments as a tool to promote teacher development;
        - Developing Arabic online courses for teacher study.
        - Simulation workshops in Arabic – Using actors to simulate various situations in the classroom.

The incremental cost of these measures is estimated at approximately NIS 56 million.

- Improving student achievement – Increasing the differential allocation of resources. Adding and pooling of differential hours, approximately 35,500 in elementary and approximately 21,500 in middle school, and implementation of a pilot for differential budgeting in high schools. In addition, the program includes additional budgeting for Hebrew study programs in the various education stages. The cost of these measures, most of which are not budgeted under Resolution 922, is estimated at approximately NIS 960 million.
- Informal Education – Within the program, informal education has begun in 76 municipalities, and the number of students taking part in these activities in 2019 is estimated at more than 91,000, higher than the goals set for the program (an updated target of 90,000 in 2021 and originally 50,000). The investment in informal education has several components:
    - Developing culturally appropriate dedicated solutions for Arab society;
    - Development of the local authority's human and physical infrastructure for institutionalizing an informal education system—appointing directors and members of the community. Establishing the school as an anchor for the community in the afternoon (classes, educational activities, young leadership, community enterprises and more), establishing 17 new community centers and more.

Municipal Solid Waste: The Problem and Economic Tools to Deal with It

- The quantity of municipal waste per capita in Israel is one of the highest among advanced economies, and the recycling rate is among the lowest in those countries.
- The waste problem in Israel is liable to become more severe due to population growth and an expected rise in the standard of living.
- Economic tools play an important role in mitigating waste quantity and improving waste treatment; Israel has been putting them to growing use in recent years. An improvement in setting the level of levies and expanding their incidence may enhance their contribution to dealing with the problem.

1. General remarks

Municipal solid waste—household garbage, commercial garbage, and yard waste[1]—causes considerable harm to the environment even when it is managed systematically. The nature and severity of the damage are affected by the quantity, composition, and methods of treatment of that waste. The growing worldwide awareness of these kinds of damage, together with the complexity of invoking policy tools to reduce the quantity of the waste and to treat it, are bringing the issue to the fore and spurring a continual search for appropriate tools. In Israel, the problem is already acute due to large quantities of waste per capita and a low recycling rate. Population growth and rising standards of living could make the situation even worse.

To negate the harmful environmental effects of municipal waste by reducing its quantity and improving its composition, economic tools are central due to their ability to influence people's behavior and their importance in creating funding mechanisms. Along with economic tools, which are often accompanied by regulatory tools, it is very important to enhance the public's awareness of the harm occasioned by this waste and of its ability to help mitigate the damage, particularly given the limitations of regulation and economic tools.

2. The harmful effects of municipal solid waste

The two principal ways of removing non-recycled waste systematically are landfill and incineration. The more these methods rely on advanced and stringent processes, the more the environmental damage associated with them can be reduced, albeit not totally eliminated.[2]

The damage occasioned by landfill includes pollution of soil, air, and water (surface and ground), greenhouse-gas emissions (chiefly methane), stench, taking up land, and

[1] Commercial waste is the kind created by businesses such as shops, marketplaces, offices, restaurants, shopping and entertainment centers. The definition of municipal waste excludes industrial waste, construction waste, and sewage. The disscussion here does not deal with them.

[2] Calculating the total cost of the damage (and comparing it with the cost of mitigation measures) is a very complex task, with which this discussion does not deal.

damage to open spaces. These ravages, or the risk of their occurrence, may last years after the landfill is closed. The greenhouse gases that originate in waste account for 8 percent of total greenhouse-gas emissions in Israel. The amount of land that Israel will have to set aside for landfill in the next twenty years is estimated at 250–400 hectares. Furthermore, the main landfill site is in the southern part of the country, making it necessary to haul the waste from population centers that are 150 kilometers away, on average.[3]

The damage caused by incinerating waste includes emissions of carbon dioxide and sundry air pollutants and the impact on land uses in the vicinity of the treatment facilities. The production of a unit of electricity by incinerating waste emits roughly as much greenhouse gas as would be emitted by using natural gas.[4] Building several incineration facilities near population centers may reduce the cost of transporting the waste but would not eliminate it totally.

3. Quantity and recycling rate of waste in Israel

Israel has one of the highest quantities of per-capita municipal waste in the developed world. This quantity has been growing over time, albeit less rapidly than the increase in income (Figures 1a, 1c).[5] The increase in quantities of waste as standards of living rise is not unique to Israel: A positive correlation is also evident when comparing among OECD countries. Such an increase, however, is not inevitable; several OECD countries have managed to reduce their quantity of per-capita waste considerably since 2000 despite per-capita GDP growth.[6]

The positive relation between the socioeconomic index of local authorities in Israel and the quantity of per-capita waste that they generate (Figure 1b) is consistent with the correlation described above. An econometric analysis of the determinants of the quantity of waste per capita in local authorities corroborates the correlation (Table 1). The elasticity of this quantity with respect to the average wage in the locality,

[3] Ministry of Environmental Protection (2018), *Policy Document on Promoting the Construction of Facilities for Energy Recovery from Municipal Waste in Israel*. For a survey of additional partial estimates of the cost of landfill use in Israel, see Doron Lavee (2020, forthcoming), "Environmental Economics in Israel," *The Israeli Economy, 1995-2017: Lights and Shadows in the Market Economy,* edited by Avraham Ben-Bassat, Reuven Gronau, and Asaf Zussman, Cambridge University Press (hereinafter: Lavee, 2020).

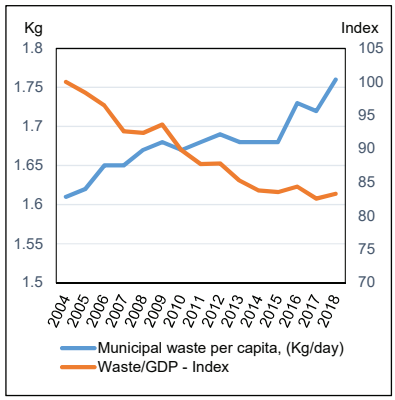
[4] Ministry of Environmental Protection (2018), *Policy Document on Promoting the Construction of Facilities for Energy Recovery from Municipal Waste in Israel.*

[5] Figure 1c shows 2017 data; therefore, several countries are missing. The 2015 data, covering most OECD countries, indicate four countries generate more waste per capita than Israel does—the US, Switzerland, Germany, and Luxembourg.

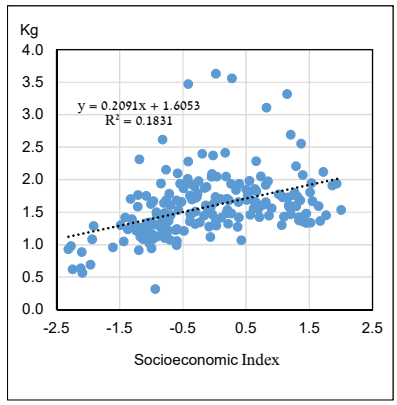
[6] OECD (2019). *Waste Management and the Circular Economy in Selected OECD Countries: Evidence from Environmental Performance Reviews* (hereinafter: OECD, 2019).

Figure 1
Municipal Waste in Israel and the OECD

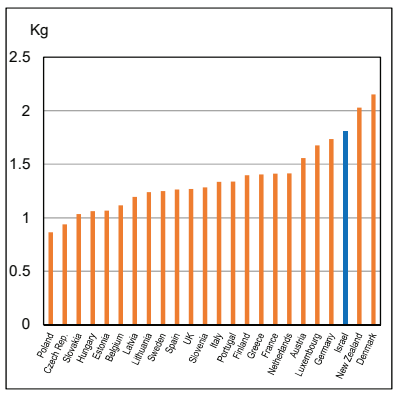
A. Waste per Capita (Kg/day) and Ratio of Waste to GDP (Index), Israel 2004–18



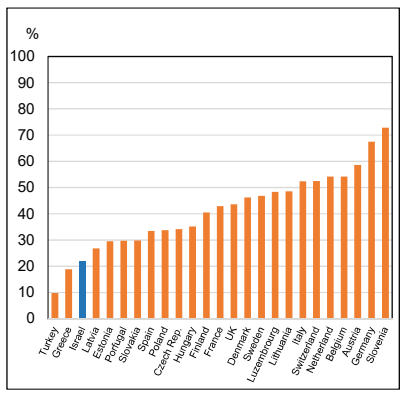
B. Waste per Capita (Kg/day) and the Locality's Socioeconomic Index, Israel 2018[a]



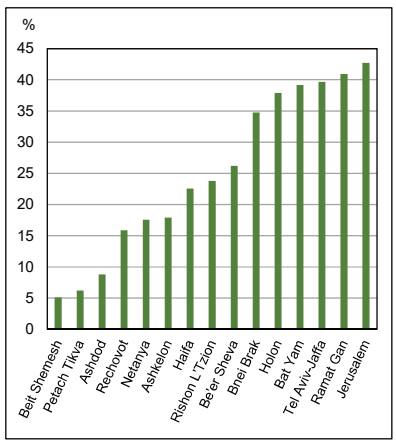
C. Waste per Capita (Kg/day), OECD, 2017



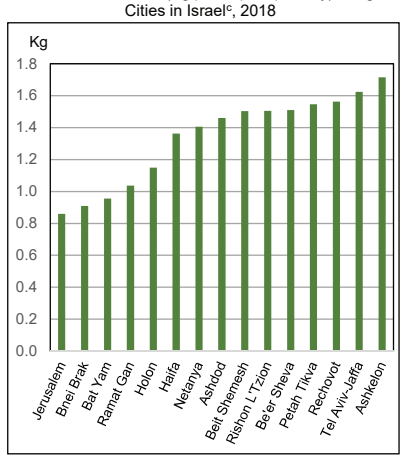
D. Recycling Rate[b], OECD, 2017



E. Recycling Rate[b], Large Cities in Israel[c], 2018



F. Waste for Landfill (Kg per capita, per day), Large Cities in Israel[c], 2018



[a] Cities and local councils. The socioeconomic index - 2015 data. Two outlier observations were excluded from the figure, adding them in strengthens the positive correlation.
[b] Recycling rate: The weight of waste (including yard waste and organic matter) sent for recycling as a percent of total weight of waste.
[c] Cities with a population at the end of 2018 of more than 100,000 residents.
SOURCE: Based on Central Bureau of Statistics and OECD.

controlling for locality characteristics,[7] is estimated at 0.39, meaning that a 10 percent increase in income boosts the quantity of waste per capita by 3.9 percent. A locality's recycling rate, however, also rises with income; as a result, the per-capita quantity of waste hauled to landfill does not increase significantly with income. This emphasizes the importance of recycling as one of the ways to cope with the waste problem. In practice, Israel has one of the lowest recycling rates in the developed world (Figure 1d).[8] The perceptible differences among Israel's major cities in their recycling rates (Figure 1e) suggest that improvements in municipal conduct may boost these rates and reduce the quantities of waste that are taken to landfill (Figure 1f). Obviously, this quantity also depends on the amount of raw (pre-recycling) waste, which is influenced by various local characteristics (Table 1).

Table 1
Determinants of waste quantity and recycling rates, local authorities in Israel[1], 2018

	Per-capita waste (log kg/day)		Waste to landfill (log kg/day/ per capita)		Recycling rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Avg. wage in locality (log)[2]	0.457***	0.386***	0.133*	0.055	25.127***	25.685***
	(0.068)	(0.063)	(0.074)	(0.071)	(2.774)	(2.877)
Area liable to residential property tax as a percentage of total tax-liable area		-0.003***		-0.003***		-0.047
		(0.001)		(0.001)		(0.032)
Area liable to commercial property tax as a percentage of total tax-liable area		0.043***		0.039***		0.296
		(0.006)		(0.007)		(0.275)
Population density per built residential area (log)[3]		-0.157***		-0.213***		4.531***
		(0.036)		(0.04)		(1.629)
R^2	0.187	0.391	0.016	0.215	0.293	0.335
No. of observations	201	197	200	196	200	196

1. Not including regional councils.
2. Average monthly wage, employees, 2017.
3. 2013 data.
Source of data: Central Bureau of Statistics (2018 local authority data file), processed by Bank of Israel.
* Denotes 10% significance level; ** 5% significance level; *** 1% significance level

[7] The more nonresidents reach a locality for employment, commerce, tourism, services, and leisure purposes, the more the locality would be expected to generate waste relative to its own population. The percentages of areas liable to residential and commercial property tax have a significant effect, in the expected direction, on the quantity of waste per capita. (Since municipal waste does not include industrial waste, there is no need to control for the extent of industry in the locality.) The less densely populated a locality is, the more area we would expect to find devoted to private gardens per capita, resulting in more yard waste. The coefficient of population density per built area comports with this hypothesis. Public-garden area per capita is not found to have a significant effect, possibly due to a large number of missing observations. There are no data that separate yard waste from waste at large.

[8] The recycling rate includes recycling of organic waste, which in Israel today is comprised largely of composting— transforming organic waste into fertilizer.

The composition of waste strongly affects its potential for treatment and recycling as well as for environmental harm. Today, there are no authoritative data on the composition of total waste in Israel in terms of substances and sources (household, commercial, yard waste). Food residues account for about one-third of household waste in terms of weight; plastic contributes only 18 percent of weight but 40 percent of volume.[9] Plastic is common in both packaging and products. Many policy tools in Israel and other countries concern themselves with it, due to both the damage it causes and the practicability of limiting its use or separating it from other waste and recycling it.[10]

4. The waste management problem—basic characteristics and principles of treatment

Like other environmental issues, the basic problem with waste is a market failure: Producers of waste do not internalize the externalities of their behavior. Therefore, the optimal and practicable solution for many environmental problems lies in identifying polluters and making them pay for their activity (or submit to compulsory regulation).[11]

Charging households or businesses a fee in accordance with the quantity and composition of the garbage they produce would do much to correct the market failure. The problem that makes municipal waste special is the difficulty in collecting such a fee (or enforcing regulation) at the time individuals toss their garbage. Furthermore, while the municipal authority collects and disposes of garbage in a concentrated way, and thus sustains the cost of these activities, it is not directly affected by much of the damage occasioned by the waste (after it is collected)—necessitating policy tools that will cause the authority, too, to internalize this damage.

Figure 2, plotting the life of a product from manufacture to the end of its treatment as waste, helps to demonstrate the problem and the principles of management derived from it. The difficulty in charging a fee when something is put in the garbage restricts the use of economic tools that act directly on this stage of the product's life, in which dependency on individuals' voluntary behavior is high. Accordingly, policy tools based on taxation, fees, and regulation focus on other stages of product life—manufacture, purchase, and management of waste (and of recyclable materials)—and are meant to

[9] Ministry of Environmental Protection (2014), *National Survey on the Composition of Waste, 2012–2013*.

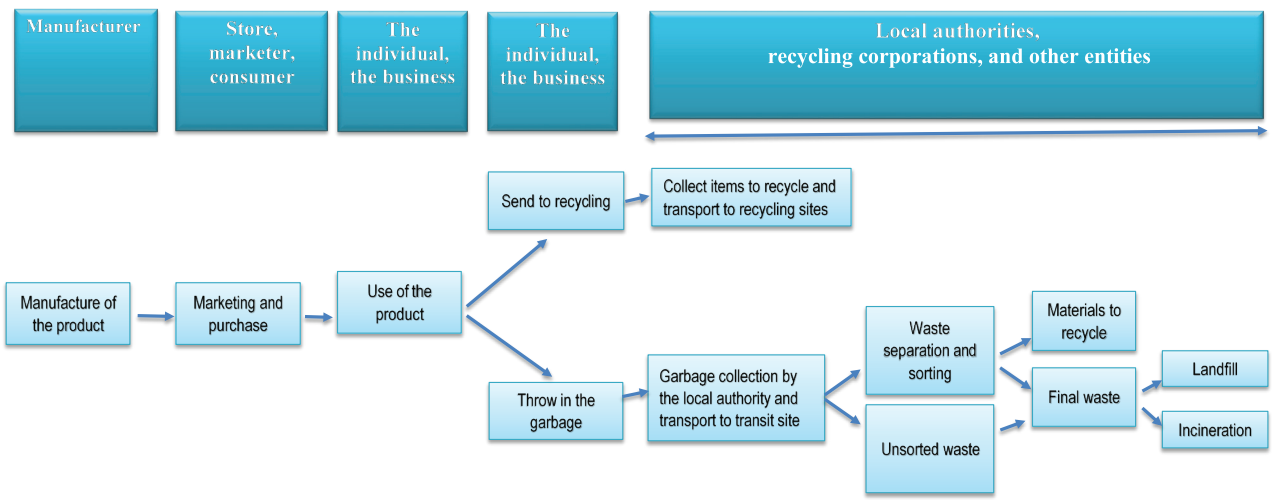
[10] The discussion here focuses on municipal waste that is systematically treated. One of the characteristics of plastic is the ease with which some of it (e.g., bags and disposable utensils) evades systematic treatment and reaches open areas, including bodies of water, causing their degradation.

[11] Examples are taxation of fuel, coal, and carbon. Taxes or regulation on the basis of direct measurement—emissions of pollutants by factories and motor vehicles, monitoring of effluent at factory exit. Advanced taxation of travel, e.g., via congestion pricing—is developing rapidly in the wake of new technologies. The consumer water rate makes it possible to build in a payment commensurate with the quantity of sewage that the consumer creates.

influence the other stakeholders as well: producers, vendors, local authorities, and so on.

From the environmental standpoint, reducing gross waste is at the top of the scale, followed by recycling, and, finally, optimal disposal of final waste. Thus, the right thing to do from this perspective is reduce the quantity of final waste as much as possible and to affect its composition, by using tools that aim to influence behavior upstream (in the manufacturing, marketing, and consumption stages) even if they are implemented downstream. As for the final waste created, the question is which method of disposal is preferable—landfill or incineration? This question is not discussed here.

Figure 2
The Product Lifecycle



5. Policy tools for waste quantity mitigation and treatment[12]

Table 3, at the end of the discussion, maps the main types of policy tools for waste management and those used in Israel and, pursuant to Figure 2, classifies them by the stages in product life at which each tool is put to use. This separation is somewhat artificial because the stages are linked and some of the tools operate at more than one stage.

(1) Manufacture, vending, and purchase

The purpose of tools that focus on the manufacturing, importation, and purchase stages is to mitigate the waste problem before it is created (i.e., at source) by affecting the composition of materials used in manufacturing the product. As the players (manufacturers, importers, consumers) can be readily identified at this stage, it is relatively easy to levy taxes and duties—that may be used to fund management of the waste at the end of product life—and to enforce product standards.[13] A conspicuous example abroad is the ban on, or mandatory charging for, single-use plastic shopping bags. In Israel, large food chains have had to charge for them since the beginning of 2017. Thus far, this is the only tool in Israel that is designed to mitigate municipal waste at source. In its first year of effect, the number of bags taken by customers at these chains declined by 80 percent.[14]

(2) End-of-use stage

When a product reaches the end of its use, the consumer decides whether to throw it out or to sort it and transfer some of it to recycling. At this stage, as stated, it is very hard to measure the quantity and composition of garbage that individuals toss. There are few examples of charging individuals commensurate with the quantities of waste that they produce, and most are based on rough and indirect estimates of the amount of the waste—meaning that individuals are not charged the real marginal cost. Actual measurement is rare and in many ways problematic.[15]

[12] For a detailed survey of the range of tools applied by various countries, see OECD (2019) and Thornton Matheson (2019), "Disposal is Not Free: Fiscal Instruments to Internalize the Environmental Costs of Solid Waste," *IMF Working Paper WP/19/283* (hereinafter: Matheson, 2019).

[13] These measures may be susceptible to pressure from groups that are harmed by the proscription of a given product or the raising of its price. As a result, these taxes are often imposed at a low rate or with narrow incidence, to the detriment of their effectiveness (Matheson, 2019).

[14] Thirty-five countries prohibit sale or apply mandatory charging today (Matheson, 2019). For discussion of Israel's statute and its effects, see Box 2 in Chapter 6 of the Bank of Israel *Annual Report* for 2017, pp. 196–200.

[15] Such mechanisms are called PAYT—"Pay as You Throw." South Korea is the most advanced country in its use: Households there pay commensurate with the quantity of unseparated waste and, from 2010 on, for food waste, that they throw out. The scheme abounds with implementation problems, including difficulty adjusting the rate. Limited PAYT systems are also in effect in parts of the Netherlands and the Czech Republic (OECD, 2019). PAYT is better suited to rural and suburban areas that have private homes than to apartment buildings. They come with high operating and enforcement costs and may encourage illegal dumping and other undesired behaviors to evade payment (Matheson, 2019).

Thus, waste sorting at this stage relies on individuals' voluntary conduct (separating waste and placing it in separate receptacles, for no monetary gain) and positive monetary incentives (as opposed to taxes and fines), such as deposits on packaging. (In Israel, deposits on certain beverage containers are mandatory under law.) Policy tools geared to this stage focus on enhancing awareness in order to encourage voluntary behavior and on creating an infrastructure to support it (putting out separate bins, activating deposit and redemption mechanisms, and collecting and hauling the separated waste). The funding and operating framework for this activity is often based on extended producer responsibility (EPR).

In EPR, manufacturers (and importers) are responsible for collecting waste created at the end of product life and treating it and/or paying for the environmental damage that it causes. Laws may include mandatory reacceptance of the product, recycling targets and fines for failure to meet them, and fees on manufacturers to fund the activity. Corporations such as recycling corporations often handle the operational end. EPRs are common around the world, especially for packaging but also for electronic waste, batteries, and lubricants. According to the OECD (OECD, 2019), they are typically relatively successful but encounter difficulties in enforcement, funding, and so on. Israel has four EPR laws that relate to collecting and recycling beverage containers, tires, packaging, and electric and electronic appliances, and batteries.[16] The collection/recycling targets set in these statutes and the rates attained are itemized in Table 2.

Table 2
Producer responsibility laws in Israel—Statutory targets and their attainment

Law		Statutory recycling rate target	Actual recycling rate	Reference year in target and attainment[1]
Deposit on Beverage Containers Law, 1999[2]				
Containers up to 1.5 liter		77	78[3]	2015
1.5–5 liter containers		55	57[4]	2017
Disposal and Recycling of Tires Law, 2007[5]				2017–18
Tire importers		85	83.7	
Motor-vehicle importers		25.5	27.7	
Packaging Management Law, 2011[5]				2015
	All packaging	60	77.1	
Thereof:	Paper and cardboard	60	113.7	
	Metal	50	54.6	
	Wood	15	175.4	
	Plastic	22.5	24.6	
	Glass	60	0.5	
Environmental Management of Electric and Electronic Equipment and Batteries Law, 2012[5]		20	20	2015

[1] The latest year for which data exist.

[2] The rates in the table pertain to rates of collection. The law specifies compulsory recycling of 90 percent of containers collected.

