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Assessing the Effectiveness of the "Technological-Scientific Reserve" and "Give Five" Programs

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Abstract

Since ,2011 the Ministry of Education (MOE) has operated the Technological-Scientific Reserve program ("the Atuda Program") in a portion of the country's junior and senior high schools with the aim of increasing the number of students who sit for 5-unit matriculation exams in mathematics and two additional technology/science subjects ("Atuda Program Cluster"). Since 2015, the MOE has also operated the Give Five program to reinforce 5-unit mathematics studies. This study examined the effect of these two programs on the probability of sitting for matriculation exams in these subjects and the results of the exams, as well the probability that graduates of the Arab education system will subsequently enter science-related programs in higher education institutions. The estimations were based on a range of administrative data sets using the difference-in-differences (DID) method.

As of 2017, the Atuda program increased the rate at which students in participating schools sit for 5-unit matriculation exams in mathematics and Atuda Program Cluster subjects by 4-5 percentage points, compared to students in non-participating schools (before the program 13% and 8% of the students in participating schools sat for 5-unit matriculation exams in mathematics and in Atuda Cluster subjects, respectively). The program's effect on girls was 1-2 percentage points greater than the effect on male students, as well as on students with higher than average scores on the standardized eighth-grade Meitzav exam .The Give Five program increased the percentage of students who sat for 5-unit matriculation exams in mathematics by close to 3 percentage points (before the program, 14% of the students sat these exams), and affected boys only. The increase in the percentage of students sitting for 5-unit matriculation exams in mathematics after participating in the program was not accompanied by a drop in students' grades or passing rate.

The Atuda program increased the probability of Arab education system graduates of entering undergraduate programs in the sciences (up to 2018) by approximately 2 percentage points (up from 5% before the program) and the probability of commencing studies in high-tech-related subjects by approximately 1 percentage point (up from to 4%). In both cases, the increases affected only students with above-average Meitzav scores. At this time, the data are not available for an analysis of the corresponding probabilities for the Give Five program and graduates of the Jewish education system.

A. Introduction

The rapid growth of the Israeli economy relies on, among other things, the appreciation of its human capital and improvements in labor productivity. Knowledge-intense sectors are the economy's growth engines, and these sectors need workers who are skilled in the sciences and technology. Various reports have indicated a shortage of such workers, which constitutes a barrier to the expansion of these sectors (Kandel, 2012; Zuk, 2014; Shaviv, 2018).[1]