[3] Recycling rate data—Lavee (2020).

[4] Ministry of Environmental Protection, https://www.gov.il/he/departments/news/large_bottle_producers_met_recycling_target

[5] Ministry of Environmental Protection, annual reports on implementation of these statutes, various years. For some materials, recycling rates may exceed 100 percent because they are calculated in terms of the weight of material treated relative to that of material vended in the year in question.

[16] For details on these statutes, see https://www.gov.il/he/departments/guides/extended_producer_responsibility. The law on deposits for soft-drink containers was not of the extended producer responsibility type at first but became so under an amendment that passed in 2010.

(3) Treatment after collection

The main economic tool that internalizes the externalities of managing waste after it is thrown away is a fee (flat or differentiated by types of waste) on the final quantity of waste that the local authority hauls to landfill or incineration. Apart from funding disposal cost, the fee is meant to incentivize the authority to reduce the final quantity of waste and improve its composition. It can do this mainly by encouraging residents to separate at source or by sorting at the transit site, thus raising the recycling rate (and that of treatment of organic matter). The authority rolls over the cost of the fee, like the other costs of waste management, to its citizens and presumably has an interest in reducing such costs. However, as stated, it is unable to pass the costs on to individual citizens commensurate with the amount of waste they produce, thereby influencing their behavior. Many countries charge landfill fees and some have in fact seen a decline in landfill rates (OECD, 2019). At times, such a decrease occurs not only due to more recycling, i.e., less waste, but also by switching to incineration.

In 2007, Israel introduced a landfill fee that varies by different kinds of waste. The proceeds, accumulated in a separate account kept by the Cleanliness Maintenance Fund, are meant mainly for developing, constructing, and enhancing the efficiency of alternatives to landfill.[17] The switch from multiple local landfills to a small number of national landfills means that the landfills are far from most local authorities. This lessens the authorities' direct exposure to landfill hazards such as odor and air pollution; therefore, it makes the fee more important as a way to internalize the externalities. In addition, local authorities do incur the direct cost of hauling waste to longer distances but have not internalized the adverse external effect of this hauling.[18]

6. Conclusion: The situation in Israel and possibilities of improving its economic policy tools

Israel generates large amounts of per capita municipal waste by developed countries' standards and is producing increasingly more. Absent a suitable policy, the country's economic and demographic development is likely to aggravate the problem further. Over time, however, the management of this waste has been improving: all unregulated landfills have been shut down, landfill quality has improved, burial of certain kinds of waste has been prohibited, more use is made of economic tools to cope with the waste, recycling rates have risen—even though they remain very low by international standards—and in 2020 a sweeping ban on burial of packaging waste was due to have gone into effect. The Cleanliness Maintenance Fund was established for purposes including treatment and recycling of waste. The Ministry of Environmental Protection's strategic plan for waste treatment through 2030 centers on sharply

[17] The fund has built up large cash balances. Per government resolution, some were transferred to other uses in the state budget and were replaced with spending-authorization budgets.

[18] In the first five years, the government subsidized the increase in haulage cost on account of the transition to distant landfills at a rate that declined over time. For further details of the process and the transition to central landfills, see Lavee (2020).

reducing the share of waste taken to landfill by engineering a major upturn in the recycling rate and incinerating non-recyclable waste. (One of the advantages of this method is the possibility of energy recovery.)[19] A mainstay of the plan is improving the ability to sort waste at the transit sites.

Looking ahead, several improvements of the economic tools should be considered:

The deposit on beverage containers: The potential gain from raising the deposit and expanding its incidence to larger beverage containers and additional kinds of packaging is worth exploring. The gap between the rate of reclamation of small containers, which carry a deposit, and large ones, which do not, gives an indication of what expanded incidence might contribute to boosting recycling rates (Lavee, 2020).

Raise the plastic-bag fee and broaden its incidence: The sharp decrease that followed the introduction of the fee shows that a minimal charge sometimes suffices to catalyze a major behavioral change, especially if consumers have alternatives handy.

Tax single-use plastics: The environmental damage that these products cause seems to be no less than that of plastic beverage containers and shopping bags. They have partial substitutes, the world is increasingly aware of the need to limit their use, and several countries have already imposed, or stated their intention of imposing, restrictions on their manufacture or sale. Questions of sharing the burden among different population groups may make public support harder to mobilize.

Offer a financial incentive for collection of batteries and electrical and electronic appliances: Currently, the law facilitates citizens in handing over worn-out items such as these for systematic disposal because businesses and local authorities are required to accept them and to contract with a licensed recycling corporation to dispose of them. The corporation even pays businesses or authorities for the cost of collecting and storing the waste until disposal. The law, however, does not give citizens a financial incentive to prefer this course of action over tossing it to the garbage bin or dumping in the street. It is worth considering a cash award to citizens who bring these appliances to a recognized collection point (in cases where vendors are not required to remove them from customers' homes). The funding for this may be arranged, for example, by upping the fee that manufacturers and importers pay the corporation today.

Raise the landfill fee and make it more differential: Israel's landfill fee is very low by advanced economies' standards and does not give local authorities enough of an incentive to switch to alternatives, including separation and recycling facilities that involve high construction costs.[20] The fee today is the same for all local authorities; it is worth considering differentiating it in accordance with the locality where the waste originates. Setting the fee commensurate with the locality's average income (or its rank on the socioeconomic index) would make it more effective by establishing a dependency between fee and income.

[19] https://www.gov.il/he/departments/policies/strategic_plan_for_waste_treatment_by_2030

[20] For an international comparison of this fee and discussion of the need to increase it, see OECD (2019) and Lavee (2020).

Table 3
Possible policy tools and mechanisms for municipal waste treatment, by stages in product life

Stage in product life	Possible tools/ mechanisms	Examples from abroad (measures in place or being considered, partial list) and remarks	What has been done in Israel?
Manufacture[1]	Standards for manufacturing inputs	- Banning use of certain materials - Mandatory use of recyclable materials - Mandatory pro-recycling manufacturing - Mandatory manufacture of reparable products	
	Taxation of raw materials or products in view of harmfulness of their waste		
Purchase	Ban/limits on sale/use of products	- Ban on sale of single-use plastics and/or limits on their use	
	Taxation of products or materials	- Charge for single-use plastic bags - Tax on tires - Tax on batteries - Deposit on beverage containers	- legislation on single-use bags - deposit on beverage containers (small plastic bottles, glass bottles, metal cans)
	General-government green procurement	Preference for recycled or recyclable products	"Green government" resolutions 1057, 5090: targets for green procurement, recycled paper, single-use cups
End of use	Redemption of deposit on packaging	Very common	Redemption of deposit on beverage containers
	Charging in accordance with quantity/composition of waste disposed (PAYT)	Small number of examples abroad (Korea, Netherlands, Czech Republic); very hard to implement and enforce	
	Voluntary separation at source (without fines/monetary incentives) of types of waste by individuals	- Common types: paper, plastic, glass, metal - Uncommon types: organic matter (food residues) - Funding mechanisms for placement of separate receptacles and waste collection	In some local authorities: separate receptacles for packaging, paper, glass, batteries, and organic waste
	Extended producer responsibility (EPR)	Very common	4 laws: beverage containers; tires; packaging; electrical and electronic appliances and batteries

Treatment of waste after collection			
Recycling	Sorting facilities	Tools for funding of construction and operation of facilities, e.g., subsidies and tax benefits	Support from Cleanliness Fund
	Recycling facilities	- Benefits and incentives for facilities - Incentives to whet demand for recycled materials	Support from Cleanliness Fund
	Export of separated materials to recycling plants abroad		Some exporting is allowed and even recognized for meeting recycling targets (Packaging Law)
Treatment of final waste	Landfill fee	Flat landfill fee or differentiation by type of waste or extent of landfill compliance with environmental standards	Landfill fee differentiated by 5 types of waste (not only municipal) since 2007
	Incineration fee	Flat incineration fee or differentiation by type of waste, incineration method, emissions from incineration, with/without energy recovery	
	Restrictions/ban on burial	- Sweeping ban on burial - Ban on burying certain kinds of waste (tires, batteries, some organic wastes, recyclables, unsorted waste, untreated food residues)	- Ban on burying tires since 2013 - Ban on burying packaging starting 2020, with option of postponing implementation
	Upgrade of landfills	- Closing unregulated garbage dumps - Upgrading landfills in accordance with strict standards	All unregulated garbage dumps were closed by 2003

[1] In principle, this may be applied to imports as well.

Israel is an outlier among developed countries in that it makes almost no use of incineration for waste disposal. The Ministry of Environmental Protection's policy for the coming years is to prefer incineration over landfill. Each method has its advantages and drawbacks, but for our purposes the economic principle is the same: Whichever disposal method is chosen, it is important to set a fee for incineration and for landfill in order to reduce the quantity of waste for final disposal and encourage recycling. The considerations for differentiating the landfill fee are valid (mutatis mutandis) for the incineration fee as well. The difference between the fees should reflect the environmental cost–benefit balance between them (beyond the operational cost–benefit balance) and should not distort the incentives in a way that would influence the choice of one over the other.

Index the fees to the average income in the economy: Such an indexation can prevent the effectiveness of the fees (deposit on beverage containers, plastic-bag fee, landfill fee, a future incineration fee) from eroding as tools for influencing players' behavior.

Concurrent with action to improve the economic tools, it is important to enhance awareness among the public and the public entities of the importance of adapting behavioral changes that will help to mitigate waste quantity at source and raise the recycling rate. The initiatives of several entities to reduce the use of single-use plastics, are a case in point.

Financing Characteristics of High-Tech Companies in Israel

- Relative to its size, Israel's share of the global venture capital funds market is substantial, with Israeli high-tech companies accounting for approximately 4 percent of global venture capital investment—ten times Israel's share of global output and of business credit.
- In recent years, the total amount of venture capital investment in late-stage companies has grown in Israel, as it has across the world. These companies naturally require relatively large investments. In 2019, venture capital funds invested a total of approximately $9 billion in Israeli high-tech companies.
- Venture capital activity brings foreign currency into Israel. The Israeli economy sells the future returns of the high-tech sector abroad, but at the same time eliminates the risk embodied in it. The coronavirus crisis highlights how the reliance of a key sector in the Israeli GDP on a single source of financing—which is correlated with global activity—can make it difficult for Israeli high-tech companies to continue to obtain financing during a global recession.
- Indeed, as a result of the coronavirus crisis, there are indications that the activity of the high-tech sector has been adversely impacted, as has been the ability of the sector to raise capital. The greatest difficulties are currently experienced by early-stage companies.

Due to the increasing importance of the high-tech (high technology) sector, we will discuss the unique characteristics of this sector's financing. First, we will briefly review how high-tech companies fund their operations; we will then present the scope of these companies' financing in the Israeli economy and discuss the unique characteristics of the sector's financing and their impact on the economy; finally, we will discuss the impact of the coronavirus crisis on the sector's financing.

A. Background - Financing of the High-Tech Industry around the World[1]

In broad terms, there are 3 life stages in the high-tech sector: (1) Early stage companies (also called start-ups) are companies that are at the initial stage of

[1] A. Metrick and A. Yasuda (2010). "Venture Capital and the Finance of Innovation". *Venture Capital and the Finance of Innovation,* 2nd Edition, Andrew Metrick and Ayako Yasuda (eds.), John Wiley and Sons, Inc.

M. Da Rin, and T. Hellmann (2020). *Fundamentals of Entrepreneurial Finance*, Oxford University Press.

M. Da Rin, T. Hellmann and M. Puri (2013). "A Survey of Venture Capital Research." In *Handbook of the Economics of Finance*, vol. 2, pp. 648573. Elsevier. M. Ueda (2004). "Banks versus Venture Capital: Project Evaluation, Screening, and Expropriation", *The Journal of Finance*, *59*(2), 601–621.

A. Winton and V. Yerramilli (2008). "Entrepreneurial Finance: Banks versus Venture Capital", *Journal of Financial Economics*, 88(1), 51–79.

W. Drover, L. Busenitz, S. Matusik, D. Townsend, A. Anglin and G. Dushnitsky (2017). "A Review and Road Map of Entrepreneurial Equity Financing Research", *Journal of Management,* 43 (6). 1820–1853. ISSN 0149-2063 DOI: https://doi.org/10.1177/0149206317690584

T. Nicholas (2019). "*VC: An American History*". Harvard University Press.

developing a product or service, and even if they already have initial revenues, are still in the early stages of developing their business model. (2) Mid-stage (also known as expansion-stage) companies are companies that already have a relatively well-formed product or service, which they are already selling, and are working to expand their business activity in order to attain profitability or obtain a significant market share. (3) Late-stage companies are companies that produce or offer a proven product or service, which are already profitable or are well on their way to profitability.

In the various life stages - especially in the first and second stages - investment in high-tech companies is characterized by significant uncertainty and asymmetric information between entrepreneurs and investors regarding the quality of the company; in addition, the incentives of the entrepreneur and those of the funding entity are difficult to match. These difficulties are resolved, inter alia, by staging investments and through non-standard contracts between the entrepreneur and the investor, which enable both sides to obtain non-monotonous returns. High-tech companies are mostly funded by venture capital funds and private investors (also known as "angels").[2] Venture capital funds (VCs) are a partnership of professional investors who manage and invest the funds of institutional entities (such as pension funds, insurance companies and endowment funds of US universities).[3] There are also corporate venture capital funds (CVCs), which are managed and funded by large corporations (such as Google and Samsung). Private investors, in contrast, are people who invest their own funds directly or as part of a group of investors. They tend to invest in early-stage companies, while later-stage companies are mostly funded by venture capital funds.

According to the literature, high-tech companies that receive funding from venture capital funds and private investors enjoy several advantages over other companies in terms of short-term and long-term performance. These benefits stem from the funding, which both enables the company to continue to develop[4] and sends a positive signal due to the very fact that it has been able to raise capital, which further increases the likelihood of additional investments. Furthermore, venture capital funds contribute directly to improving companies' performance: The companies benefit from the managerial expertise that investors bring to the table, since the latter choose to intervene in their portfolio companies' management, and thanks to their connections. Theoretical papers show the differences between VCs and banks, arguing that while VCs are better at understanding and pricing start-up companies, they also charge them higher rents. The papers show that venture capital funding is optimal if a company is

[2] For more information on the development of these financing tools to finance high-tech companies, please see Box 4.1 "Financing of Start-Up Companies" in Chapter 4 of the Bank of Israel's 2014 Annual Report.

[3] For more information on the venture capital mechanism, please see Box 4.1, "Investment of Financial Institutions in Israel in Private Equity and Venture Capital Funds," in the Bank of Israel's 2017 Annual Report.

[4] Most early stage high-tech companies lack other significant means of funding.

unable to put up collateral and if the probability of success is low but the return on investment in case of success would be high.

The development of investment by venture capital funds around the world was gradual, and was affected by technological advances and regulatory changes that took place in Israel and around the world.[5] In the 1980s, venture capital funding was mainly provided to early-stage start-up companies. By the late 1990s, when the market had matured and venture capital funds had grown, most of their activity was directed towards mid-stage companies. Later on, the 2000s bubble burst, followed by the financial crisis of 2008. Currently, venture capital funds mostly invest in mature, later-stage companies. Although there are still numerous VCs specializing in earlier-stage companies, due to their relative small size (since a single investment in an early-stage company is relatively small), their percentage of total activity has declined. In recent years, with the diversion of VC funding to later-stage companies, private investors have become more active, taking up an increasingly greater share of the investments in the earlier stage companies. According to some estimates, private investors' share in worldwide investments currently equals that of venture capital investments.[6] In the past, once the development stage of a product or service was concluded successfully, mature high-tech companies continued to finance their activity and provide returns to investors through initial public offerings (IPOs) (mainly in the US) or an "exit" via a sale to another company.[7] In recent years, companies remain private for longer periods of time and the time to exit (whether by acquisition or IPO) is deferred. Since the life of an average venture capital fund is up to 10 years—and in order to provide investors with an exit even before an acquisition or IPO—since the mid-2000s dedicated venture capital funds have emerged, aimed at acquiring investments directly from other VCs and funding relatively later stage companies.

Below, when we review VC capital investments in Israel and worldwide, we also include data on capital investment from private investors.

B. High-Tech Financing in Israel vs. the Rest of the World[8]

The Israeli high-tech sector has grown in recent years, and its share in the economy is increasing. As of the end of 2019, the ICT sector (the sector representing most of the high-tech companies) accounted for 11 percent of GDP and 14 percent of business sector product. By international comparison, the uniqueness of the sector's share in

[5] For example, change in the investment laws of pension funds in the late 1970s allowed institutional investors to start investing widely in venture capital funds. And in Israel, the Yozma Funds - which were established in the early 1990s contributed to the development of the local VC market.

[6] VC capital investment data are usually partial, since as private entities, the companies and investors are not bound by reporting requirements. Data on angels' investments—which are small and diverse in nature—are even more partial.

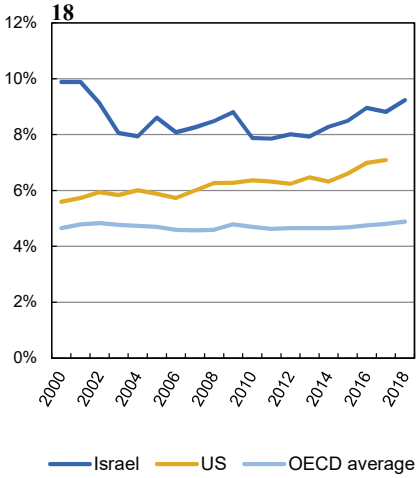
[7] In recent years, the more common "exit" method has been selling a start-up to another company, rather than by way of IPO.

[8] Analysis of the characteristics of venture capital and private investors' investments in Israel is based on dedicated databases of IVC and Startup Nation Central (SNC), which contain information about investments in Israeli companies from 1998 to the first quarter of 2020.

Israel's GDP is obvious (Figure 1).[9] For more information regarding the effect of the high-tech sector on the current account and structural change in the economy, please see Chapters 1 and 2 in the Bank of Israel's 2019 Annual Report.[10]

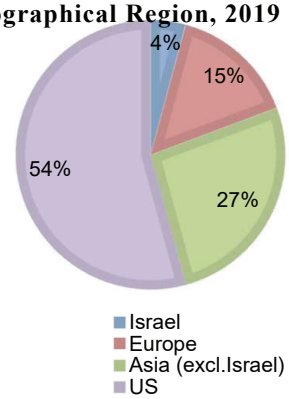
Israel is also a significant player in the global venture capital market, with Israeli high-tech companies accounting for approximately 4 percent of global venture capital investment (Figure 2)—ten times Israel's share of global output and of business credit.[11]

Figure 1
Share of ICT Industry in GDP, International Comparison[a], 2000–18



SOURCE: Based on OECD data.

Figure 2
Distribution of Venture Capital Raised, by Geographical Region, 2019



SOURCE: Based on CBinsights MoneyTree report 2019 ,IVC ,SNC.

Since Israel is a major player in the field, global trends are also reflected in its capital investments. As a result, in Israel too, most of the VCs' money is invested in relatively mature companies. As of 2019, about 65 percent of companies that raised capital from VCs are defined as mid- to late-stage companies and are not classical start-ups (Figure 3). High-tech companies worldwide and in Israel raise venture capital in "rounds". Early stage investments are called pre-seed or seed rounds. Later financing rounds are assigned letters: Round A, Round B, Round C, etc.[12] The financing rounds are not necessarily in line with a Company's growth stage - mature companies may raise early rounds while start-ups may raise A, B or C rounds. There

[9] Only in Ireland is the share of the ICT sector in GDP is higher than in Israel.

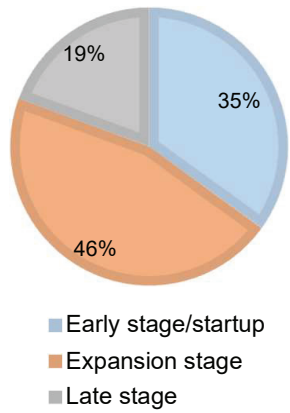
[10] For more information about exports of high-tech companies, please see Chapter 7 of the Bank of Israel's 2017 Annual Report.

[11] In 2018, Israel's share of global output was 0.4 percent (according to World Bank data) and its business credit amounted to 0.3 percent of global credit (according to BIS data).

[12] There are also some types of other VC investments that are not structured in funding rounds. They are mostly aimed at funding specific processes or bridging financing gaps between rounds.

is, however, a correlation between the stages: Mature companies mostly raise venture capital in later rounds, after having funded their early activity through previous financing rounds. In line with the trend—both worldwide and in Israel—of funding later-stage companies, the number and dollar amount of late-stage funding transactions has risen (Figure 4). The time-to-exit of Israeli companies has also risen—from an average of 9 years in 2019 to an average of 11 years in 2018—a development that is in line with the general trend of financing mostly companies at relatively later stages.[13]

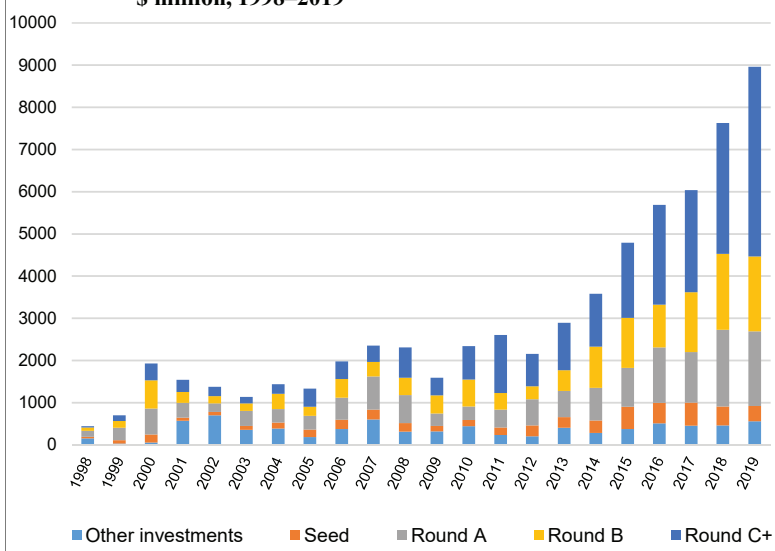
Figure 3
Distribution of lifestages of companies that raised venture capital in Israel in 2019



SOURCE: Based on IVC and SNC data.

With the increase in the number of high-tech venture capital transactions—especially in the later stages of their development—the share of this type of funding out of the total funding in the Israeli economy has grown. In 2019, Israeli

Figure 4
Amounts Raised in Venture Capital in Israel, $ million, 1998–2019

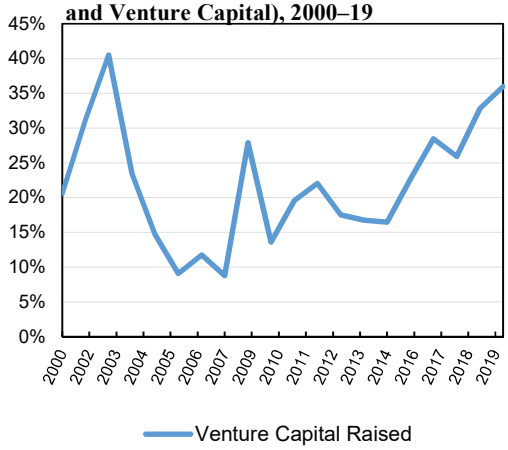


SOURCE: Based on IVC and SNC data.

[13] Source: https://www.ivc-online.com/Portals/0/RC/Survey/IVC-Meitar%20Exit%20Report%20-%202018%20-%20final.pdf

high-tech companies raised a total of approximately $9 billion (approximately NIS 31.5 billion) in venture capital. To illustrate the sheer scale, note that venture capital-raising in 2019 accounted for approximately 36 percent of the Israeli business sector's total fund raising (bond issues, equities, and venture capital) (Figure 5). In the US, the country where most of the high-tech activity is conducted, VC's capital investment constitutes only 1.5 percent of GDP, compared with 2 percent of GDP in Israel.[14]

Figure 5
Venture Capital Raised out of Total Funds Raised by Companies in Israel (Bond Issues, Equity Issued in Israel and Abroad, and Venture Capital), 2000–19



Equity issues abroad includes issued by Israeli firms in foreign currency on exchanges abroad.

SOURCE: Based on IVC, SNC, and Bloomberg data.

C. Characteristics of Venture Capital Funding and their Impact on the Israeli Economy

The large amount of capital invested in the high-tech sector through venture capital funds and its unique characteristics may have a macroeconomic effect on the Israeli economy.

First, venture capital funding is primarily foreign in origin. Most of the money comes from foreign venture capital funds,[15] and even the local VC funds are largely financed by foreign investment. For more information about the low percentage of investment by Israeli financial institutions in the high-tech industry, please see Box 4.1 in the 2017 Bank of Israel Annual Report.[16] The fact that a significant amount of the continually growing financing amount comes from foreign sources raises questions about the impact of such financing on Israel's financial account. The funding of the high-tech sector by venture capital is classified as direct investment by nonresidents under direct equity investments. While the volume of financing activity of venture capital grew, as described above, direct investments of nonresidents in the Israeli economy through equity investments grew substantially and uncharacteristically (Figure 6). In 2019,

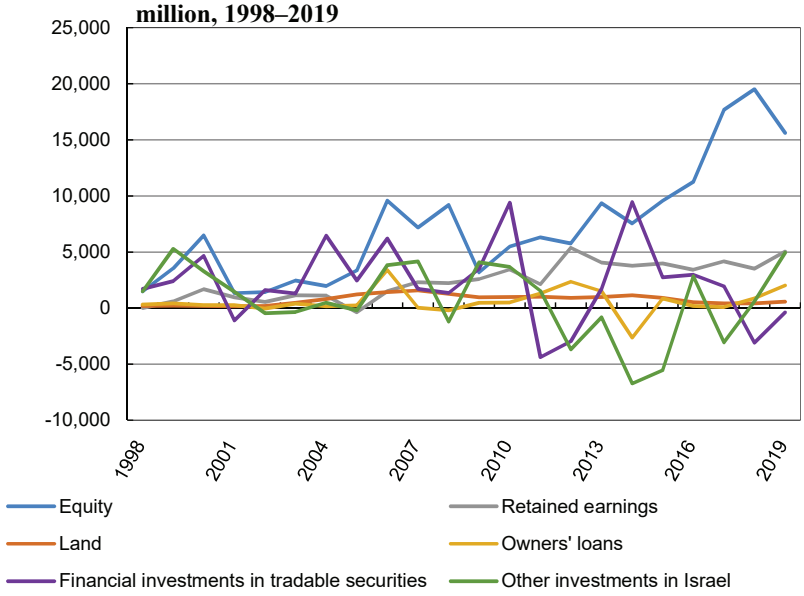
[14] According to CB Insights. The share of total VC capital investments out of global output is less than 1 percent.

[15] According to IVC data, the percentage of foreign venture capital funds leading a round of funding out of total rounds for which there is information on the entity leading the round has been on the rise since the early 2000s, and has exceeded 65 percent of the transaction dollar amount since 2013.

[16] Regarding the Box, we shall emphasize that the taxation of venture capital fund managers depends on the taxation scheme of their investors. The fact that foreign investors enjoy exemptions from local capital gains tax and VAT encourages fund managers to raise money from them.

capital investment from VCs accounted for 85 percent of new equity investments[17] in the Israeli economy (Figure 7). The increase in direct investment in the Israeli economy is indicative of the increase in foreign residents' investment therein and the attractiveness of investing in Israel, especially in the local high-tech sector. The fact that the effect of the high-tech sector is reflected in the balance of payments in both the financial account and current account through exports—as described in Chapters 1 and 2 of the Bank of Israel's 2019 Annual Report—is a unique case of an activity attracting inflows of foreign currency into the economy on both ends of the balance of payments.

Figure 6
Nonresidents' investments in Israel, the financial account—main sections, and details on components of direct investment, $ million, 1998–2019

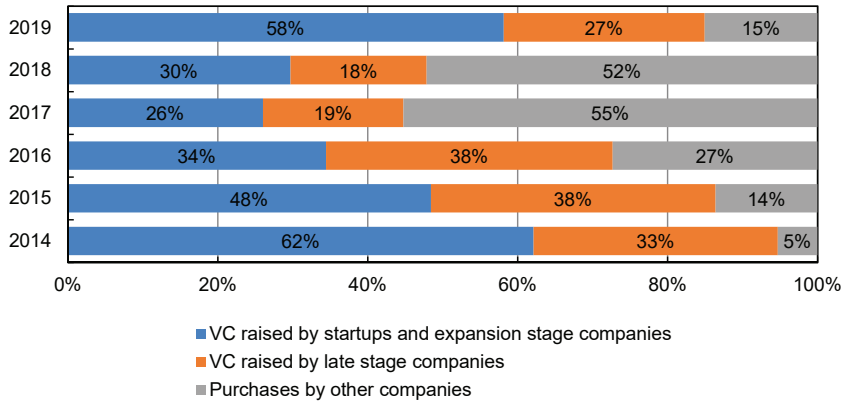


SOURCE: Bank of Israel.

Venture capital is a financial tool for funding companies' activity. Therefore, when it comes to acquisitions and especially to paying salaries, venture capital investments must be converted from foreign currency to shekels. Note that despite substantial media attention to "exits" (transferring ownership in the form of a sale, corporate merger or stock exchange offering), their direct economic impact appears to be lower than that of venture capital investments. Unlike venture capital investments, in an "exit", some of the money remains overseas, and ownership is transferred, at least in part, between foreign entities. The "exit" activity in the Israeli economy is depicted

[17] Direct equity investment net of retained earnings. Retained earnings are gains in nonresident-owned companies which have not been withdrawn. They are defined as direct investment in the economy, although there has been no transfer of funds between the Israeli economy and a foreign country. For more information, please see the Statistical Bulletin for 2019.

Figure 7
Distribution of New Investments out of Direct Investments Flowing into the Economy, 2014–19



[a] New investments in the economy include incoming new direct investment in equity. They do not include retained earnings that were not distributed to investors and are defined as new investment in the economy, even though they are classified as equity and as direct investment in the economy. New investments do not include investments in land or owners' loans. The data do include investments in tradable and nontradable stocks, and nontradable venture capital investments.
[b] The definitions of startup companies and expansion stage companies in this figure also include high tech companies at later stages of initial funding (up to Round A).
[c] Purchases by other companies primarily includes "exits": mergers and acquisitions, and investments in tradable securities. About 95 percent of new investments are not tradable.

SOURCE: Based on IVC and SNC data.

in Figure 7 under "Acquisition by other companies", which includes "exits" of high-tech companies by way of their acquisition or through an IPO, but also acquisitions, mergers and investments of private equity in companies outside the high-tech sector.

Another aspect of nonresident investment in the high-tech sector is its contribution to diversifying risk in the Israeli economy, particularly with high-tech investment being high-risk. Venture capital investment is an equity investment, which transfers ownership (unlike debt issuance), and has two components: the bringing forward, to an earlier point in time, the receipt of expected cash flows from the high-tech company's future activity, and the sale of the risk and uncertainty embodied in the activity to other entities. The first component implies that the VC funding amount is impacted by an assessment of future economic activity embodied by a high level of uncertainty. The second component mitigates the risk to the economy and helps in smoothing the high-tech sector's volatility: In case of an adverse shock to the high-tech sector, the loss would be partly incorporated in the value of nonresidents' holdings. (However, if the investment were to succeed and significant gains would be achieved, the economy would not enjoy the full profits.) This manner of financing increases the economy's resilience to idiosyncratic shocks to the high-tech sector. Moreover, since venture capital funds' money is unrelated to the rest of the financial system in Israel, and there is no risk of interconnectedness and contagion, in the event of a temporary crisis in the high-tech sector, the impact on other sources of financing in the economy will be lower. The risk mitigation is especially important in light of the significant exposure of the Israeli economy to the high-tech sector.

However, VC capital investments in Israel and around the world are highly impacted by the global financial cycle.[18] During global economic downturns, capital investment for Israeli high-tech companies declines, hurting these companies' growth and development. There is concern that, in case of a global economic downturn, capital investment in the high-tech sector will come to a halt, since Israeli companies have no alternative funding sources. Since funding for the high-tech sector is mainly based on foreign sources, during a crisis, it will be difficult for the Bank of Israel and the government to encourage investment in this sector. Quantitative easing and the expansion of domestic credit from banks are not relevant to financing the high-tech sector, and the impact of fiscal intervention is limited: If venture capital funds do not have independent sources of investment due to the crisis, government guarantees of investments will not change the situation; moreover, providing government guarantees to foreign funds is technically difficult. Direct government investment in the high-tech sector presents difficulties as well, including the inability to place the brunt of the financing costs on the private sector, the need for underwriting and investment management, compounded by the very fact that the government will become an owner of the companies.

D. The Coronavirus Crisis

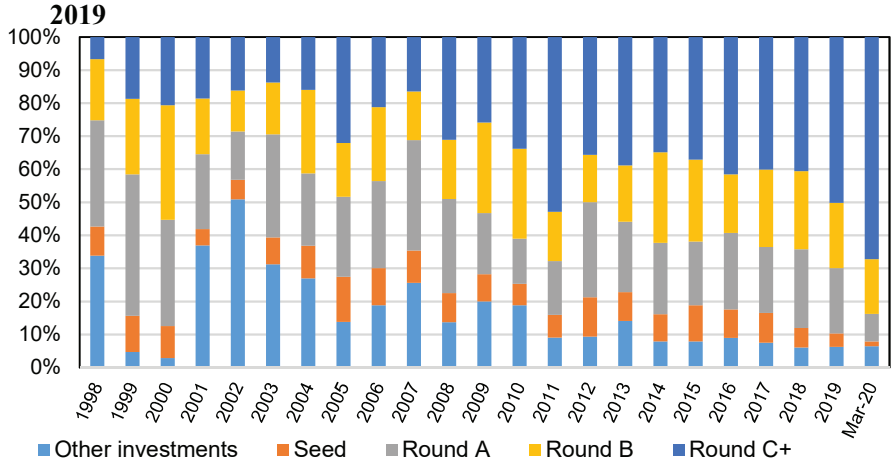
The coronavirus crisis, which erupted towards the end of the first quarter of 2020, has had a worldwide impact. The Central Bureau of Statistics' Business Tendency Survey and the Survey of Businesses in Israel during the Coronavirus Crisis indicate that the negative impact on high-tech companies' activity at the height of the crisis was relatively moderate, since employees are able to telecommute and some companies have no sales to date and therefore have not experienced a drop in revenues. As of May, the average decline in high-tech companies' revenue was 14 percent, while the average for all companies was 20 percent. In the high-tech sector, the percentage of active employees did not fall below 80 percent during the entire period (compared with a 60 percent average for all companies in March and April, during the height of the first lockdown in Israel). As of early June, 34 percent of high-tech employees work from home (compared to an average of 10 percent for all companies). Yet in contrast, there are early indications that the adverse impact on employment in this sector is higher than in others: As of May, approximately 4.2 percent of employees in the high-tech sector were laid off due to the virus (compared to an average of 3.8 percent for all companies), and companies that employ 26 percent of those employed in the industry reduced wages (compared to an average of 18 percent for all companies). The surveys also show that only 23 percent of the companies in the industry received government support[19] (compared to an average of 41 percent for all companies).

[18] Weekly Economic Review of the Chief Economist Department of the Ministry of Finance, published on December 30, 2019.

[19] Grants, loans or other types of support.

It appears that as early as the first quarter of 2020, venture capital investment was affected by the crisis as described above. Although the amount of venture capital invested in the first quarter of 2020 was high—$2.7 billion—the mix of investments in the quarter was different than in previous years and even than in previous crisis periods (Figure 8). In the first quarter of 2020, the number of transactions and the percentage of investment in late-stage companies (Round C and later) increased significantly compared to a decrease in the percentage of invested funds and the number of transactions in early investment rounds (seed to Round A). It appears that the reason for the decline is that VCs with available funds save their money for follow-on investment in their portfolio companies, to help companies under their control survive the crisis and avoid further risks. In addition, some VCs may already be having trouble raising funds during this period, and therefore do not have any available money to invest. The decline in investments in early-stage companies will affect their ability to develop in the coming years.

Figure 8
Distribution of Amounts Raised in Venture Capital, 1998–2019



SOURCE: Based on IVC and SNC data.

It is interesting to note another difference between the current mix of investments and their mix during previous crises. In the early 2000s, and even less so in 2009, the percentage of "other investments"—which include investments that provide liquidity to companies between rounds of capital investment—was up. During crisis periods, such type of funding is expected to increase, but it is too early to see evidence to that effect in Israel.

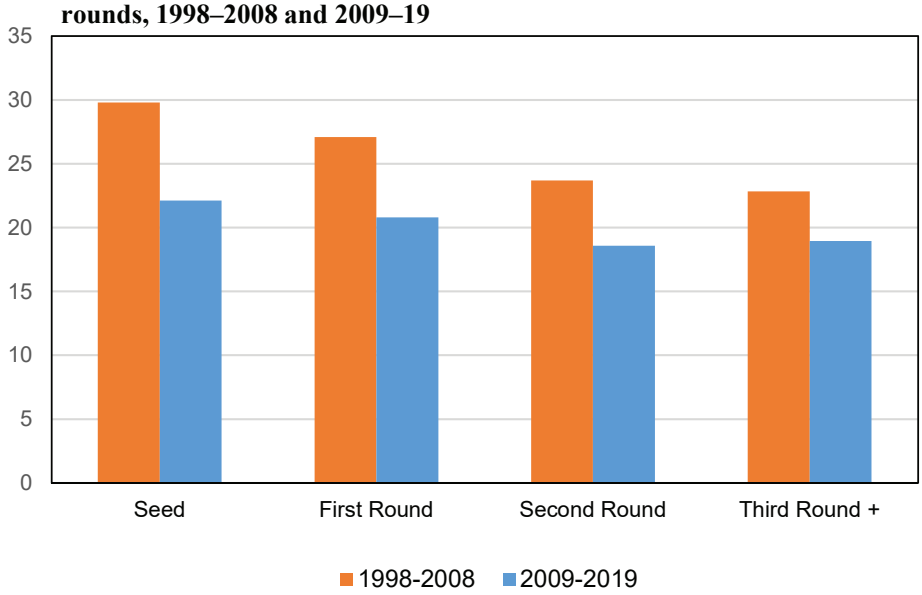
Figure 9 shows that the time between rounds of capital investment by high-tech companies is decreasing. Today, companies require an additional funding round in less than two years (approximately 20 months) to continue their activity. If we rule out seasonality, every four months an average 20% of the rounds take place. Thus, the

longer the crisis continues, especially in the US, the greater the expected damage to the financing and profitability of companies, even ones in more advanced stages of development.

Due to the crisis, the Israel Innovation Authority received a budget of NIS 600 million for general grants and another NIS 50 million for grants to high-tech companies whose products will help fight the coronavirus. In addition, the Authority guarantees the establishment of domestic investment funds for a total of NIS 500 million. The guarantee will be up to a loss of 30 percent of financial institutions' nostro (own) funds and up to 50 percent of savers' funds managed by institutional investors, such as pension and provident funds savings. In return, the government will receive a portion of the excess return over government bond yield, if there is any (10 percent and 15 percent of the excess return on the funds of financial institutions and savers' funds, respectively). The funds will be required to provide funding to companies over the next year and a half. The objective of the program is to diversify financing sources for Israeli high-tech companies by creating new local sources of finance, alternatives that will be relevant even after the crisis. The problem with the program is that its structure mainly encourages investment in mature companies and it is not aimed at the shortage of funding for companies in early stages that has resulted from the crisis.

In summary, the importance of the high-tech sector to the Israeli economy has increased in recent years, as has the importance of its financing and sources. The fact that large volumes of venture capital account for a significant part of the financing of Israeli companies, and that most of it comes from foreign sources, is reflected in the financial account of the Israeli economy. Moreover, the growth trend in high-tech financing—financing that focuses on the relatively late stages of corporate life and therefore involves large sums—is expected to increase the impact on the financial account. As a result of the coronavirus crisis, there are indications that the activity of the high-tech sector has been adversely impacted, as was the ability of the sector to raise capital. The greatest difficulties are currently experienced by early-stage companies. Later-stage companies continued to raise funds at high rates even in the first quarter of 2020. The negative impact on activity and the lack of capital investments of early-stage companies may hurt these companies' growth and ability to develop in coming years. The longer the crisis, the greater the damage to the financing ability of high-tech companies and the greater the chances it will spread to other companies, even later-stage ones.

Figure 9
Average number of months between venture capital funding rounds, 1998–2008 and 2009–19



SOURCE: Based on IVC and SNC data.

The Middle Class in Arab Society

- A sizable, powerful middle class can serve as a bridge between distinct groups with conflicting interests, thus contributing to economic growth, to stabilizing political systems, and to the social fabric.
- Given the considerable disparities between Arabs and Jews in Israel, a growing Arab middle class may mitigate some of the adverse effects of the disparities between the groups.
- Out of the various definitions used in the literature to define middle class, we opted for the one according to which lower middle class includes households where the equivalized disposable income per capita ranges from 75 percent to 125 percent of the median, and upper middle class comprises households whose equivalized disposable income per capita is between 125 percent and 200 percent of the median.
- Only 28 percent of Arab households belong to the middle class, and they are at the upper part of the income distribution among Arabs. In the past two decades, the lower middle class has grown in Arab society, while the incidence of poverty has declined.
- Middle class Arab households and individuals are markedly different from their non-ultra-Orthodox Jewish counterparts, and their share in Israel's middle class as a whole has not increased substantially in the past two decades, despite modernization processes and some improvement in living standards.
- In the past twenty years, education disparities between middle-class Arabs and non-ultra-Orthodox Jews have widened.

The role of the middle class in fostering economic growth, stabilizing political systems and reducing conflicts is widely acknowledged in the literature, and many studies have been devoted to these issues. The fundamental idea in this literature is that distinct groups with different characteristics may find it difficult to reach common ground and work together to achieve common goals. The further apart these groups are, the more difficult it is for them to bridge their differences. The middle class can serve as that bridge, mitigating these differences and thus contributing to alleviating conflict and stabilizing political systems and social structures. (See, for example Birdsall 2016, OECD 2019).[1]

Israel's income distribution is characterized by high inequality and significant disparities between population groups, with one of its main ones being between Arabs and Jews. The level and quality of education, as well as employment rates, wages and consequently the income in the Arab population are considerably lower

[1] "Under Pressure: The Squeezed Middle Class", OECD Publishing, Paris. OECD (2019); https://doi.org/10.1787/689afed1-en; N. Birdsall (2016) "Middle-class heroes: The best guarantee of good governance". Foreign Affairs, https://www.foreignaffairs.com/.articles/2016-02-15/middle-class-heroes.

than in the Jewish population. Despite declining birth rates among Arab families in recent decades, Arab households are still larger on average than Jewish households, and a significant proportion of them live in the country's geographic periphery. The percentage of poverty among Arab households is therefore higher. Alongside the political-security conflict in the Middle East, the situation makes it difficult to create a common language to promote goals that matter to Israeli society as a whole. Below we shall examine whether an Arab middle class has been forming in recent decades that could bridge the disparities and mitigate tensions.

A study by Khamaisi (2017)[2] depicts the growth of an Arab middle class and its impact on how municipalities are managed. The researcher argues that the Arab middle class has expanded, attributing it to the growth of young educated generations and the formation of a middle-class tradition that combines socioeconomic status with social affiliation (clan, ethnicity, neighborhood). The growth of the middle class raises the need for another type of local leadership, which is not necessarily based on the traditional clan affiliation, but rather on skills and education. The study's findings support the claim that the old clan social order is being undermined and is being replaced by a new order - which has yet to be fully developed – which seeks new political and leadership behavior patterns that will directly impact Arab local government, at both the political and administrative levels. Thus, concludes the study, the expansion of the middle class in Arab communities may be able to contribute not only to the finances of its households but also to the economies of their communities and the country as a whole.

Despite well-acknowledged significance of the middle class, there is no consensus regarding the correct way to define the middle class or measure its size. Multiple methods and approaches are used, each of which has its advantages and disadvantages.[3] For the purpose of the analysis below, let us define two cohorts that belong to the middle class: the lower middle class - households in which the equivalized disposable income exceeds 75 percent of the median income and is lower than 125 percent of the median income, in line with Thurow's definition (1984);[4] and the upper middle class - households whose income is higher than 125 percent of the median income and less than twofold (200 percent) the median income. This definition has been widely adopted by numerous studies and policy papers, thus enabling a more convenient comparison to other countries and over time. Its main flaws are the arbitrary nature of setting a specific range around the median and the fact that it relies (as do a range of other definitions) on income in the current year as the sole determinant of class affiliation, ignoring other important aspects of that affiliation.

[2] See Khamaisi (2017). "The Growth of the Middle Classes and their Impact on the Management of Local Governments in Arab Communities", a research report summary, Jewish-Arab Center, University of Haifa.