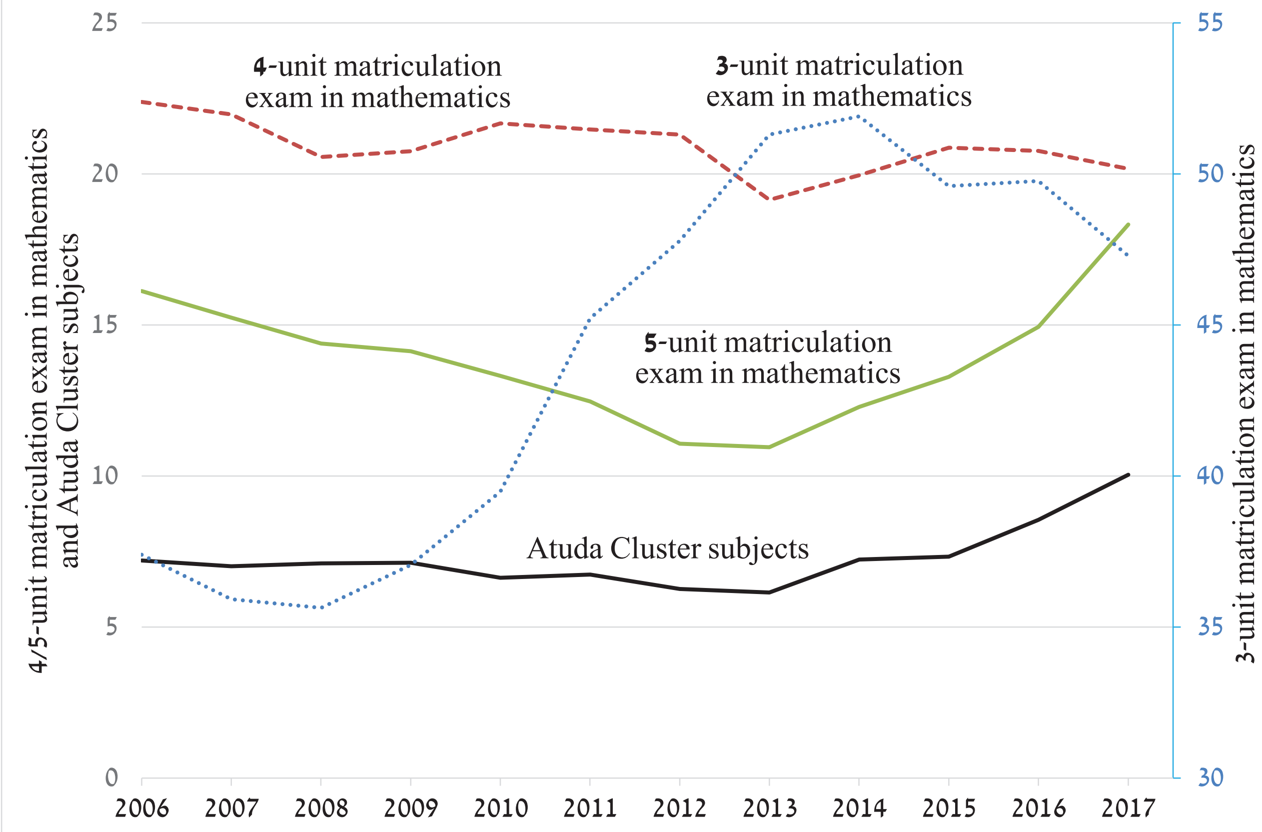
This shortage may develop for several reasons, including a small number of students who study STEM subjects at an accelerated rate in high school, post-secondary school, and academic institutions, and an insufficient standard of teaching in these schools. In the study sample (described below), between 2013 and 2016 the number of students who sat for-5 unit matriculation exams[2] in mathematics declined by one third, and the percentage of these students of all 12-grade students dropped from 16.1% to 10.9%, while the number of students who sat for 4-unit matriculation exams in mathematics remained stable in this period and the number of students who sat for 3-unit exams increased sharply[3] (see Figure 1). Similar trends were recorded for female and male students, for students in the Jewish and the Arab education systems, and for students from high and low SES backgrounds. The number of students sitting for 5-unit exams in mathematics was relatively lower for girls, students in the Arab education system, and students from weak socioeconomic backgrounds. In the same period, the number of students sitting for 5-unit exams in other science/technology subjects (physic, chemistry, biology, computer science, electronics, etc.) remained almost unchanged. As a result, the share of students sitting for-5 unit exams in mathematics and two additional science-technology subjects ("Atuda Cluster") declined slightly (see Figure 1).

[1] In contrast, Bental, and Peled (2016) argue that there is no shortage of individuals with academic degrees in science and technology, with the exception of a recent shortage in the field of software development in R&D. They claim that colleges graduates in these fields are possibly not at the appropriate standard, which creates a sense of shortage (one indication is that Achdut et al. [2018] show that the wages of college graduates with an undergraduate degree in computer science are much lower than the wages of university graduates, after controlling for differences in aptitudes); Brand (2018) expects no significant increase in the percentage of individuals employed in the high-tech sector in Israel for the following reasons: According to an international comparison, this sector employs a large percentage of workers in the economy and hires a high percentage of extremely high-skilled individuals while such individuals who work in other sectors have prestigious occupations and their probability of moving to the high-tech sector is therefore small.

[2] The study refers only to students who sit for matriculation exams in the summer (that is, the study does not include students in "external" high schools).

[3] A similar picture emerges among the entire education system, see Figure A-1 in the Appendix.

Figure 1. Twelfth-grade students[1] sitting for exams in mathematics and Atuda Cluster subjects[2] (%)



Source: Ministry of Education, Central Bureau of Statistics, and data processing by authors.
(1) In the study population.
(2) 5 units mathematics, 5 units physics/chemistry/biology, and an additional 5 units in physics/chemistry/biology/computer science/electronics.

Rimon and Romanov (2012) argued that the education system previously set a target of increasing the number of students eligible for a matriculation certificate ,but not necessarily a high-quality certificate,[4] and therefore schools did not encourage students to select STEM subjects at an accelerated rate. Moreover, university admission requirements included a matriculation certificate that meets minimal criteria and hardly encourages the study of these subjects at an accelerated rate.[5] These authors also showed that at the beginning of the decade there was significant potential to

[4] From 2015, the MOE conveys its "educational picture" to all high schools (and publishes it at the local government level), which includes a range of measures in the following areas: values and educational climate, attrition and perseverance, the educational team, and achievements. Since 2017, achievements not only include the percentage of students eligible for a matriculation certificate, but also the following measures: the percentage of students eligible for a matriculation certificate that includes mathematics at the 4 or 5-unit level, the percentage of students eligible for a matriculation certificate that includes English at the 4- or 5-unit level, and the percentage of students eligible for an outstanding matriculation certificate (5-units in English, at least 4-units in mathematics, and a minimum average grade of 90 in all subjects, in addition to an outstanding grade in an individual development program and involvement in a community-social service program).