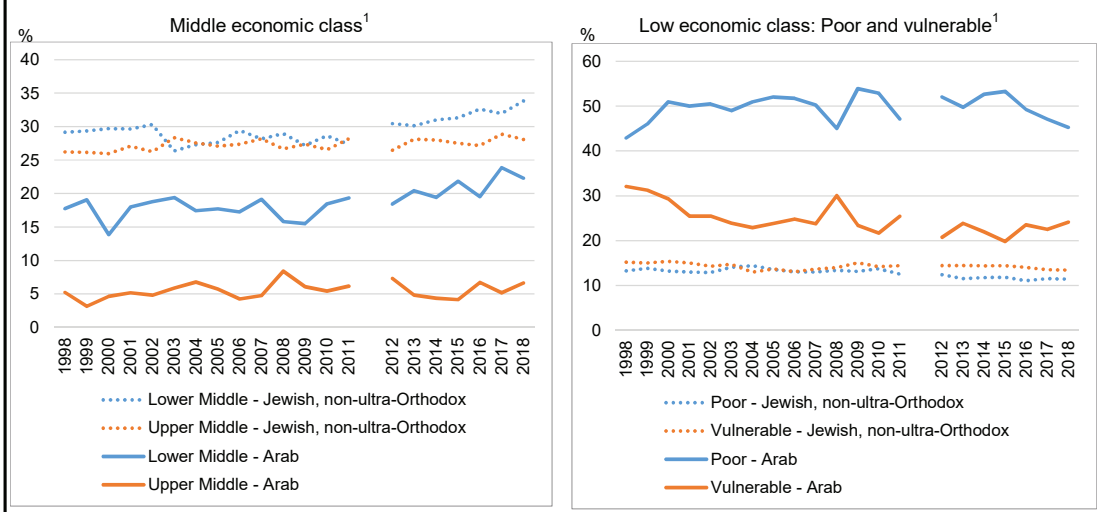
[3] For more information regarding the various methods for defining the middle class, see O. Peled Levy (2020). "The Middle Class in Israel", to be published in the *Bank of Israel Survey.*

[4] L. Thurow. (1984). "The Disappearance of the Middle Class", New York Times, February 5, 1984.

Figure 1 shows the distribution of Arab and non-ultra-Orthodox Jewish households among economic classes. The division into classes was determined in accordance with the above definition of middle class and with the formal Israeli definition of poverty (households whose equivalized disposable income is less than half the median income).[5] Between the poor and middle class is another class, which we will call the "vulnerable" class - households whose income is indeed higher than the poverty line, but who do not enjoy the economic security of middle-class households. Literature has found such households to be at higher risk of falling into poverty than households earning higher incomes.[6] The definition of the vulnerable class is also under dispute.

Figure 1
Development of the Composition of the Economic Classes, 1998–2018

Share of households whose net equivalized income is within the range of incomes of each class.



[1] Poor: Households with equivalized income per capita of up to 50 percent of median income. Vulnerable: Households with equivalized income per capita of 50–75 percent of median income. Lower Middle class: Households with equivalized income per capita of 75–125 percent of median income.Upper Middle class: Households with equivalized income per capita of 125–200 percent of median income.

SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

[5] Equivalized income: Equivalization is a statistical technique in which members of a household receive different weightings. It is based on the common assumption of economies of scale in a household's consumption, that is, the assumption that the number of persons in the household does not uniformly and equally affect the standard of living from a given income. Total household income is then divided by the sum of the weightings to yield a representative income. Equivalization scales are used to adjust household income, taking into account household size and composition, mainly for comparative purposes.

[6] See, for example:

H-A. H. Dang, and P. F. Lanjouw (2016) "Welfare dynamics measurement: Two definitions of a vulnerability line and their empirical application", *Review of Income and Wealth.* Available online at https://doi.org/10.1111/roiw.12237

Table 1

The class composition of households: 2007-09 and 2016-18[a]

Share that belong to each class out of the group

Households headed by 25-64 year old in survey year

	Poor (up to 50%)	Vulnerable (up to 75%)	Lower middle class (75-125%)	Upper middle class (125-200%)	High economic class (exceeds 200%)	Group's share in total population
			2016–18			
Jewish, non-ultra-Orthodox[b]	9.3	13.1	35.2	29.3	13.2	78.4
Ultra-Orthodox	50.3	24.1	18.0	5.6	1.9	5.4
Arab	45.9	24.4	22.6	6.0	1.1	16.2
Total population	17.4	15.5	32.2	24.2	10.6	**100.0**
Share of net income	6.9	10.6	29.0	31.6	21.8	100.0
			2007–09			
Jewish, non-ultra-Orthodox[b]	11.5	13.9	30.4	28.1	16.0	80.1
Ultra-Orthodox	53.8	20.7	16.6	6.0	2.8	4.2
Arab	52.7	24.8	15.9	5.4	1.0	15.6
Total population	19.7	15.9	27.6	23.6	13.1	**100.0**
Share of net income	6.5	9.1	24.8	30.3	29.3	100.0
			Change from 2007–09 to 2016–18			
Jewish, non-ultra-Orthodox[b]	-2.2	-0.8	4.7	1.2	-2.8	-1.7
Ultra-Orthodox	-3.5	3.4	1.4	-0.4	-0.9	1.2
Arab	-6.8	-0.5	6.7	0.6	0.0	0.5
Total population	-2.3	-0.4	4.6	0.6	-2.5	
Share of net income	0.4	1.5	4.3	1.4	-7.5	

[a] The analysis is based on a merge of expenditure surveys from 2007 to 2009 and from 2016 to 2018. The year 2017 is the first year for which we have data on the type of most recent diploma for each individual. Choosing the period for comparison in this table is intended to maintain the uniformity in how the data are presented.

[b] Includes "Other"—households that are neither Jewish nor Arab.

SOURCE: Based on Expenditure Surveys conducted by the Central Bureau of Statistics.

The basis for determining the income range that defines each class is the equivalized median income in all households in Israel.[7] That is, economic status is determined relative to the general population rather than within each population group. Under this definition, Arab households belonging to the middle class are at the top of the income distribution among the Arabs, since the income level of Arab households is generally much lower than that of Jewish households, especially among the non-ultra-Orthodox: Arabs have a higher incidence of poor as well as vulnerable households. Additionally, the proportion of Arab households belonging to the middle class is significantly lower than that of their non-ultra-Orthodox Jewish counterparts. In the past decade, the share of lower middle class Arab households increased slightly as did that of non-ultra-Orthodox Jewish households. In contrast, the proportion of Arab households belonging to the upper-middle class has not changed significantly in two decades.

Table 1 depicts the population distribution by class and by population group in the past decade. During this decade, the middle class (i.e., the proportion of households

[7] In 2018, the median of equivalized income was NIS 5,750. Equivalized income of middle class households during that year ranged from NIS 4,313 to NIS 11,500.

belonging to it) grew, and its share of total income increased. The Arab lower middle class grew, in parallel with the decline in the share of poor households. In contrast, among the non-ultra-Orthodox Jewish households, the weight of those belonging to the middle class - both the lower- and upper-middle class - increased at the same time as the weight of households at the outer edges of the distribution decreased: the lower class (the poor and vulnerable) and the upper class.

Table 2

Demographic characteristics of middle-class households[a], 2016–18[b]

	Other households[c]		Lower middle class (75–125%)		Upper middle class (125–200%)	
	Arab	Jewish non-ultra-Orthodox	Arab	Jewish non-ultra-Orthodox	Arab	Jewish non-ultra-Orthodox
Share of households that belong to each class	**71.5**	**39.3**	**22.3**	**32.6**	**6.2**	**28.0**
Years of schooling						
0–10	49.1	15.6	33.0	13.5	17.7	7.4
11–12	31.9	24.4	30.3	30.1	24.6	24.4
13–15	10.7	23.6	15.3	24.8	11.7	25.3
16+	8.2	36.4	21.4	31.6	46.0	42.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Age						
18–24	2.2	2.8	1.6	1.7	0.7	0.7
25–34	16.3	13.9	18.1	17.0	13.0	15.0
35–54	50.3	32.1	47.6	43.0	49.4	42.0
55–64	12.7	18.4	20.3	15.5	23.9	19.6
65+	18.5	32.8	12.3	22.8	13.0	22.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Family status						
Not married	12.5	38.3	11.9	31.1	14.1	27.8
Married, no children	16.1	29.3	28.5	22.4	38.9	33.1
Married, up to 3 children	45.1	20.3	51.0	35.0	43.4	32.9
Married, 4 or more children	18.4	4.6	5.5	4.7	0.9	2.3
No married, with 1-2 children	4.1	6.2	3.0	6.2	2.5	3.5
Not married, with 3 or more children	3.8	1.3	0.1	0.6	0.3	0.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Peripherality index						
Very peripheral	3.1	2.7	3.5	2.7	3.4	2.2
Peripheral	36.6	9.1	42.8	8.6	46.9	7.3
Medium	29.7	22.4	32.7	24.0	37.0	19.1
Central	9.0	19.7	10.6	19.9	6.1	20.6
Very central	21.7	46.1	10.4	44.8	6.6	50.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

[a] The demographic characteristics are determined according to the head of household.

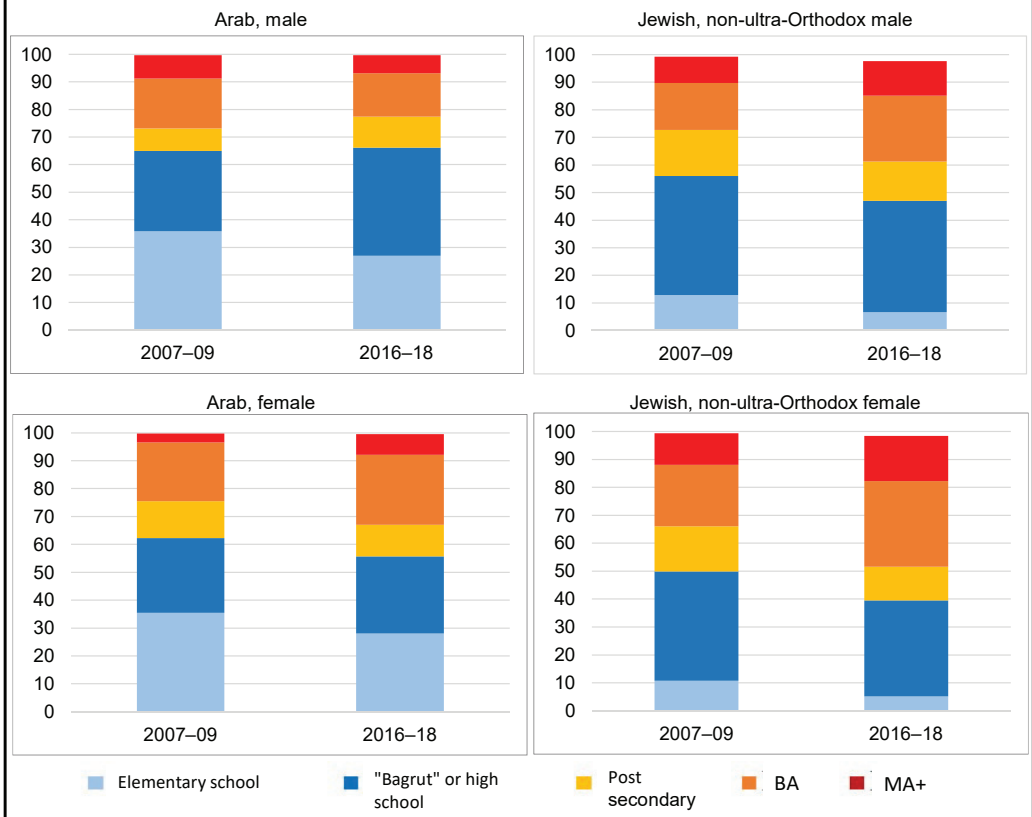
[b] The analysis is based on a merge of the Expenditure Surveys between 2016 and 2018.

[c] Other households are those that do not belong to the middle class: poor, vulnerable, and those that belong to the higher class. Among Arabs, this group includes mainly poor (around 64 percent of the group) and vulnerable (34 percent of the group). Among Jewish households, it includes those from the upper socioeconomic class (37 percent of the group) as well. See also Table 1.

SOURCE: Based on Expenditure Surveys conducted by the Central Bureau of Statistics.

Figure 2
Distribution of Schooling of Individuals Belonging to the Middle Class, Based on Type of Most Rrecent Diploma

Individuals aged 25–54 during the survey year



[a] The share of those holding their most recent diploma of a certain type, among the group. Data do not sum to 100 due to exclusion of the "Other certification" category. The analysis is based on merging Expenditure Surveys in respect of 2007–09 and 2016–18. The year 2007 is the first year for which we have data on the type of most recent diploma for each individual.

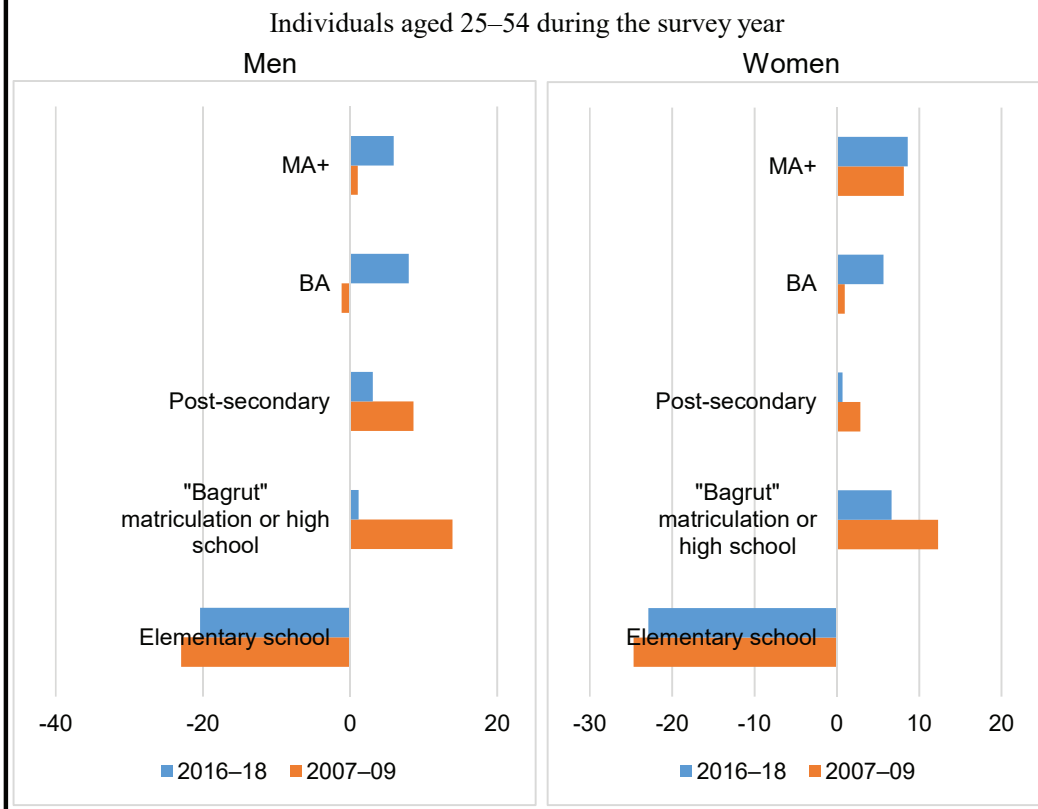
SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

Which Arab households belong to the middle class? Table 2 depicts the demographic characteristics of Arab households compared with those of non-ultra-Orthodox Jewish households. Significant disparities are evident across all characteristics: Arabs have fewer years of education; their heads of household are younger; a higher percentage of them are married with children; and larger households are much more prevalent among them. Arab households are concentrated in Israel's geographic periphery, while Jewish households are mostly located in either central or very central locations.

The disparities between Arab households belonging to the middle class and their Jewish counterparts are also reflected in the education distribution. Figure 2 depicts the distribution of education among Arabs and Jews belonging to the middle class, by gender. Some of the differences may be attributed to significant age composition differences between educated Arab men and educated men in the other groups (the educated Arab men are younger, on average). Another reason may be the considerable disparities in the quality of education and skill level of educated Arabs compared to educated non-ultra-Orthodox Jews. Despite the considerable increase in the

Figure 3

Schooling Gaps between Jews and Arabs in the Middle Class[a]



[a] The schooling gaps are calculated as the difference between the rate of Jews holding their most recent diploma of a certain type and the rate among Arabs.
The analysis is based on a merger of expenditure surveys from 2007 to 2009 and from 2016 to 2018. The year 2007 is the first year for which we have data on the type of most recent diploma for each individual.

SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

proportion of Arab women with an academic degree, the rate of improvement has not caught up with the increase in the proportion of college-educated women in the non-ultra-Orthodox Jewish population, and the gap has grown, especially when it comes to bachelor's degree holders. Unlike other groups in the middle class, the share of Arab men with post-secondary and academic education decreased, despite the increase in their share among Arab men in the whole population. Figure 3 depicts the development of educational disparities.

The employment patterns of middle-class households (Table 3) demonstrate the complexity of characterizing the middle class as a bridging factor - one that contributes to shared interests due to the similarity between the Jewish and Arab populations. Middle class Arab households have similar employment rates to Jewish households in the same class or higher: About 80 percent of middle class Arab households have two or more earners. Yet at the same time, while middle-class Jewish households constitute

Table 3

Employment characteristics of households[a]

Households headed by 25–54 year old

	Other households[b]		Lower middle class (75–125%)		Upper middle class (125–200%)	
	Arab	Jewish not-ultra-Orthodox[c]	Arab	Jewish not-ultra-Orthodox[c]	Arab	Jewish not-ultra-Orthodox[c]
Share of households that belong to each class	72.0	33.7	22.2	36.5	5.9	29.8
Employment patterns among the households						
No employed persons	11.7	8.6	0.0	1.4	0.0	0.6
One part-time employed person	9.9	11.1	2.8	3.6	0.8	1.5
Several employed persons in part-time posts	1.4	3.0	2.7	1.9	2.9	1.0
One full-time employed person	44.3	27.5	15.1	23.6	15.2	17.0
At least 1 employed person in a part-time post and 1 employed person in full-time post	15.1	18.7	27.3	24.4	21.6	23.5
2 or more full-time employed persons	17.6	31.2	52.1	45.1	59.5	56.3
Total	**100**	**100**	**100**	**100**	**100**	**100**

[a] The analysis is based on a merge of the Expenditure Surveys between 2016 and 2018.

[b] Other households are those that do not belong to the middle class. Among Arabs, this group includes mainly poor (around 64 percent of the group) and vulnerable (34 percent of the group). Among Jewish households, it includes those from the upper socioeconomic class (37 percent of the group) as well. See also Table 1.

[c] Includes "Other"—households that are neither Jewish nor Arab.

SOURCE: Based on Expenditure Surveys conducted by the Central Bureau of Statistics.

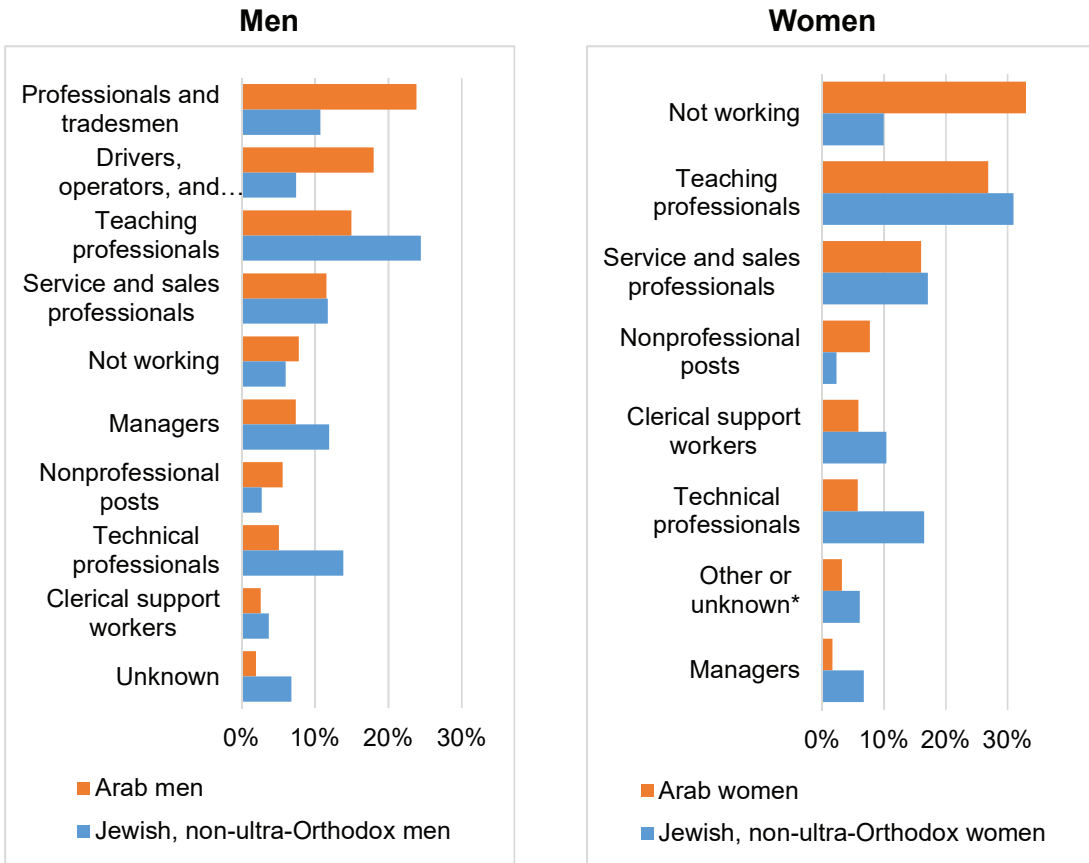
approximately two-thirds of the non-ultra-Orthodox Jewish population - which is indeed a middle group in this population - middle-class Arab households constitute a minority in Arab society, one that is markedly different from other Arab households. The considerable disparities in the distribution of occupations also indicate that these are markedly disparate groups.

Figure 4 depicts the distribution of occupations among Arabs and Jews belonging to the middle class, by gender. Due to the considerable disparity in employment rates in Arab and Jewish societies, the "not employed" category has been added to the list of occupations. Unlike their non-ultra-Orthodox Jewish counterparts, middle-class Arab men are under-represented in high-status white-collar occupations that require college education, such as academia, management, and technical occupations such as practical engineers and technicians - that are associated in many sociological studies with middle-class or social elite affiliations. Most middle-class Arab men are engaged in manual labor and service provision (tradesmen and craftsmen, plant and machine operators, assemblers of products and machinery, and drivers) - low-status occupations, which rarely offer employment security and stability, and are associated with belonging to the lower classes. Nevertheless, the occupational differences between middle-class Jewish and Arab men are moderate compared to the differences between Jewish and Arab men in the general population, where considerable differences in class composition are also evident.

Figure 4

Distribution of occupations[a] of individuals belonging to the middle class, 2016–18[b]

Individuals aged 25–54 during the survey year



[a] For simplicity, we merged some of the occupations and shortened their names:
Among women, “Other or unknown” includes those who work in the following professions: Skilled agricultural, forestry and fishing workers, Tradesmen in manufacturing and construction and other tradesmen, Plant and machine operators, assemblers of products and machinery, and drivers, or when the occupation is unknown.
Among men, the “Professionals and tradesmen” includes those who work in one of the following occupations:
Skilled agricultural, forestry and fishing workers, Tradesmen in manufacturing and construction and other tradesmen.
Among men, “Drivers, operators, and assemblers” includes those who work as Plant and machine operators, assemblers of products and machinery, and drivers.
Among men, "Technical professions" include the following occupations: practical engineers, technicians, agents and associate professionals.