[5] The minimum condition is a matriculation certificate that includes a passing grade in mathematics at the 3-unit level, English at the 4-unit level, and one additional subject at the 5-unit level or higher. Bonuses are calculated as follows: 10 points for a 4-unit matriculation exam in any subject (and 12.5 points if the subject is English or mathematics), and 20 points for a 5-unit matriculation exam in any subject (and 25 points if the subject is English or mathematics).

expand the study of STEM subjects. For example, only one third of the students with high eighth-grade Meitzav scores in sciences and mathematics completed a science/technology matriculation certificate; The number of female students eligible for a science/technology matriculation certificate was lower by one third compared to the number of eligible male students, despite the fact that gender differences in Meitzav scores were small – which indicates a potential for increasing female students' eligibility for a science/technology matriculation certificate.

Evidence of the potential for increasing the percentage of high school students who study mathematics at an accelerated pace can be found in the fact that in the past decade, Israel placed in the bottom third of all western countries (countries in which less than 15% of students study mathematics at an accelerated pace) – Hodgen et al. (2010).

The need to expand STEM subjects in schools is also reflected in Israeli students' poor achievements in international comparisons. Mathematical and science literacy of 15-year-olds in Israel is at the bottom of the list of OECD countries, as indicated by scores on the PISA exam, which have been administered for two decades, with broad differences in students' achievements by socioeconomic background (National Authority for Measurement and Evaluation in Education, 2017a). In addition, the percentage of students with outstanding achievements in these fields is very low, especially among students in the Arab education system. A review of the achievements of Israeli students in mathematics and sciences on the TIMSS exams indicates a somewhat more encouraging picture: Average scores on these exams are in the top part of the bottom third of all OECD countries, and the percentage of students with outstanding achievements, which was low before the 2011 exams, increased significantly since then (National Authority for Measurement and Evaluation in Education, 2017b). Israel's ranking among OECD countries in mathematical and science literacy on PISA and TIMSS increased over the past two decades but Israel remains in the bottom third.

In contrast, Israeli students' achievements on national exams in mathematics and sciences improved considerably. This can be assessed since 2008 using standardized Meitzav scores. From 2008 to 2017, scores on fifth- and eighth-grade mathematics exams and on eighth-grade exams in science and technology showed a considerable steady increase (of approx. 13%, 7%, and 17%, respectively) that affected girls and boys, students of the Jewish and Arab education systems, and students from weak and strong socioeconomic backgrounds (National Authority for Measurement and Evaluation in Education, 2017c).

Finally, studies showed that accelerated mathematics and science studies in high school in Israel are correlated with the probability of continuing to science/technology programs in higher education, especially in engineering and computer science, and ultimately significantly improve individual earning potential (Kimhi and Horovitz, 2015; Harpaz-Mazuz and Krill, 2017; Achdut et al., 2018). Kimhi and Horovitz showed that a hypothetical transition of student from 4-unit to 5-unit mathematics studies is correlated with an increase of approx. 8% in their subsequent hourly wage:[6] an indirect increase of 3% (due to an increased probability of pursuing higher education in disciplines

[6] Similar results are obtained when we limit the analysis to students who received a grade of 80 or higher on a 4-unit matriculation exam in mathematics.

that offer a favorable return in the job market) and 5% directly. The anticipated rise in women's wages is twice as high as the effect on men's wages.

In view of the continued decline in the number of students eligible for a science/technology matriculation certificate in the past decade; the poor achievements of Israeli students on international exams in these fields; the economy's need for workers skilled in science and technology, especially in knowledge-intense sectors; the needs of the IDF; and of course, the desire to increase the earning potential of graduates of Israel's education system – the Ministry of Education launched two programs to reinforce mathematics and science studies in schools: The Technological-Scientific Reserve ("the Atuda Program") and Give Five.

The current study examines the effects of these programs on the probability of sitting for and attaining successful outcomes in 5-unit matriculation exams in mathematics and sciences, and on the probability of pursuing an undergraduate degree in the sciences in institutions of higher education. The paper proceeds as follows: Chapter B describes the programs; Chapter C introduces the database, the study population, and the profiles of participating students; Chapter D presents descriptive statistics; and Chapter E describes the estimation method and results. Chapter F concludes.