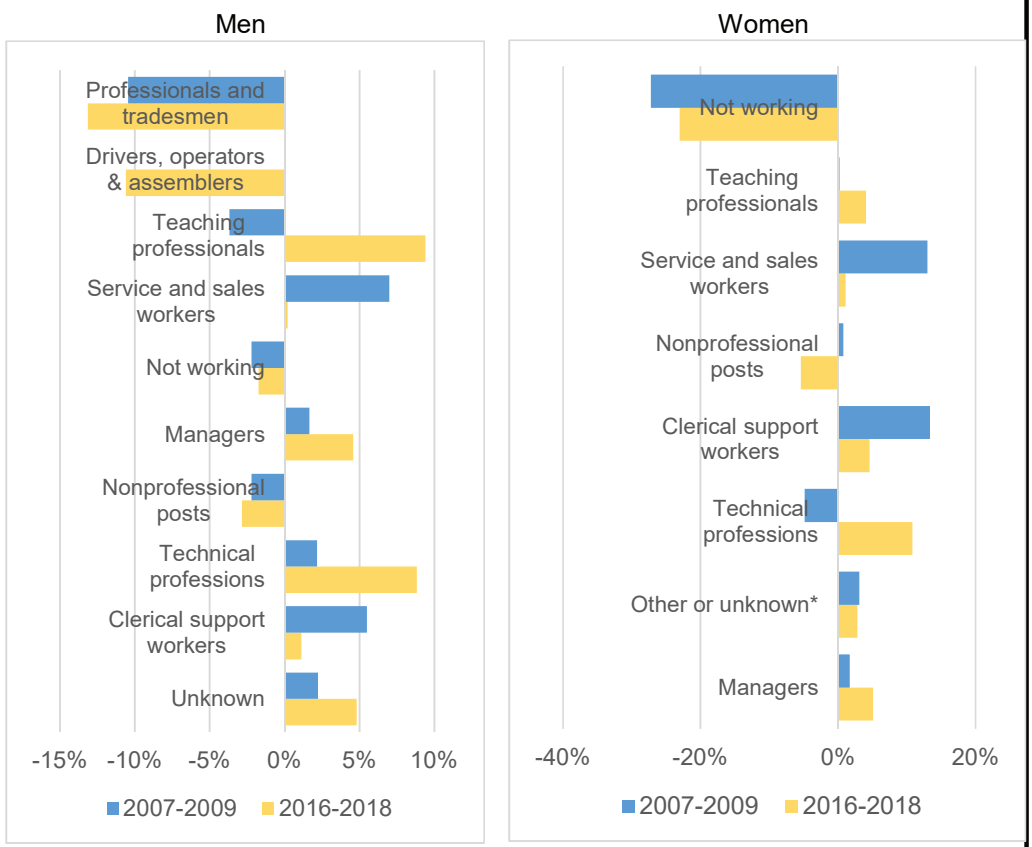
[b] The analysis is based on a merger of expenditure surveys from 2016 to 2018.

SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

Figure 5

The Gap in the Distribution of Occupations[a]

Individuals belonging to the middle class, aged 25–54



[a] The gap in percentage points between the share of Jews in a specific occupation and the share of Arabs in that occupation. For simplicity we combined some of the occupations and shortened their names. See note to Figure 4. The analysis is based on a merger of expenditure surveys from 2007 to 2009 and from 2016 to 2018.

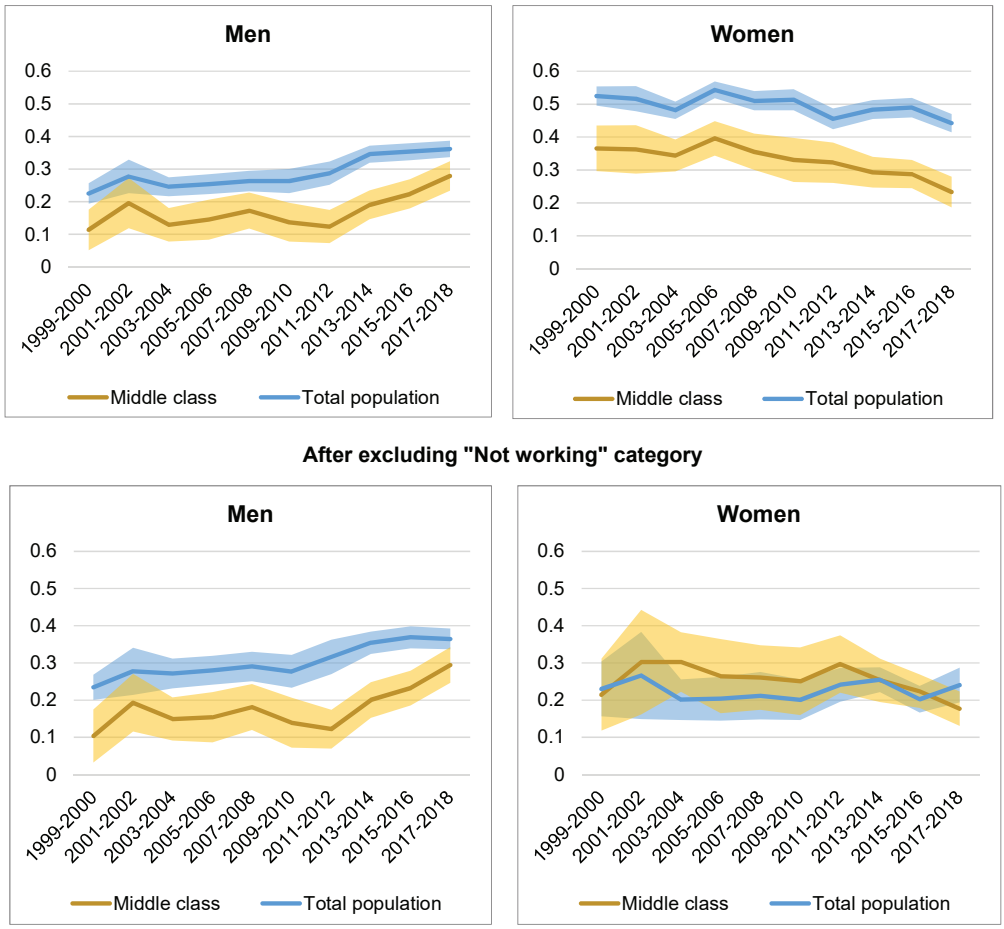
SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

Among middle-class women, the most significant difference between Arab and Jewish women is their employment rates. In terms of working women's occupations - compared to their Jewish counterparts, middle-class Arab women are well represented in occupations requiring college-education and in services and sales, but are under-represented in management and technical professions. The share of Arab women in non-professional occupations is higher than that of Jewish women.

As the education gap between Arabs and Jews widened, so did the occupational gap. The difference in the shares of occupations requiring college education among Jews and among Arabs became larger (Figure 5).

Figure 6
Segregation in Occupations

Individuals belonging to the middle class, aged 25–54



Segregation indices calculated via the dicseg.ado stata model. See Gardin, Carlos (2015): Dicseg.ado version 2.2.
SOURCE: Based on Expenditure Surveys by the Central Bureau of Statistics.

In order to evaluate the significance of the occupational disparities and understand the development of these disparities, we estimated occupational segregation indices between Jews and Arabs by gender and economic class (Figure 6). Simply put, occupational segregation is how dissimilar two groups are. Most segregation indices estimate the distance from an equal distribution, with a value of 1 signifying a total dissimilarity (in our example: all Arabs are engaged in certain occupations while all Jews are engaged in others). A zero value signifies that the occupations distribution is the same for both groups, i.e., that there is the same share of employees in each

occupation in each group. One of the commonly used segregation indices is the Duncan and Duncan Segregation Index (1955), given by:[8]

$$D = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{A_i}{A} - \frac{J_i}{J}\right|$$

where:
J-1*A* - the number of Arabs and Jews in the general population, respectively
Ai and *Ji* - the number of Arabs or Jews in the occupation i.
n - number of occupations

The Segregation Index is estimated for the occupational classification at the section (major groups) level (single digit classification).[9] The data used for the estimation include two breaks; in 2012, following the transition to monthly Labor Force Surveys and cancellation of the Income Surveys, a significant change in the expenditure surveys was introduced; in 2013, the classification of occupations was altered. Due to the few observations of Arabs belonging to the middle class, we merged the survey data for each pair of years from 1999 to 2018.

The occupational segregation between Jews and Arabs belonging to the middle class is significantly lower than in the general population. The finding is true for both men and women, but among women - the segregation is mainly due to the difference between employment rates among Arab and Jewish women. The segregation between middle-class employed Arab and Jewish women is not significantly different from the segregation between employed Jewish and Arab women in the general population. This is probably due to the fact that in most middle class Arab households - women work (although not all working Arab women belong to the middle class).

Among men, segregation has increased significantly in the past decade, while remaining unchanged or decreasing among women. In most years, the segregation between Arab and Jewish women is higher than between Arab and Jewish men. This is mostly due to the difference between Jewish and Arab women's employment rates. Throughout most of the period, the occupational segregation between employed Arab and Jewish women is lower than that between employed Arab and Jewish men in the general population, but in the middle class, segregation between employed Jewish and Arab women is higher than among men.

[8] O. D. Duncan & B. Duncan, (1955). "A Methodological Analysis of Segregation Indexes." American Sociological Review, vol. 20, no. 2, 1955, pp. 210-217.

[9] This classification is quite rough, thus it may lead to a relatively lower level of segregation in comparison with an estimate based on the classification of occupations by two to three digits. Thus, for example, Major group 2 – Professionals, includes both sub-major group 21: science and engineering professionals, and sub-major group 23: teaching professionals. In other words, in the same section (major group) there will be, for example, electrotechnology engineers (minor group 215) as well as secondary education teachers (minor group 233).

Middle class Arab households also differ from those of the Jews in their consumption patterns (Table 4). The difference between these households is indeed smaller than the difference between Arab and Jewish households in the general population, but it is still noticeable for several key consumption items. Middle-class Arab households spend less on current consumption per capita than their non-ultra-Orthodox Jewish counterparts. Nevertheless, since Arab households are, on average, larger than Jewish ones and their income is lower on average, the rate of expenditure out of

Table 4
Consumption characteristics of middle-class households, 2016–18

	Total population		Middle class[a]	
	Jewish non-ultra-Orthodox[b]	Arab	Jewish non-ultra-Orthodox[b]	Arab
Equivalized expenditure (average, NIS)	6,785	4,649	6,777	6,121
Financial expenditure, as a percent of total financial expenditure	100	150	80	91
Total expenditure, as a percent of total income	85	131	84	93
Distribution of expenditures, as a percent of total income				
Food (excluding fruit and vegetables)	11.3	26.3	10.9	15.9
Fruit and vegetables	2.9	6.9	2.7	4.2
Housing	26.2	27.9	24.7	16.1
Home maintenance and	8.2	12.7	8.1	8.5
Home furniture and equipment	2.6	5.4	2.6	4.2
Clothing and footwear	2.3	5.4	2.3	4.5
Health	5.1	5.8	5.0	4.4
Education, culture and entertainment	8.5	9.4	8.8	7.5
Transport and communication	14.4	23.3	15.1	21.5
Other products and services	3.5	8.0	3.5	6.1
Selected expenditures, as a percent of total income				
Monthly rent	8.1	3.5	7.2	2.0
Actual housing consumption	17.4	24.3	16.9	14.1
Other housing expenditures	0.5	0.1	0.5	0.1
	4.1	5.0	4.4	4.0
Other expenditures on education, culture, and entertainment	4.4	4.4	4.4	3.4
Travel on public transportation	0.6	0.8	0.5	0.4
Travel abroad	3.2	2.8	3.2	3.2
Vehicle expenses	8.4	15.1	9.1	14.6
Other transport and communication expenditures	0.3	0.6	0.3	0.4

[a] Households whose equivalized disposable income is greater than 75 percent of median income and less than 200 percent of the median income.

[b] Includes "Other"—households that are neither Jewish nor Arab.

SOURCE: Based on Expenditure Surveys conducted by the Central Bureau of Statistics.

their income is higher (and their savings are lower). This is despite the expenditure including attribution of housing expenses for homes owned by households - which is less prevalent among residents of Arab localities and is estimated on the basis of the property values and rental prices in the locality, which are not easily comparable among the sectors. Middle-class Arab households spend a smaller share of their income on health, education, and cultural activity (despite being larger on average) and a greater portion on food and transport. The higher transport expenses may be partly explained by the fact that middle-class Arab households are located in more geographically peripheral areas than their Jewish counterparts are. In addition, the quality of public transport services in Arab localities - especially urban ones - is lower than in other localities, i.e., middle-class Arabs are probably more dependent on private transport.[10]

We therefore see that despite modernization processes, an increase in women's employment and in the rate of college graduates, as well as a certain increase in the standard of living in Arab society (factors associated with the emergence of a middle class according to its sociological definition), there has yet to be a continuing process of increasing Arab society's share in Israel's middle class. Even Arab households and individuals belonging to the middle class - a relatively small cohort at the higher end of the income distribution in Arab society - are significantly different from their non-ultra-Orthodox Jewish counterparts. Due to the significance of the middle class as a stabilizing and bridging factor, which may also contribute to the economic integration of the rest of Arab society in Israeli economy - for example, by leading local government in Arab localities - there is evidently a need for policy measures to boost skills and productivity in Arab society and to decrease the disparities between Arab society and the non-ultra-Orthodox Jewish population.

Some of these policy measures were included in the Five-Year Plan for Economic Development in the Minority Population for 2016-2020 (Government Resolution No. 922 dated December 31, 2015). The government had decided to invest approximately NIS 15 billion in reducing social and economic disparities between minority sectors and the general population in Israel, while changing its allocation mechanisms. Resolution No. 922 was supplemented by Government Resolution No. 1480: Government Plan for the Empowerment and Socioeconomic Strengthening of the Bedouin Localities in Northern Israel for 2016-2020, dated June 2, 2016. The plan focuses on three key domains: empowerment of local governments, housing, and formal and informal education.[11]

[10] Bank of Israel (2019), "The Supply of Bus Services to Arab localities", in Selected Policy Analysis and Research Notes. Barak (2019) found that to support an increase in employment rates in Arab society, other barriers must be removed, with public transport being, at most, a complementary factor. Improving public transport has mainly helped women who have already overcome the structural and cultural barriers and were on the verge of employment (A. Barak, 2019). "The Effect of Public Transit on Employment in Israel's Arab Society." Discussion Paper Series, Bank of Israel, March 2019.

[11] For more information on the government's actions on education under Resolution No. 922, please see Chapter 6 in the Bank of Israel's 2019 Annual Report.

The Worldwide War on Global Warming and Its Implications for Israel[1]

- In the 2015 Paris Agreement, Israel undertook to reduce its greenhouse gas emissions from 10.1 tonnes per capita in 2015 to 8.8 tonnes in 2025 and to 7.7 tonnes in 2030. Israel will be able to meet these targets by carrying out its plans to convert coal-fired power plants to gas-powered ones by 2024 and meeting its target of raising the share of renewables in power generation to 30 percent.
- Since the Paris Agreement was signed, the United States and Australia have withdrawn from the agreement's emissions targets. The European Union, in contrast, is acting to toughen the targets. Total global emissions have not been declining, but in 2019 they leveled off relative to the previous year.
- To raise the greenhouse-gas emission targets, as the EU and other countries are expected to do the next few years, meaningful action to reduce emission beyond existing plans will be necessary in Israel, too, e.g., switching to electric vehicles and expanding the use of renewable energy.
- Taxation of carbon emissions ("carbon tax") in Israel is an effective way of reducing emissions further. Complementary measures to make it easier for groups that will bear the burden of this tax will make the measure easier for the public to accept.
- In recent years, many countries' central banks have been dealing with the implications of global warming for financial stability. The macroprudential implications of changes in the profitability of firms that produce fossil fuels and those that rely on their use, inter alia, are being explored.

Global warming is becoming increasingly important in economic discussions and decision-making processes around the world.[2] Although the intensity of the phenomenon, its implications, and the extent to which it is caused by worldwide economic activity are still disputed, international economic institutions, foremost the UN, the IMF, and OECD, the EU, and the IEA, consider it a threat that demands

[1] Before writing this report, we consulted with Lihi Goldenberg, Shahar Dolev, Arye Wagner, Yuval Laster, Amir Foster, Eitan Parnass, Avital Eshet, and Nir Shaviv. Galit Paltsur was very helpful in explaining the economic aspects of climate change.

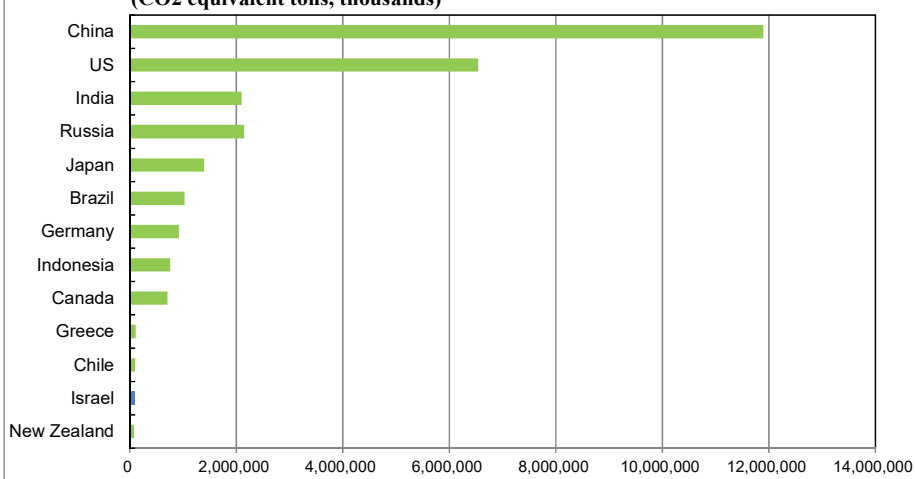
[2] This report deals neither with emissions of pollutants that do not affect global warming nor with non-energy areas of activity that do affect global warming, such as agriculture, because these have much less of an effect on warming than does energy.

a comprehensive policy response.[3] The report that follows deals with how Israel and the international community are coping with global warming and the potential implications of the war on global warming for Israel if the war gathers momentum.

Underpinning the global warming phenomenon is a market failure: Although the production and consumption processes that power it are having adverse effects of global magnitude, each individual polluter causes only a minute portion of the damage and therefore does not refrain from causing it. From an economic standpoint, coping with global warming entails, first of all, a change in the relative price of energy from sources that emit greenhouse gases and increased investments in the infrastructures of energy sources that emit less (or none) of this kind of pollution. Since market mechanisms have not brought about these changes thus far, and since there is no reason that they will occur by themselves, government intervention is needed and, as explained below, action within a multinational framework is also necessary.

Given its small size, Israel has little impact on global warming. According to OECD data, greenhouse gas emissions in Israel, like other small advanced economies, is about half a percent of the worldwide total (Figure 1). China alone, in contrast, is responsible for 30 percent of global greenhouse gas emissions. Nevertheless, Israel,

Figure 1
Greenhouse Gas Emissions
(CO2 equivalent tons, thousands)



SOURCE: Based on OECD.

[3] IPCC, 2014, Climate Change 2014: Synthesis Report, Intergovernmental Panel on Climate Change, Switzerland.

IPCC, 2018, Global Warming of 1.5'C, Climate Change Intergovernmental Panel on Climate Change, Switzerland.

USGCRP, 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I, U.S. Global Change Research Program, Washington, DC.

USGCRP, 2018, Impacts, Risks, and Adaptation in United States: Fourth National Climate Assessment. Volume II, U.S. Global Change Research Program, Washington DC.

IMF, Fiscal Monitor, How to Mitigate Climate Change, October 2019.

as a developed country that is integrated in the global economy, has not been able, and will not be able, to refrain from adopting the international standards that the developed countries have shouldered. The multinational process of cutting emissions has manifested thus far mainly in political persuasion; in the future, however, economic measures are also likely. It is possible that the first indication of imposing sanctions on countries (not EU members) that fail to meet EU standards for greenhouse gas emissions can be seen in a statement of intentions published by the EU Council in late 2019,[4] speaking of the future imposition of EU tariffs and trade restrictions against those that fail to adopt the EU's emission-prevention standards.

This report is divided into three sections. Section 1 gives the background for the discussion of global warming, primarily from the perspective of economic policy, with attention to (1) the global-warming phenomenon; (2) economic tools for coping with it; and (3) measures that various countries have already taken. In Section 2, Israel's integration into the international effort to tackle global warming—what has already been done and measures expected going forward—is described and analyzed. Section 3 concludes and offers several policy proposals and recommendations in Israel on the topic.

1. Background

a. Global warming—characteristics, economic measures, and economic implications

The past decade has seen growing scientific recognition of the existence of non-cyclical global warming—not the kind observed in previous eras but a steadily accelerating phenomenon with potentially existential implications for much of the world's population.[5]

Human activity is responsible for some of this warming, most of which stems from steeply rising concentrations of greenhouse gases—foremost carbon dioxide (CO2)—in the atmosphere (ibid.).[6] According to accepted forecasts, if the current trends in human activity continue, atmospheric CO2 will continue to grow and global warming will accelerate, with an increase of 1.5 degrees Celsius by the middle of the twenty-first century and around 3 degrees by its end. As temperatures rise, the damage to human activity and welfare will grow apace. These forecasts are premised on many

[4] https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

[5] IPCC, 2014, Climate Change 2014 Synthesis Report, Intergovernmental Panel on Climate Change, Switzerland.

IPCC, 2018, Global Warming of 1.5'C Climate Change Intergovernmental Panel on Climate Change, Switzerland.

USGCRP, 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I, U.S. Global Change Research Program, Washington, DC.

USGCRP, 2018, Impacts, Risks, and Adaptation in United States: Fourth National Climate Assessment. Volume II, U.S. Global Change Research Program, Washington. DC.

[6] For a different view, see https://www.bundestag.de/resource/blob/580504/2b96f368c0a785e5e4a09bb1d9797449/19-16-143_fachgespraech_cop24_prof_nir_shaviv-data.pdf

working assumptions. For example, Glosove et al. (2014) find that small changes in discounting rates in long-term models manifest in very large changes in estimates of the cost of the damage.[7]

The extent of future impairment of economic activity due to global warming is unknown and will vary from country to country.[8] The expected negative impact is associated with the flooding of islands and coastal areas by rising ocean waters; changes in distribution of precipitation and natural disasters—floods, fires, and droughts; harm to ecological systems, flora and fauna, and in its wake, agriculture—humankind's sources of food; degradation of biodiversity, and more. All of these, of course, are likely to cause grave harm to human welfare.

It is hard to model these phenomena and produce convincing forecasts about them, since the uncertainty is reflected both in gradual forecasts and scenarios and in those of catastrophic implications. Preparing for these outcomes, in contrast, entails enormous expenses as a matter of certainty. Therefore, it is not easy to build a consensus around measures that should be taken, which, moreover, require multinational action despite wide variance in the vulnerability among countries and regions. Nevertheless, it is widely agreed that if current trends in global warming continue, major, if not catastrophic, economic damage will result. By extension, the need to take action on the matter is also widely acknowledged on the international scene. However, since the methods of action appear to entail impairment of economic activity in the present in order to head off negative impacts in the future, the response depends on the preferences of the public and its policymakers, their reliance on the forecast, and the relevant discounting rates.

The uncertainty in forecasting includes the possibility that the effects of warming will be slower and milder than the current estimates have it. It is also within the realm of possibility, however, that even more devastating geophysical scenarios will come to pass in the near future, e.g., due to permafrost melting. In the field of human behavior, the disaster scenarios relate, among other things, to mass waves of migration that will cause immense harm.

Coping with global warming is roughly divided in two[9]:

1) adaptation, i.e., preparing for the implications of global warming, e.g., evacuating localities in areas that face flooding[10];
2) mitigation of greenhouse gas emissions.

[7] M. Golosov, J. Hassler, P. Krusell, and A. Tsyvinski, 2014. "Optimal Taxes on Fossil Fuel in General Equilibrium," *Econometrica* 82, no. 1: 41–88.

[8] Certain countries may gain from global warming, e.g., if their permafrost becomes cultivable or if currently frozen maritime routes open up.

[9] The UN Framework Convention on Climate Change (UNFCCC) adds subdivisions such as capacity building and funding for climate and technology transfer. See https://unfccc.int/resource/bigpicture/

[10] The Israel Ministry of the Environment has prepared a methodological working paper on the topic: "Israel's Deployment for Adjustment to Climate Change," adopted by government resolution. See https://www.gov.il/he/departments/policies/dec4079_2018 (Hebrew). It seems, however, that the preparations, particularly in setting schedules and allocating requisite budgets, have not yet begun. On the expected effects of global warming on Israel—declining precipitation and higher heat loads—see Y. Yosef, et al. (2019).

Adaptation depends on each country's specific conditions and demands readiness at the country (or geographic-region) level. Action to stanch global warming, in contrast, is possible only via international cooperation because warming in each country is affected by emissions from all other countries.

In view of the aforementioned forecasts, a broad international effort is underway to determine ways of coping with global warming. The pinnacle of this effort, thus far, is the 2015 Paris Agreement on Climate, signed by 197 countries and aiming to hold total global warming to 0.3 degrees above the 2015 level. The accord demands a meaningful mitigation of emissions (of CO2 and additional greenhouse gases) by 2030 and a flatline of zero (net) emissions[11] in 2050 and thereafter. To attain these goals, it will be necessary to raise the relative prices of fossil fuels, make public investments in low greenhouse-gas-emission infrastructures, and carry out the relevant research and development.

The Paris Agreement attempts to bridge the clashing interests of various groups of countries, divided into two:

1) In developing countries, the standard of living and the extent of greenhouse-gas emissions (per capita) is lower than in industrialized countries, prompting them to demand equality before emission restrictions are imposed.
2) Countries that have stable or falling populations prefer to use total emission criteria and those with growing populations—including Israel—favor criteria of per-capita emission.

The Paris Agreement left it to each signatory country to draw up its own mitigation roadmap. The countries are expected meet the targets—even if they are not formally and legally required to do so—and even to toughen their standards every five years. For lack of a formal and statutory commitment, however, no mechanism for the enforcement of the various countries' mitigation roadmaps has been established. The only inspection mechanism agreed upon is public reporting on meeting the goals once every five years (starting in 2023). In addition, the countries must report every other year on their progress in carrying out their stated undertakings within the framework of the Agreement.

In the estimation of the International Monetary Fund (IMF, Fiscal Monitor, 2019)[12] and the International Energy Agency (World Energy Outlook, 2019), the various countries' commitments under the Paris Agreement will not suffice to meet the targets agreed upon. Furthermore, it is not clear how well the countries are acting in accordance with their commitments (ibid.).

Since the Paris Agreement was signed, the consensus hammered out under its aegis has begun to fray. In 2017, the United States announced its intention of withdrawing from the Agreement and, under the terms of the Agreement itself, it can do this in

[11] Net emissions are total emissions less absorption of greenhouse gases, e.g., by planting trees. Since the reckoning takes place on a country basis, one country can reduce total emissions by importing goods produced through high-emission methods instead of making them at home.

[12] IMF, Fiscal Monitor, How to Mitigate Climate Change, October 2019.

2020.[13] The European Commission, in contrast, adopted in late 2019 a policy paper centering on lowering greenhouse-gas emissions to zero by 2050 in the European Union states. Although the EU has a much lower level of emissions than the US and certainly China have, the paper also relates explicitly to the possibility of applying diplomatic pressure to the EU's trade partners for action in the same direction—a matter of special relevance for a small and open economy such as Israel, which does much of its trade with the EU. Furthermore, the paper states that, in order to preclude unfair competition with EU manufacturers, the EU may impose taxes on imports from countries that fail to accept its environmental norms. It is also stated in the document that the EU will not sign additional trade accords with countries that fail to meet the targets that they accepted in the Paris Agreement.[14]

b. Economic tools for dealing with global warming

The accepted macroeconomic approach toward testing the utility of fighting global warming compares the costs of mitigating warming in the present (in terms of lost output and welfare) with the costs of lost output and welfare in the future on account of the warming (Nordhaus, 2014).[15] The Paris Agreement is based on this approach.

An important instrument in this context is a set of policy tools for internalizing the environmental costs of CO2 use, so that the mitigation decided upon can be carried out in an economically efficient way. The two principal ways of mitigating emissions efficiently are taxation of CO2 emissions and cap-and-trade schemes, i.e., the ability to buy and sell authorizations to emit limited quantities of CO2, thus making it possible to control emission quantity and create a market of permits. Both methods have shown empirical success in mitigating CO2 emissions (Krogstrup and Oman, p. 20).[16] A recent analysis shows that the carbon-tax mode of action is preferable (IMF, p. 7)[17] because, among other things, it is less complex and complicated to operate than the alternative. Emission taxation, however, does not lend itself to ab initio determination of its desired extent, and frequent changes in the tax rate are politically difficult to implement. Furthermore, a correct design of emission taxes, one that brings them into accordance with the structure of the external costs, is no trifling matter. (For a discussion of the carbon tax, see below.)

Many central banks that include financial stability in their purviews have a direct stake in global warming[18] due to the growing realization that assuring financial stability

[13] Australia's commitment to fight global warming has also waned since the Paris Agreement was signed.

[14] https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf.

[15] W.D. Nordhaus, 2014. A Question of Balance: Weighing the Options on Global Warming Policies, Yale University Press, New Haven and London. A certain weakness of this approach is that it is based on scenarios involving very high uncertainty.

[16] S. Krogstrup and W. Oman, September 2019, Macroeconomic and Financial Policies for Climate Change Mitigation: A Review of the Literature, IMF, WP/19/185.

[17] IMF, Fiscal Monitor, How to Mitigate Climate Change, October 2019.

[18] The Bank of Israel is an exception in this respect because its duties include serving as the government's economic adviser.

entails appropriate reference to the risks of global warming due to their immensity and materiality.[19] The systemic financial risks associated with global warming include, among others, risk to investment credit, to assets exposed to warming damage, and to the entities that insure these assets. Firms whose production processes involve high levels of greenhouse-gas emission face business risks because they are susceptible to policy measures taken in the effort to mitigate the emissions (Ploeg and Rezai, 2019[20]; NGFS, 2019[21]). Indeed, for several years now, central banks around the world have been dealing with the global-warming issue and its possible macroprudential effects. The activities of some fifty central banks and financial regulators in this field, including those of large European countries (but not the United States), are coordinated by a voluntary international body, the NGFS.[22] In the years to come, the share of central banks in tackling global warming may branch into additional areas (BIS, The Green Swan, 2020).[23]

c. Measures taken by various countries in view of the Paris Agreement

At the core of the Paris Agreement are the participating countries' NDC (Nationally Determined Contribution) programs, i.e., undertakings to cut back on their greenhouse-gas emissions by 2025/2030.

The large majority of signatories to the Agreement have already drawn up such schemes. However, it appears that the cumulative result is actually an increase of 10 percent in emissions in 2030. Thus, the terms of the Agreement are such that the countries should be establishing stricter NDCs once every five years, with 2020 as the first milestone on this roadmap of presenting plans with increasingly strict measures[24]:

— 184 of the 197 signatory states have presented NDC programs and quite a few are preparing to unveil more stringent programs of this kind in 2020.

— Many advanced economies are promoting action plans that envision the total cessation of greenhouse-gas emissions by 2050. Around a dozen of them (including the UK, Germany, Japan, Canada, and France) have already designed programs of this type and many others have expressed the intention of doing the same.

— A large majority of countries has made systematic progress in establishing statutory, administrative, and technical mechanisms that would allow them to implement their NDC programs.

— Given that funding difficulties are likely to burden developing countries in implementing these schemes, developed countries have undertaken to help to

[19] See https://www.bankofengland.co.uk/climate-change)

[20] NGFS (Network of Central Banks and Supervisors for Greening the Financial System). 2019, A Call for Action: Climate Change as a Source of Financial Risk. Paris: NGFS Secretariat.

[21] A. Rezai and F. van der Ploeg, 2019. Stranded Assets in the Transition to a Carbon-Free Economy.

[22] https://www.ngfs.net/en/page-sommaire/governance .Israel is not a member of this body.

[23] BIS, 2020. The Green Swan, Central Banking and Financial Stability in the Age of Climate Change. Proposals have also been put forward for direct involvement of central banks in providing investment credit or guarantees for the prevention of emissions. Practically speaking, such measures amount to fiscal intervention by the central bank and are more relevant in developing countries.

[24] See UNFCCC, UNDP, 2019. The Heat is On, Taking Stock of Global Climate Ambition.

fund them. At the present writing, however, there are no specific agreements and mechanisms for this.

As for actual developments, the picture is mixed. In 2018, emissions of carbon dioxide (the main greenhouse gas) increased by 1.7 percent and the share of CO2 in the atmosphere set a record—overshadowing the agreements already made and clarifying the need for more aggressive policy measures. This increase, however, did not recur in 2019; CO2 emissions remained at the 2018 level.[25]

2. Israel's integration into the worldwide war on global warming[26]

Emissions—the situation today

Israel's greenhouse-gas emissions in 2017—the latest year for which data are available—came to 80 million tonnes, up 0.4 percent from 2016, a small year-on-year increase relative to the 1 percent average in the past decade. Most of Israel's greenhouse-gas emissions, like those elsewhere, are of carbon dioxide. (The other main greenhouse gases are methane and hydrofluorocarbons).

To express the effect of greenhouse gases in schematic terms, it is customary to express it in terms of CO2 on the basis of an index that reflects the global warming potential of each gas.[27] The share of carbon dioxide in Israel's total emissions fell from 86 percent in 2010 to 82 percent in 2017.

Most emissions around the world, and in Israel, are byproducts of energy production. The rest comes from industrial processes, agricultural activity, and solid waste (Table 1). Energy production includes the energy industries (producers of electricity and gas and fuel industries), energy used to power motor vehicles (transport), energy production in manufacturing and construction, and households.[28] In 2016, the most recent year for which inter-country data are available, electricity production accounted for about half of greenhouse-gas emissions in Israel, far above the 30 percent average weight among OECD member states. The difference traces, among other things, to a 20 percent difference between Israel and the OECD countries in the intensity of carbon in energy production, because the processes used to produce energy in these countries are more efficient on average, in terms of the climate, than in Israel. This is the outcome of differences in the sources of energy: In some OECD countries, nearly all energy is produced by means of nuclear power or renewables. The share of greenhouse-gas emissions by households in Israel is below the OECD average, probably because Israeli households consume little natural gas and other fuels for

[25] ttps://www.iea.org/news/defying-expectations-of-a-rise-global-carbon-dioxide-emissions-flatlined-in-2019.

[26] The source for the Israel data in this part of the report is the site of the Central Bureau of Statistics; that for the other countries is the OECD statistics site, unless otherwise stated.

[27] The index relates to the amount of heat trapped by a unit of atmospheric gas in a given period of time. It is expressed in CO_2 terms because this gas is believed to be the main culprit in trapping heat in the atmosphere. It is customarily presented for periods of 20, 100, and 500 years.

[28] Households produce energy mainly by using compressed gas for cooking and kerosene for heating.

home heating (evidently making more extensive use of electricity). Another difference between Israel and the OECD countries is the large share of waste in greenhouse-gas emissions in Israel; the environmental damage occasioned by solid waste in Israel is especially acute (see Box 1).

Table 1
Greenhouse gas emissions, by sector
(Percent of total emissions, 2016)

	OECD	Israel
Energy	81	80
Energy industries	30	50
Manufacturing and construction industries	13	6
Transportation	23	23
Households; for residences	11	1
Other	1	0
Manufacturing processes and use of products	7	9
Agriculture	9	3
Waste	3	8

SOURCE: Based on OECD.

Table 2 itemizes the mix of energy sources in Israel in 2018, the mix in 2014, and the coefficient of carbon intensity in producing energy from each source.[29] The table shows, for example, that coal produces 1.8 times more CO2 emissions for energy production than does natural gas. Also visible is the change in the sources of energy used to produce electricity in Israel in recent years. In 2014, almost half of Israel's energy was produced by burning coal (49 percent); by 2018, the share of coal fell to 30 percent whereas that of natural gas climbed to 66 percent. This transition to a less polluting source of energy helped to reduce Israel's greenhouse-gas emissions considerably, and if several foreseen measures (detailed out below) come to pass, the trend and its contribution may gather strength by 2030.

Table 2
Emission coefficient and fuel mix in electricity generation
(Percent of total production, in tons of crude oil equivalent)

	2014	2018	*2030	Coefficient (ton of coal emission per ton of crude oil equivalent)
Coal	49	30	0.7	3.7
Natural gas	48	66	69	2.1
Heating oil	0	0.08	0	2.9
Diesel	0.008	0.3	0	2.9
Solar energy	0.15	2	30	0.0

*Scenario in line with the Ministry of Energy's decision regarding shifting coal-burning plants and generating 30 percent of electricity via renewable resources.

SOURCE: Based on Central Bureau of Statistics and US Energy Information Administration.

[29] This coefficient is defined as the quantity of greenhouse gases emitted per unit of energy produced from the same source; it may be interpreted as the cost of producing a unit of energy in terms of CO_2 emission.

The second most significant gas in global warming is methane, the share of which in pollution in Israel has risen slightly in recent years and came to 9 percent in 2017. The hundred-year Global Warming Potential (GWP) index for methane is 28. Namely, over a period of 100 years, a unit of methane traps twenty-eight times as much heat in the atmosphere as does one of carbon dioxide. The main precipitants of methane emissions are solid waste and its deconstruction, and agricultural activity.[30] In recent years, the share of CO2 in total greenhouse-gas emissions has been falling as against an increase in the share of hydrofluorocarbons (HFC), the third most important gas. HFC gases, emitted mainly as a consequence of industrial refrigeration processes, accounted for 7 percent of total emissions in 2017. The GWP index for hydrofluorocarbons is estimated at 1300–1500.[31]

It is customary to deconstruct changes in an economy's total greenhouse-gas emissions on the basis of the Kaya identity,[32] which separates sources of emissions into factors of emission intensity (the environmental footprint of energy production), intensity of energy production in GDP, per-capita GDP, and population increase, as follows:

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Energy}} * \frac{\text{Energy}}{\text{GDP}} * \frac{\text{GDP}}{\text{Population}} * \text{Population}$$

Figure 2, breaking down the components of the Kaya identity for the Israeli economy and the OECD average, shows that the decline in pollution in Israel in recent years traced mainly to a decrease in the intensity of energy in GDP, which remains high by the standards of developed countries. This intensity is declining in advanced economies due to greater production efficiency in each industry and, to a lesser extent, a restructuring of the economy that manifests in switching to less energy-intensive industries. The downturn was abetted by a decrease in carbon intensity in energy production due to switching from coal to natural gas. In 2006–10, in contrast, the main contributing factor to the decrease in emissions was the change in intensity of carbon in energy production. In those years, Israel made growing use of natural gas for electricity production due to the activation of the Yam Tethis reservoir and the import of gas from Egypt. However, growth of population, per-capita GDP, and energy intensity in GDP at that time abetted an upturn in emissions and offset the decrease occasioned by the other developments, allowing total emissions to increase by 1 percent per year. In the OECD countries, in contrast, energy intensity in GDP

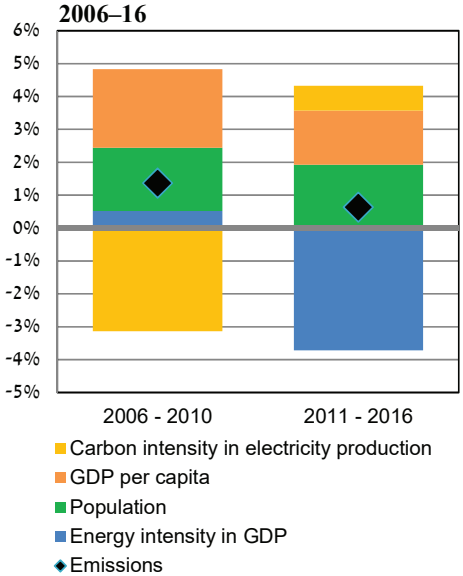
[30] Methane is the main component of natural gas; its combustion produces carbon dioxide.

[31] In 2016, HFCs were added to the Montreal Protocol, signed by member countries in 1987 pursuant to the Vienna Convention for the Protection of the Ozone Layer (1985). The protocol specifies substances harmful to the ozone layer in order to mitigate their use. HFCs are volatile synthetic substances developed in the United States pursuant to the ban on the use of substances listed in the Montreal Protocol. Over the years, notwithstanding their contribution to attenuating damage the ozone layer, HFCs have been found to abet the trapping of heat in the atmosphere.

[32] Kaya, Y., and Okoboji, K., 1997. Environment, Energy, and Economy: Strategies for Sustainability. Tokyo: United Nations University Press.

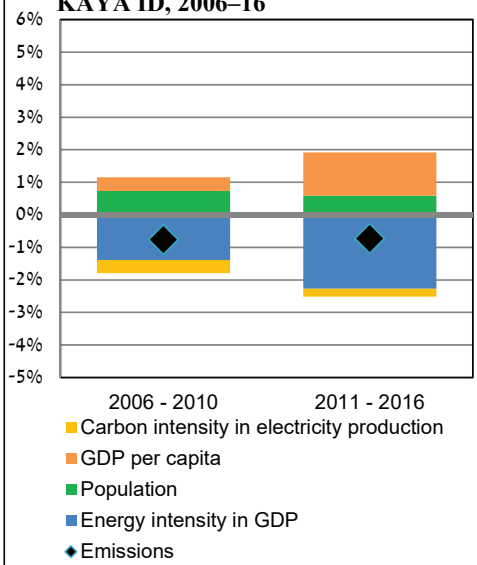
continued to fall throughout that period and was the main factor in allowing CO2 emissions to decline.

Figure 2a
The Change in CO2 Emissions in Israel, by Factors - KAYA ID 2006–16



SOURCE: Based on OECD statistics.

Figure 2b
The Change in CO2 Emissions in OECD Countries, by Factors - KAYA ID, 2006–16



SOURCE: Based on OECD statistics.

3. Potential effects of international global-warming mitigation processes on Israel

The objective of the Paris Agreement, as stated, is to hold global warming to 0.2 degrees above the 2015 level. In accordance with the rules of the agreement, Israel Government Resolution 542 (2015) sketched a road map of policy objectives in terms of tonnes of emission per capita; this document was presented to the UN climate convention secretariat ahead of the signing of the climate-convention accord at the end of that year.[33] The resolution sets forth a detailed trajectory of mitigation: from 10.1 tonnes per capita emission in 2015 to 8.88 in 2025 and 7.7 by 2030.

Along with Israel's participation in the global effort, the Israeli commitment to the world climate targets also derives from the risk of deviating from the global norm and, foremost, concern about swerving from the ambitious downward emissions trajectory that the European Union countries have been promoting. For this reason, it will be important for Israel to consider a policy scenario that would lead to zero emissions in the long-term—by 2050, for example—in accordance with the EU targets.

[33] See Government Resolution 542, September 20, 2015:

Policy trends around the world are shrouded in uncertainty because impediments to the emission-mitigation policy, foremost the United States' declaration of withdrawal from the climate agreement in 2020, are also at work.[34] China and India are also continuing to promote and develop coal-fired power plants and some European Union countries, such as Poland, Greece, the Czech Republic, Romania, Bulgaria, and Croatia, are continuing to produce electricity by means of coal and, at the present writing, have no implementable plan to switch to alternative energy sources. Conversely, forces emanating from multinational organizations and developments in the European Union may create pressure to speed up the attainment of the emission-mitigation targets. It is not just a theoretical matter to understand the implications of these international processes for Israel, because adopting the target of zero emissions by, say, 2050, will have immediate repercussions for Israel. This is because the Israeli economy's current investments in gas and electricity-production infrastructures and the country's building regulations have implications to a term of twenty years ahead, and the emission targets will impact both.

The Minister of Energy recently decided to convert Israel's coal-fired power plants to gas by 2025 and raised the target for use of renewable energy sources to 30 percent of total electricity produced.[35,36] These measures will allow Israel to meet its commitments under the Paris Agreement. Figure 3 shows per-capita emissions in Israel from 2006 to 2017, the targets that were set within the framework of the roadmap, and the national per-capita CO2 emission forecasts in view of the policy measures taken, i.e., converting coal-fired power plants to gas and raising the share of renewables in electricity production to 30 percent.[37] To facilitate comparison, the figure also shows average per-capita emission levels in OECD countries in the past. The per-capita level in Israel declined from 10.5 tonnes in 2010 to 9.7 in 2017[38] and was below the OECD average throughout the period, with the exception of an episode in 2012 in which the supply of gas from Egypt was interrupted, forcing Israel to turn to polluting energy sources.

To develop the estimate, we assumed that total per-capita emissions from activities other than electricity production (e.g., transport and industry) will remain constant. This assumption, in our judgment, sets an upper bound for the quantity of emissions that trace to this source. The changes in total emissions from factors other than

[34] Twenty-two US states, however, including most of the large ones, are continuing to pursue the emission-mitigation roadmap despite the Federal Government's policy. For details, see http://www.usclimatealliance.org/.

[35] https://www.gov.il/he/departments/news/ng_131119

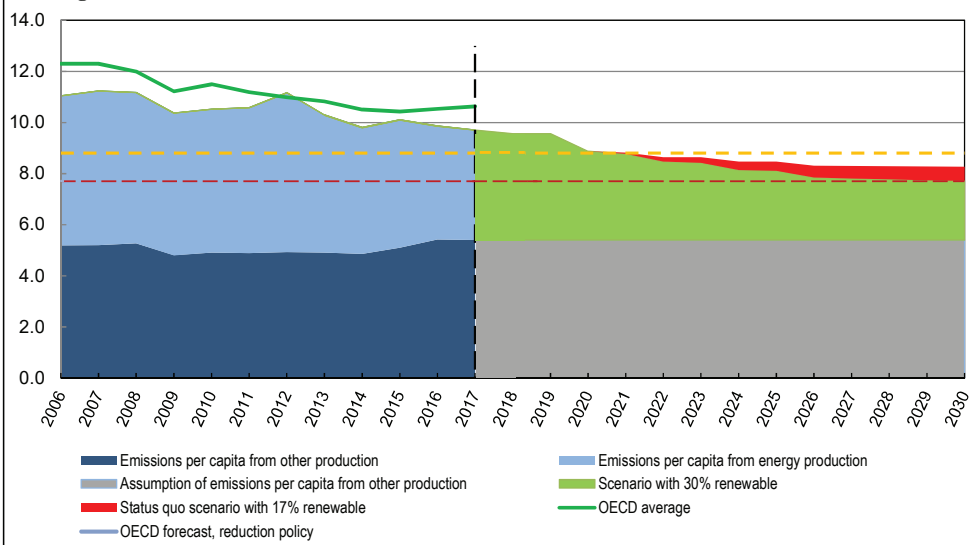
[36] https://www.gov.il/he/Departments/publications/Call_for_bids/shim_2030yaad

[37] The rate of increase in electricity consumption in this scenario is derived from estimates of the Israel Electricity Authority, which are consistent with those of the Bank of Israel (Gallo, 2017). The coefficients of emissions per unit of energy produced were calculated in accordance with those of the Authority. See consultation ahead of setting policy of mitigation up to full discontinuation of use of coal, Electricity Authority, https://pua.gov.il/Publications/PressReleases/Pages/coil_policy.aspx

[38] See *Mitigation of Greenhouse-Gas Emissions at Israel—Followup Report on Implementation of the National Program and Targets for Mitigation of Greenhouse-Gas Emissions,* November 2018.

electricity production were slower than population growth in the past decade and, turning to the transport industry, the share of electric vehicles may grow and some manufacturing will switch from heavy fuel oil, kerosene, and diesel fuel to natural gas. These factors are supportive of the possibility of a decline in per-capita emissions not originating in electricity production.[39] This estimation is supported by research showing that the electrification of transport would probably do much to help mitigate emissions.[40]

Figure 3
CO2 Emissions per Capita: 2006–17 Data for Israel and OECD Countries, Policy Scenarios through 2030



SOURCE: Based on OECD Statistics and IEC.

Figure 3 indicates that even without converting power plants and increasing the use of renewables in production, per-capita greenhouse-gas emissions are likely to attain the target of 8.8 tonnes per capita by 2021, three years before the target date. It may also be seen that *ceteris paribus* converting Israel's coal-fired power plants to natural gas by 2025 will not suffice to meet the 2030 target, but increasing the share of renewables in electricity production to 30 percent, in accordance with the roadmap set forth in the Electricity Authority's scenarios, will make this possible. Experience, however, shows that the path to this achievement will not be an easy one. Since

[39] See Table 2 in this Report, which presents the emission coefficients of the various fuels.
[40] See Nathan Sussman et al., *Israel 2050—A Thriving Economy in a Sustaining Environment: Effects on Macroeconomic Growth in Israel,* Israel Democracy Institute (Hebrew).

the government's previous targets in this regard were not attained,[41] Government Resolution 542 set a target of 10 percent for 2020 and 17 percent by 2030. In 2020, the Israeli economy will probably meet the government's original target for the first time. This will happen due to the elimination of entry barriers to renewable electricity production, better management of tenders for renewable energy production, and more efficient bureaucratic procedures. In addition, the Encouragement of Investments in Renewable Energy Law allows a tax writeoff on the proceeds of home production of electricity using renewable sources.[42] The downing of the entry barrier to this kind of production will probably have a major effect on the energy sector because rooftops are believed capable of generating 7–32 percent of electricity countrywide.[43]

Meeting the renewable energy targets, together with the external utilities of developing this sector, make this a preferred policy instrument because it is well defined, measurable, and practicable.[44] In the estimation of the Ministry of Energy, however, weak exposure to light in the winter and in many daytime hours, along with the expected costs of renewable energy storage, rule out reliance on photovoltaic energy at more than one-third of electricity capacity for the time being.[45] Furthermore, it would be highly wasteful to operate fossil-fuel power plants as backups for the seasons and times of day when renewable energy is not available due to the capital unemployment that this would cause. Therefore, it is not being considered, at least until the imputed costs of pollution go up and are reflected in an increase in taxation. It is also important to remember that the planned increase in the share of renewable energy poses major challenges, such as closing the gap in energy infrastructure investment.[46]

4. The road ahead—a carbon tax?

Even though the Israeli economy is expected to meet the government's carbon emissions targets as expressed in Resolution 542, the dynamics of international processes may lead to the toughening of emission targets abroad in the next few years, necessitating further action to reduce per-capita emissions in Israel and make further

[41] After the fact, given the major decrease in prices of production by means of renewable energy sources, the economy saved 10 percent on its expenditure for electricity by not attaining the goals but fell behind the government's environmental targets for this reason. See Bank of Israel, Research Department, September 2017. "The Development of the Electricity Market in Israel: Toward a Sustainable Electricity Market," policy analyses and research issues.

[42] Encouragement of Investments in Renewable Energy (Tax Benefits for Electricity Production from Renewable Energy) Law, 5777-2016.

[43] R. Vardimon, 2011. "Assessment of the Potential for Distributed Photovoltaic Electricity Production in Israel," Renewable Energy, 36/2, pp. 591–594.

[44] See consultation ahead of setting policy of mitigation up to full discontinuation of use of coal, Electricity Authority, https://pua.gov.il/Publications/PressReleases/Pages/coil_policy.aspx

[45] See "Testing the Assimilation of a High Percent of Renewable Sources in the Israel Electricity Grid," Israel Energy Forum, The Heschel Center for Sustainability (in Hebrew).

[46] See Bank of Israel, Research Department, 2015. "Use of Renewable Energy in Israel," *Recent Economic Developments 140*, April–September.

progress after 2030. Resolution 542 includes several policy tools that are meant to suppress electricity consumption by 17 percent and reduce private travel by 20 percent relative to a "business as usual" scenario. Another policy instrument that is attracting growing attention around the world is a carbon tax.

Resolution 542 instructed the ministers of Infrastructure, Environmental Protection, Finance, and the Economy to present the Government with a detailed plan for attaining the climate targets. In April 2016, on the basis of the ministers' recommendations, the Government adopted (in Resolution 1403) a national program for the attainment of the greenhouse-gas emission mitigation targets in various specific ways[47] including NIS 500 million in state loan guarantees for investment in energy efficiency and mitigation of greenhouse-gas emissions, NIS 300 million in grants for investments in energy efficiency, accelerated depreciation for energy-saving products, green building standards, and a tax exemption for home producers of energy. It was also determined that a steering committee headed by a representative of the Ministry of Environmental Protection would be appointed to implement the national plan.[48]

One of the weaknesses of the energy-efficiency targets is that they are poorly defined, not measurable, and hard to estimate in terms of efficiency. For example, the efficiency targets are defined relative to a "business as usual" scenario, but the scenario on which they were built assumes a 3.2 percent annual average growth rate of energy consumption,[49] similar to the average rate in the decade preceding the resolution and in the forecast attached to the national plan for implementation of the Paris Agreement. In a subsequent forecast, however,[50] the growth rate of electricity consumption (corresponding to the GDP growth forecast in Tsur and Argov, 2018), was found to be only 2.7 percent, reflecting slower overall economic growth irrespective of greater efficiency in energy use. Furthermore, according to a more recent study, even this growth rate is biased upward because global efficiency processes and spillover of knowledge about production efficiencies are causing electricity consumption intensity in the OECD countries to decline.[51] Similarly, there is no reliable forecast of travel demand; therefore, it is problematic to set a target of mitigating travel as against the benchmark scenario.

Another weakness of the energy-efficiency targets is that estimating the effectiveness of subsidies for this, for investment purposes, is based on a geometric calculation of unit electricity consumption with and without a subsidy. This efficiency index rests

[47] See https://www.gov.il/he/Departments/policies/2016_des1403.

[48] Since it was established, the committee has published two follow-up reports. See https://www.gov.il/en/departments/publications/reports/reports_reducing_ghg_emissions_in_israel

[49] See Ministry of the Environment, National Plan for Implementation of the Paris Agreement, September 2016: https://www.gov.il/blobFolder/policy/natl_plan_for_ghg_reduction_and_energy_efficiency_april_2016/he/climate_change_and_energy_efficiency_natl_plan_to_implement_paris_agreement_sept_2016.pdf

[50] L. Gallo, 2018. *Long-Term Forecast of Electricity Demand in Israel.*

[51] L. Gallo, 2019. "Electricity Intensity in the Developed Countries: Global Divergence, Club Convergence and the Role of the Structure of the Economy," https://fsr.eui.eu/wp-content/uploads/2020/03/Gallo-FSR-CLIMATE-2019-Electricity-intensity-convergence.pdf

heavily on the assumption that new capital investment would not be made without the subsidy. If a capital investment that is more effective in terms of energy would be made even without the subsidy, it amounts effectively to nothing but a government expenditure that subsidizes capital investment. The saving on emissions due to such investments is, ipso facto, already built into the "business as usual" scenario. This aside, the subsidy is liable to create an incentive contrary to its purpose by supporting firms that manufacture at high electricity intensity that might otherwise have left the market. Thus, it may provide artificial support to energy-intensive firms and industries.

The weaknesses of these policy tools undermine the ability of energy-efficiency targets to mitigate greenhouse-gas emissions. It is true that the targets and the message they send the public have value in terms of consciousness-raising. However, the budget cost of these policy tools and the difficulty in monitoring their effectiveness subvert their credibility. For this reason, the carbon tax is increasingly discussed around the world as a policy tool that may deliver a more effective system-level response to the need to mitigate pollution.[52] A carbon tax is imposed on economic activity that causes greenhouse gases to be emitted into the atmosphere. Given the difficulty in taxing different activities differentially and in quantifying emissions in each activity, it is the tendency at this stage to apply the carbon tax to the core economic activity that causes pollution: energy production.[53] The development of scientific and economic tools in coming years, however, may make it possible to apply carbon taxes to a broader range of activities that cause considerable levels of emission.

The main advantage of the carbon tax is that it goes to the heart of the problem. This policy device directly addresses the main market failure, which originates in the absence of property rights to air. For this reason, one cannot price pollution without government intervention; therefore, the price mechanism creates a distorted equilibrium. The carbon tax makes national resource allocation more efficient by being imposed on the polluting product, forcing producers and consumers to build its external effects into their prices, thus encouraging correct prioritization of energy use. Admittedly, it is hard to gauge the future effect of this tax on the level of emissions, but its rate can be adjusted commensurate with the gap between the outcomes of its use and the effect desired. For this reason, the carbon tax appears to be the most effective method to use among those that influence pollution directly. The IMF substantiates this view in a report that compares various intervention mechanisms.[54] According to the IMF's calculations, the global tax rate that is needed to meet the targets in the Paris Agreement is $75 per tonne of CO2 emitted. The effect of such a tax on electricity and fuel prices in developed countries varies widely from country to country[55]; this is

[52] See Nathan Sussman, et al., *Israel 2050—A Thriving Economy in a Sustaining Environment: Effects on Macroeconomic Growth in Israel,* Israel Democracy Institute (Hebrew).

[53] In an OECD survey, carbon taxes were examined at large, on fuel, and on electricity. The taxes in question were imposed in Denmark, Finland, Norway, and Sweden in the 1970s, and in Chile, Colombia, France, Ireland, Japan, Mexico, Portugal, northern Africa, and Switzerland in the past decade.

[54] IMF, October 2019. *Fiscal Monitor: How to Mitigate Climate Change*.

[55] Ibid. p. viii.

also expected to create variance in public sentiment toward such a tax. Palatnik and Shechter (2008)[56] found that, under the conditions of the Israeli economy, a carbon tax would probably be effective in mitigating emissions. It should, however, be imposed gradually in order to allow firms to adjust their production inputs to the new price ratios and for consumers to adjust their home appliances, e.g., by installing home climate-control systems.

Another advantage of the carbon tax is that its effect is estimated on the basis of an assessable parameter—price elasticity of demand, particularly in electricity production and motor-vehicle use, the two predominant sources of pollution. These elasticities have been estimated abroad at 0.2–0.6,[57] meaning that a 1 percent increase in electricity price is expected to reduce electricity demand by 0.2–0.6 percent. Gallo (2018)[58] estimated 0.3 elasticity in Israel.[59] Even though these studies assume as a working hypothesis that price elasticity of demand is constant, it is often found in the professional literature that elasticity is not such and that, sometimes, this may be manifested in the opposite effect.[60] Thus, in the case of air pollution, the risk is that a too-low tax will lead to the sense that the price of pollution is worth paying for the right to pollute—a phenomenon known in the literature as "a fine is a price." To avert such a situation and attain the goal, the tax has to be high enough. In the IMF report, several simulations tested the level of carbon tax that would lower emissions to a scale congruent with the Paris Agreement targets; they found that the tax per tonne of CO2 emitted should be $75 per tonne.

Another advantage of the carbon tax over other emission-mitigating measures is the ability to track the population groups on which it is imposed, its impact on them, and its effect on the rest of the economy. This is particularly advantageous because it helps to deal with two issues that may sway decision-makers against the carbon tax: its regressivity (Krogstrup and Oman, p. 20)[61] and its differential effect on different industries, possibly allowing affected industries to unite more easily for political resistance to the tax. Exact measurement of the implications of the carbon tax for income distribution is complicated because the cost of taxing different sources of energy is distributed across many goods. However, direct measurement of household

[56] Ruslana Rachel Palatnik and Mordechai Shechter, 2008, "Analysis of the Impact of Economic Incentives to Control Greenhouse Gas Emissions within the Framework of a General Equilibrium Model of the Israeli Economy," The Economic Quarterly, 55:4, pp. 545–573 (December).

[57] For a meta-analysis of the empirical outcomes of price elasticity for energy demand, see X. Labandeira, J.M. Labeaga, and X. López-Otero, 2017. "A Meta-Analysis of the Price Elasticity of Energy Demand," *Energy Policy,* 102, pp. 549–568.

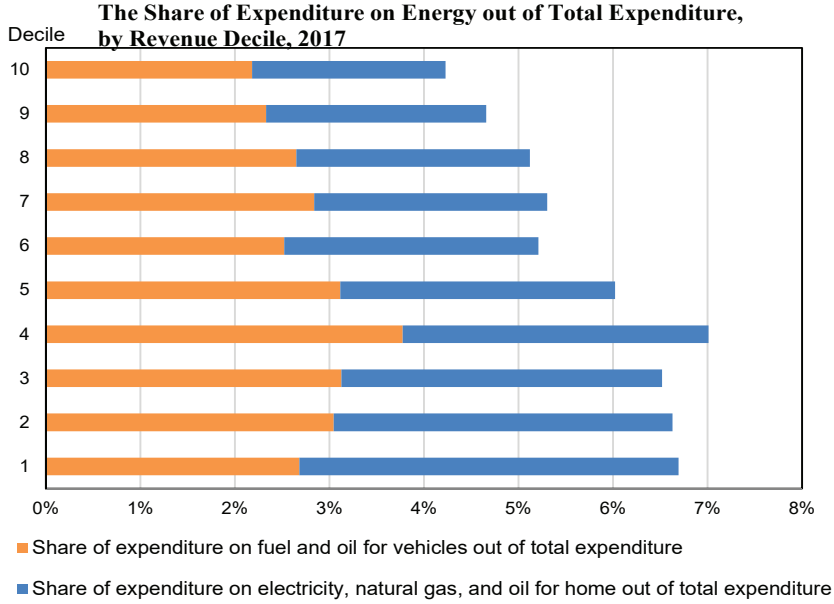
[58] The growth rate of electricity consumption in the scenario is derived from estimates of the Israel Electricity Authority, which are consistent with those of the Bank of Israel (Gallo, 2018).

[59] Although this study makes no explicit reference to the possibility of an effect of demand on price, this possibility does not stand to reason because electricity prices in Israel are set on the basis of estimates of production cost.

[60] See U. Gneezy and A. Rustichini, 2000. "A Fine Is a Price," *Journal of Legal Studies,* 29(1), pp.1–17, and discussion in the literature surrounding this article.

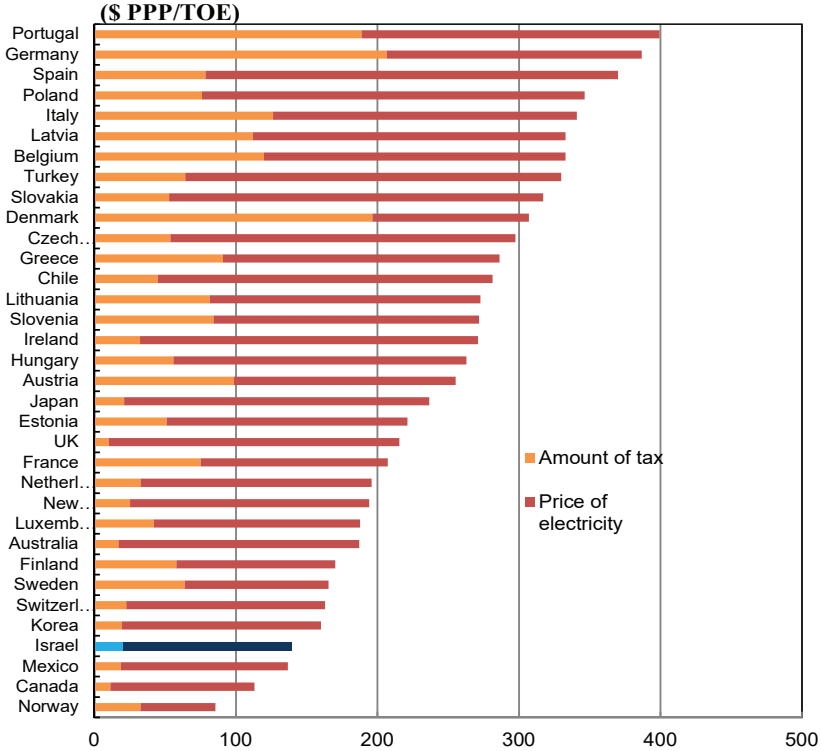
[61] S. Krogstrup and W. Oman, September 2019. Macroeconomic and Financial Policies for Climate Change Mitigation: A Review of the Literature, IMF, WP/19/185.

Figure 4
The Share of Expenditure on Energy out of Total Expenditure, by Revenue Decile, 2017



SOURCE: Based on Central Bureau of Statistics.

Figure 5
Electricity Price - Households, 2016
($ PPP/TOE)



SOURCE: Based on IEA.

expenditure on energy consumption only, in the form of electricity and motor-vehicle fuel, shows that this expenditure is higher in low-decile households (Figure 4). (Although this is not an absolutely precise metric, these are the data that are available to the public and that may influence public opinion.) Furthermore, since much energy expenditure is on motor-vehicle fuels and oils, the tax may inflict greater harm on inhabitants of peripheral areas—prompting, for example, the acute resistance to a similar tax in France that ultimately led to its repeal. It is important to give thought to these problems in planning a carbon tax before the decision to implement one is made. One possible solution is to use some of the receipts to compensate affected population groups (see Box 1).

The importance of a potential carbon tax in Israel also flows from the low price of electricity in Israel by OECD standards (Figure 5), originating in low cost of electricity in Israel and low taxation of this product. This enhances the use of electricity in Israel and abets the development of electricity-intensive industries and an electricity-intensive structure of consumption, resulting in higher greenhouse-gas emissions.

Box 1: A Carbon Tax in Israel—How Much Revenue Will It Generate?

In this box, we provide a rough estimate of the revenues that a $75 per tonne tax on carbon dioxide emissions—the rate that the International Monetary Fund has found necessary to lower global emissions to the Paris Agreement targets—may bring in. The calculation that follows rests on the assumption that the tax will apply only to the use of fuels for electricity production, transport, energy production in the business sector, and home heating, and relates only to carbon dioxide and not to emissions of other greenhouse gases. For example, the analysis does not address itself to taxation of greenhouse-gas emissions originating in agriculture—8 percent of total greenhouse-gas emissions in Israel—and by the chemical industry and industries that make extensive use of refrigeration gases. One of the future decisions relating to the application of a carbon tax will be whether to expand its incidence to these fields, broadening its coverage but at the price of making implementation more complex.

Table 1 presents the main points of the calculation. Line 1 shows the quantity of fuel combusted in Israel in 2017 for electricity production, transport, and households parsed by type of fuels; Line 2 presents the amount of CO2 emitted into the atmosphere by the combustion of one tonne of one of these fuels.[1] The product obtained by multiplying the quantity of fuels by the emission coefficients, i.e., total emission caused by each fuel, is shown on Line 3. Under these data appear the coefficients of emissions per unit of energy, fuel prices, the current rate of excise tax on the fuels, and the increase in fuel price occasioned by the imposition of the carbon tax. In this simulation, we lower the fuel excise because the carbon tax is meant to replace the excise in representing the external effects of their use. To the extent that the excise tax is intended to represent other external effects—such as the congestion effects in vehicle transportation—the carbon tax can be added to the existing excise tax.

[1] These data differ from the coefficients of pollution per unit of energy noted above. This is because one tonne of different fuels may yield different amounts of energy. For example, 1.93 times more energy may be produced from a tonne of natural gas than from a tonne of coal.

A carbon tax at the level examined here raises fuel prices in electricity production by 60—140 percent with the exception of diesel fuel, which is charged a much higher excise than the proposed carbon tax. Weighted by the current composition of fuel consumption, the total cost of the fuels for electricity production will increase, according to our calculation, by 87 percent, and given that fuel cost accounts for 63 percent of the electricity rate,[2] the tax will translate into a 55 percent rate increase. According to Gallo's estimate of the price elasticity of electricity consumption (Gallo, 2017)—approximately 0.3 on weighted average across all uses—such an upturn in price will manifest in a 16 percent contraction of demand for electricity insofar as the distribution of fuels does not change.[3] According to the calculation, after the downturn in excise receipts is offset—factoring in the decrease of electricity use, and assuming that there will not be a shift to use of energy that does not emit CO2—state revenues from the carbon tax are estimated at NIS 7.5 billion per year. They may be used to offer relief to households that will be harmed by the tax increase, e.g., lowering the rate of VAT by 1 percentage point across the board or reducing the lowest income-tax bracket by 1 percentage point—or by any other combination of tax relief, increase in public expenditure, or deficit reduction that the government may prefer. In a test that we ran, we found that the effect of imposing this tax concurrent with lowering VAT by 1 percentage point would be an increase of up to 0.3 percent in spending by the lowest income quintile as against a 0.1 percent decrease by the uppermost quintile. Insofar as the tax encourages more replacement of high-polluting fuels with less-polluting ones or with renewable energy, tax revenues will fall but the efficacy of the tax in reducing emissions—our goal—will grow. For example, terminating the use of coal and replacing it with natural gas would create in a revenue loss of more than NIS 1.5 billion per year but would reduce CO2 emissions in the manner shown in Figure 5.

A carbon tax on fuels used for transportation—before netting out its effect on travel—will increase government revenues by NIS 4.7 billion per year, which is essentially an addition of 15–20 percent to the current cost of gasoline (including the excise). Although the price elasticity of gasoline demand varies greatly among countries, there is a worldwide consensus that it is very low.[4] Therefore, and as there is no suitable transportation alternative, the effect of this tax increase on vehicle emissions is expected to be limited. In addition, already today a considerable excise tax is imposed on gasoline and diesel fuel, and to the extent that the excise already reflects the effects of travel on air pollution—and not other externalities such as congestion, funding road infrastructure, etc.—the question will arise of if, and to what extent, it will be correct to reduce it in lieu of the carbon tax.

An additional source of CO2 emissions is home cooking gas, which is also used for heating in some households. At current usage levels, a carbon tax on home cooking gas will only increase government revenues slightly. However, it is important that the taxation on it will be equal to that on electricity in order to prevent a shift of demand from heating with electricity to heating with home cooking gas as a result of taxes on fuel in generating the electricity.

[2] See description and analysis of structure of the electricity rate for 2019: Noam Botosh, The Knesset, Research and Information Center, Budget Supervision Department (in Hebrew).

[3] The change in distribution of fuels will be determined on the basis of the response of the electricity system management company (the "system manager") to fuel prices.

[4] Havranek, T., Irsova, Z. and Janda, K., 2012. Demand for Gasoline is More Price-Inelastic Than Commonly Thought. Energy Economics, 34(1), pp.201-207.

Carbon tax - Tax amount and revenues simulation

Fuel type		Coal	Natural gas	Heating oil	Diesel
Fuel used to produce electricity (2017)	(ton)	8,306,000	6,039,400	31,800	153,400
Emissions coefficients	(ton of CO2 per ton)	2.3	2.8	3.1	3.2
CO_2 Emissions	(ton)	19,186,860	16,759,335	97,880	487,352
per unit of energy	emission per ton of	3.7	2.1	2.9	2.9
Current price per ton (excl. excise tax)	(NIS)	360	1,002	1,314	1,600
Excise tax (current rate)	(NIS/ton)	46	17	15	2,945
"Carbon tax" per ton of fuel, at $75 per ton	(NIS per ton of fuel)	624	749	831	858
New price of fuel (includes carbon tax)	(NIS/ton)	984	1,751	2,145	2,458
Old price of fuel (includes excise tax)	(NIS/ton)	406	1,019	1,329	4,545
Addition to price	(NIS/ton)	578	732	816	(2,088)
New price per unit of energy (includes carbon tax)	(NIS/KwH)	0.37	0.25	0.72	1.30
Old price per unit of energy (includes excise tax)	(NIS/KwH)	0.15	0.14	0.44	2.41
Addition to price	(NIS/KwH)	0.22	0.10	0.27	(1.11)
Total government revenues - current consumption	(NIS million)	5,180	4,525	26	132
Net of excise revenues (that will be cancelled)	**(NIS million)**	**4,797**	**4,420**	**26**	**(320)**
Taking reduced demand into account	**(NIS million)**	**4,030**	**3,713**	**22**	**(269)**
Ratio of post-change price to current price		*2.42*	*1.72*	*1.61*	*0.54*

[a] Carbon Dioxide

[b] Exchange rate of NIS 3.6/$)

SOURCE: Based on Central Bureau of Statistics and Ministry of Energy.

5. Discussion, proposals, and recommendations

Thus far, Israel has not attained its self-set goals for power production from renewable resources. However, it is expected to meet the target in the current year and to attain the carbon dioxide emissions target for 2025 (8.8 tonnes per capita). If it succeeds in meeting its 2030 target for power production from renewable sources (30 percent), it will also, in all likelihood, attain the CO2 emissions target for that year (7.7 tonnes per capita) as well.

Notwithstanding the progress made thus far, it is important for the government to examine its ability to meet stricter targets in the coming decade and through 2050. As recognition of the dangers of global warming escalates, the international community will impose increasingly strict greenhouse-gas emission requirements and accompany them with tougher deadlines. If such developments actually occur, they will severely challenge Israel's decision-making system and the executive mechanisms that are tasked with implementing decisions in this matter, particularly in view of the intention of switching the economy to natural gas (which also contributes to global warming, albeit much less than does coal).

To date, Israel has not thoroughly examined ways of coping with greenhouse-gas emissions by means of a dedicated tax (e.g., carbon tax and/or cap-and-trade). Once such an examination begins, it should relate to the contribution of the fuel excise (a tax unique to Israel) to mitigating emissions, the possibility of imposing a carbon tax, the implications of taxing greenhouse gases for national income distribution, and the role of such taxation in the broader matrix of the government's budget sources.

Improvement of Public Transport Services and Raising the Cost of Travel by Private Vehicle as Tools For Dealing with Road Congestion

- As a result of the increase in the standard of living in parallel with the growth of employment and dispersal of the population, the growth rate of private vehicular travel in the past two decades has been rapid—about 4 percent per year. Roughly 65 percent of workers travel to their jobs by private vehicle, and in the past five years, their percentage has increased by about one percentage point per year.
- The COVID-19 crisis may lead to some decline in the volume of travel due to increased work from home, but it is likely that following a one-off adjustment, the growth rate of private vehicular use will remain rapid.
- The way to encourage a transition from traveling to work by private vehicle to traveling to work by public transit is to improve public transit services and make traveling by private vehicle more expensive. Improving public transit services includes shortening overall travel time, increasing reliability, and improving travel convenience.
- In order to improve public transit infrastructure—designated public transit routes, preference at traffic lights, underground rail, convenient parking (for vehicles and bicycles) at central bus and train stations, and more—a massive increase in investment is needed.
- The ratio between the cost of traveling to work by private vehicle and the cost of travel by public transport is currently slightly higher than it was 20 years ago, but taking into account the increase in per capita income, this gap has become less significant. The gap is particularly low for individuals who in any case own a private vehicle and do not bear the cost of parking at their place of work.
- As current technological changes make it possible to collect tolls based on road usage and travel time without interrupting traffic, this seems to be the proper course of action.

Israel's roads are growing increasingly crowded, and a significant change is needed in order for the transport situation in all its aspects not to worsen. As a result of the increase in the standard of living, in parallel with the increase in employment and the dispersal of the population, the growth rate of travel by private vehicle has been rapid in the past 2 decades—about 4 percent per year (the growth rate in the past decade is even higher—4.6 percent per year). The rapid growth rate of private-vehicle kilometers traveled reflects, in part, the high growth rate of the population in Israel, as well as the fact that the number of vehicles per thousand adults is relatively low, and is still not close to saturation.[1] Therefore, looking forward, the transportation problem that is afflicting all advanced economies is more acute in Israel's metropolitan areas.[2]

[1] See, for instance, Figure 3.5 in *Research Department Special Report: Raising the Standard of Living in Israel by Increasing Labor Productivity*, August 2019.

[2] For a discussion of the factors, and particularly the policy factors, that have contributed to the increase in private vehicle travel in Israel, see "Private Transportation in Israel: An Analysis of Developments in the Past Two Decades", *Selected Research and Policy Analysis Notes*, Bank of Israel, February 2019.

Currently, about 65 percent of workers travel to work in private vehicles. In the past five years, the increase in this rate has been about one percentage point per year (Figures 1 and 2).[3] The rapid increase in private-vehicle kilometers traveled increases the load on transport infrastructure, and the volume of investment in infrastructure is not matching the increase in use (Figure 3).

The COVID-19 crisis led to a reduction in travel to work, but at the same time, it increased the rate of those traveling to work by private vehicle, at least temporarily. It is difficult to assess the extent to which the changes in travel-to-work patterns are permanent. However, we must assume that without encouraging the use of public transit, the growth rate of private-vehicle kilometers traveled to work will return to its previous pace once the new equilibrium is found.

The way to encourage a transition from traveling to work by private vehicle to traveling to work by public transit is a combination of improved public transit service and making private vehicle travel more expensive. Improving service includes shortening overall travel time, increasing reliability, and improving travel convenience. Together, these will help public transit offer a good alternative to traveling by private vehicle. In this context, Suhoy and Sofer (2019) showed that when there is an alternative of commuting by rail, a form of travel that is considered more pleasant and faster than travel by bus, the rate of those with access to a private vehicle who travel to work by train is similar to the rate among those who do not have access to a private vehicle.[4] Without a change in policy that includes the diversion of some private vehicle travelers to use of public transit, the roads in crowded areas will become less efficient during more hours of the day, and the negative impact to well-being will intensify.

Potential ways to shorten overall travel time by public transit include providing right-of-ways for public transit (public transit lanes—PTL), reducing wait times at stations, and improving service and infrastructure for "last kilometer" travel.[5] Data on travel on regular bus routes indicate an increase in service frequency over the past 15 years (Figure 4). The increase in travel by train also apparently reflects improved service (Figure 5). However, the continued expansion of private vehicle travel at the expense of travel by public transit, particularly for those living in Gush Dan, which is a congested area with the potential for efficient public transit, shows that more must be done in order to generate a trend of transition from private vehicle travel to travel by public transit.[6]

[3] These figures are from prior to the COVID-19 crisis.

[4] For a discussion of the marginal impact of the frequency of service and the duration of travel to work by public transit on the choice of how to get to work, see T. Suhoy and Y. Sofer (2019), "Getting to Work in Israel: Locality and Individual Effects", Bank of Israel Research Department, Discussion Papers Series 2019.02.

[5] "The Last Kilometer" is the segment connecting the point of departure to the nearest station serving the public transit vehicle traveling to the destination, and the segment between the station closest to the destination and the destination itself. A long travel duration in "the Last Kilometer" may have a dire effect on the worthwhileness of using public transit.

[6] For more on the relatively low choice of using public transit in Gush Dan, see Box 2.1 of the Bank of Israel *Annual Report* for 2017.

In order to improve public transit infrastructure—designated PTLs, preference at traffic lights, an underground railway (with its own level), convenient parking (for vehicles and bicycles) at central bus and train stations, and more—a massive increase in investment is necessary. In recent years, there has been some increase in investment in transport infrastructure, particularly in rail infrastructure (Figure 6), but this is a moderate increase that is not sufficient to provide for the rapid increase in demand.

The Metro project in Gush Dan, which is comprised of three lines that will connect residential areas in Gush Dan with employment centers and will integrate with the Tel Aviv light rail system, is currently in planning, and will be a significant anchor for investment in transit infrastructure in the area. The overall estimated cost of the project is about NIS 150 billion, and it is expected to be spread out over about 15 years. This represents an annual investment of more than 0.5 percent of GDP. Synchronizing the metro lines with the other components of the public transit network, and the location of the stations, are important to the success of the project. It is therefore proper that maximum attention be paid to these elements. From this standpoint, it is preferable to vest authority in a metropolitan authority (or similar body) that will consolidate the needs of all residents of the region and streamline the decision-making process that currently depends to a great extent on the agreement of the localities through which the metro is planned to pass.

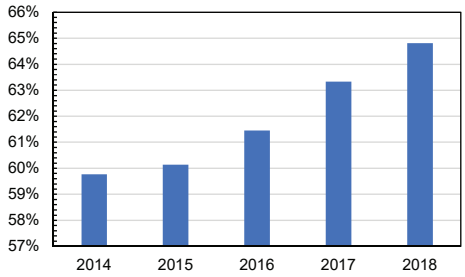
Financing for the project is a separate question, but it is relevant for the decision-making regarding the project. Since this is an expensive undertaking that has positive externalities, it is neither possible nor desirable to finance its construction only through its users (in the form of cost of travel). The distribution of the burden is a fiscal decision, and requires an all-encompassing view of government investments in infrastructure, including a comprehensive determination of how progressively the government wishes to finance the project.[7] One of the recommended options is to require businesses in Gush Dan and residents who are expected to benefit from the project to finance part of it. This was the method used, for instance, when the new Crossrail line was built in London. A significant part of its construction was financed through a designated tax on businesses in London, and by the municipality and Transport for London.[8]

When it comes to investment in road infrastructure for public transit, it is difficult to quantify the investment in designated public transit lanes (PTLs), since at the investment stage, there is no need to distinguish between a PTL and a lane intended for general travel. The division of travel lanes by designation is possible on the existing

[7] Given a fixed investment budget, investment in one place comes at the expense of investment in another place. As such, the government must determine an order of priorities for investment, relating in part to geography as well. If the investment decision increases the investment budget, the government must decide how it is to be financed. The distribution of the financing burden between the citizens is also an important government decision.

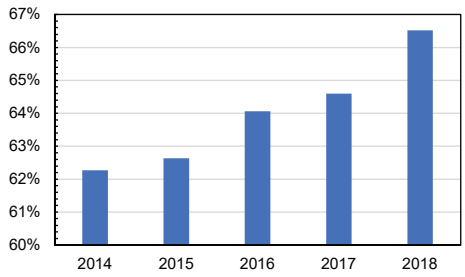
[8] In countries with federal systems of government, it is common that infrastructure projects serving residents are financed to a large extent through taxes on local residents. In Israel, where the central government is concentrated and metro lines are expected to pass through numerous local authority areas, the distribution of the financing burden is managed by the central government.

Figure 1: Those travelling to work by private vehicle*, 2014–2018 (percentage, nationwide)



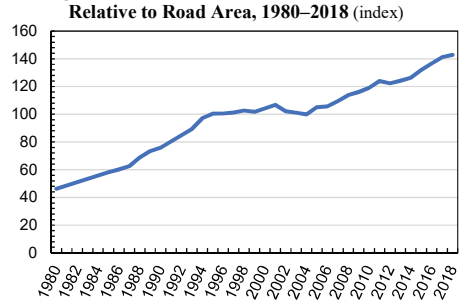
* Including commercial vehicles and motorcycles.
SOURCE: Based on Central Bureau of Statistics Social Survey.

Figure 2: Those travelling to work by private vehicle*, 2014–2018 (percentage, Gush Dan)



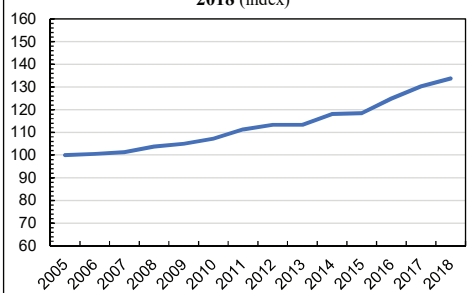
* Including commercial vehicles and motorcycles.
SOURCE: Based on Central Bureau of Statistics Social Survey.

Figure 3: Private-Vehicle Kilometers Traveled Relative to Road Area, 1980–2018 (index)



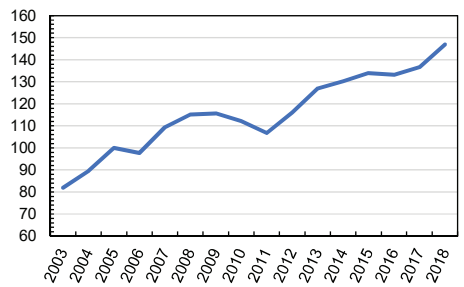
SOURCE: Based on Central Bureau of Statistics data.

Figure 4: Bus Kilometers Traveled Per Capita, 2005–2018 (index)



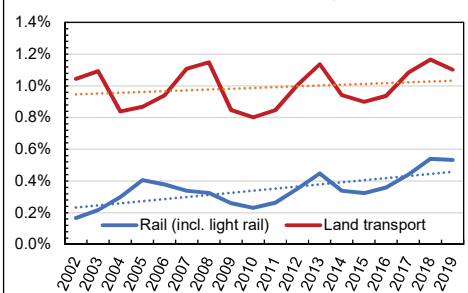
SOURCE: Based on Central Bureau of Statistics data.

Figure 5: Train Kilometers Traveled Per Capita, 2005–2018 (Index)



SOURCE: Based on Central Bureau of Statistics data.

Figure 6: Investment in Land Transport Infrastructure as a Share of GDP, 2002–2019



SOURCE: Based on Central Bureau of Statistics data.

road network, as was done in setting aside the 2+ lane on the Coastal Highway. Converting existing lanes that are open to general traffic to PTLs can reduce the gap in travel time between public transit and private vehicle travel through a combination of shortening the public transit travel time and increasing the private vehicle travel time.[9]

The other tool for balancing demand between public transit and private vehicle travel is monetary. It involves widening the gap between the cost of traveling by private vehicle and the cost of public transit. It is important to use both tools together—shortening time and improving quality of travel by public transit and widening the

[9] Prohibiting the travel of taxis in crowded PTLs may also ease the congestion in those lanes.

price gap—because the use of just one tool will make it necessary to set a very high price for travel by private vehicle or drastically slowing such travel (and negatively impacting the utilization of road infrastructure).

The ratio between the cost of traveling to work by private vehicle and the cost of travel by public transit is currently slightly more than it was 20 years ago, but taking into account the increase in per capita income, we can say that the gap has become significantly smaller. It becomes especially narrow when individuals own a private vehicle for other reasons and don't bear the cost of parking at their place of work. Under varying assumptions, we estimate that the average daily gap in the variable costs between travel by private vehicle and travel by bus is between 10 and 15 shekels per day.[10]

Private vehicle owners currently pay a number of taxes: (1) purchase tax, import tax, and VAT; (2) licensing fee; and (3) excise on fuel (gasoline and diesel) based on their vehicle's fuel consumption. Purchase tax, import tax, and VAT (excluding VAT on fuel), and the licensing fee are paid regardless of the vehicle's use. The tax's dependency on the value of the vehicle, its pollution level, its safety accessories, and its country of manufacture greatly reduces the link between the total tax payment and the owner's use of infrastructure, thereby lowering the efficiency of taxes as a tool for reducing the use of private vehicles. The same is true of the licensing fee, which is a fixed amount irrespective of use. The tax on fuel is, to a large extent, a usage tax, except that it does not take into account the time of day or area of the country in which the road is being used, and it depends on the vehicle's fuel consumption. With the entry of hybrid and electric vehicles into the market, the variance between the fuel consumption of different vehicles has increased greatly, and as the share of such vehicles increases, the excise tax per kilometer driven declines. Thus, fuel excise tax is having less of an effect on the choice to travel by private vehicle as opposed to travel by public transit.

At the same time, there are technological changes that now make it possible to collect tolls based on road usage and travel time without interrupting traffic. As such, it seems that charging for the use of a public resource while relating to the externalities of travel by private vehicle (Pigovian tax) seems more proper than in the past. Vehicle taxation, which does not depend on use, can be lowered in parallel, thereby streamlining taxation in the industry.

The cost of traveling to work by private vehicle can be increased by charging a congestion fee at the entrance to metropolitan areas. Such fees are already being charged in a number of main cities around the world, including London, Singapore,

[10] The variable costs per private-vehicle kilometer traveled are currently less than one shekel per kilometer (based on data from "Kol Natun", variable costs per kilometer for a Group 3 vehicle), and the average distance traveled to work among all workers is about 12 km (assuming 5 km travel for individuals working in their residential localities, and Social Survey Data showing that individuals working outside their residential localities travel an average of about 19 km to work). A trip of 24 km by private vehicle (12 km each direction) costs a little more than NIS 20 per day, meaning less than NIS 500 per month, while a monthly pass for travel by public transit generally costs between NIS 200 and NIS 250 per month.

Milan, and Stockholm. The advantage of these fees is that they impose on travelers during peak hours and in congested areas a cost that takes into account the external effects of those entering the city by private vehicle. However, the congestion fees are imposed only on those entering a congested area, and not on all travelers in the area, and the payment level does not depend on the volume of travel within the congested area. These lower the efficiency of the fees.[11] We emphasize that in order for the congestion fees to be more effective, it is very important that they be used in parallel to fund improvements in public transit. The success of congestion fees also depends on the construction of "Park-and-Ride" lots next to the public transit terminals at the entrances to the cities, such as the parking lot at Shappirim interchange that is currently being expanded in view of the increasing demand for its services. These will help shorten public transit travel time to work, and will increase the substitution between travel by private vehicle and travel by public transit. The higher this substitution is, the greater the elasticity of demand (relative to price) for private vehicle travel is, and the more significant the effect of the congestion fee or any other tax on private vehicle travel becomes.

Increasing the cost of parking is another means of encouraging travel by public transit. Many workers currently benefit from free parking, which is financed by their place of work. This benefit is tax-free. In contrast, the employer's payment for travel by public transit is taxable. Taxation of the parking benefit together with exempting the employer's payment for actual use of public transit will cancel this tax system support for private vehicle travel. Encouraging employers to give their employees a monetary benefit in exchange for giving up the use of parking will provide further support for public transit.[12] Another factor encouraging people to come to work by private vehicle is the current provision of low-cost roadside parking. The price difference between roadside parking and parking in a designated lot in congested areas creates extra travel in the search for a parking spot. This is another reason to correct the distortion inherent in the low price of roadside parking both for residents of the city and for commuters. Therefore, it is proposed to cancel the maximum payment under the law for road side parking, and to allow local authorities to raise the prices.

[11] For a discussion of the efficiency of various kinds of congestion fees (transition between rings, travel within an area defined as congested, travel by kilometer, and more), and their potential to reduce congestion, see OECD (2019), *Assessing Incentives to Reduce Congestion in Israel*.

[12] Many studies have found that subsidized parking has a significant effect on the choice of how to travel to work. For a summary of studies on this topic, see, for instance, R. W. Willson and D. C. Shoup (1990), "Parking Subsidies and Travel Choices: Assessing the Evidence", *Transportation*, 17(2): 141–157. For a more recent study on the effect of granting a monetary exchange for giving up parking in order to reduce private vehicle travel in Germany, see, for instance, "C. Evangelinos et al. (2018), "Pricing Workplace Parking via Cash-Out: Effects on Modal Choice and Implications for Transport Policy", *Transportation Research Part A:* Policy and Practice, 113: pp. 369–380.