B. The Atuda and Give Five Programs[7]

The Technological-Scientific Reserve ("the Atuda Program") was designed to significantly increase the number of students in the following clusters: 5-unit mathematics, one 5-unit subject in natural sciences (physics, chemistry, or biology), and one 5-unit subject in the sciences (physics, chemistry, biology, or computer sciences); or 5-unit technology track subjects (software engineering, electronics, mechanical engineering, biotechnology, etc.); without creating a corresponding decline in students' achievement levels.[8]

The program's principles, defined by its developers, include exposing promising students in those fields to a challenging program of study at a high standard, and giving all students equal opportunity to participate by bridging socioeconomic disparities and encouraging girls' participation.

Promising students identified in seventh grade are given additional study hours in science and technology contents. In junior high school, studies are conducted in special classes or groups of at least 25 students.[9] Students in these classes receive, on average, an additional 20 weekly hours of tutoring and learning support beyond the regular junior high school curriculum, and an additional 15-24 weekly hours in high school (depending on the number of participants).[10] Resources are also allocated to purchase equipment for workshops and labs. Junior high school students continue the program in high school on the basis of their grades in their final year in junior high school (or on an

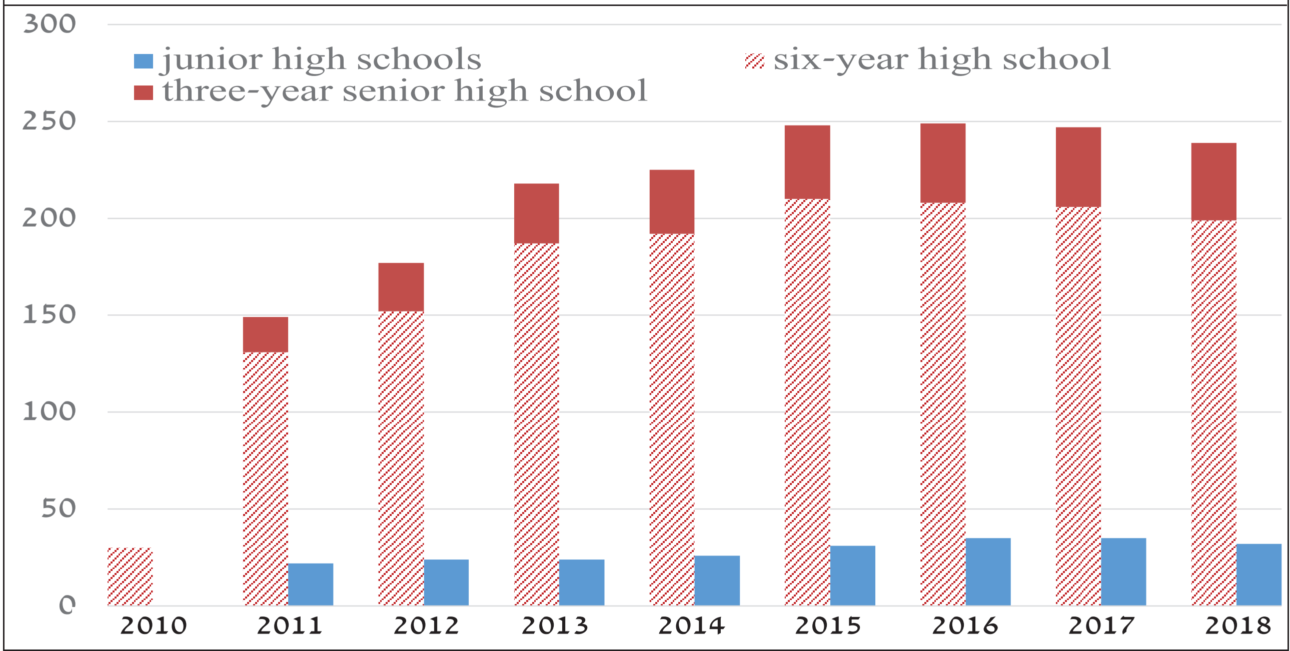
[7] For the measures taken by the Council of Higher Education, beginning from the 2013 school year, to increase the number of students in science/technology disciplines, including computer science, see Shaviv (2018). It is important to stress that the ability of the higher education system to achieve this goal largely depends on the supply of high school graduates with basic knowledge and a desire to pursue an academic degree in these fields.
[8] For additional information, see MOE (2018).
[9] In addition, at least 20% of each grade in schools with fewer than 100 students.
[10] In senior high schools, the Atuda program is taught in designated classes or groups, in contrast to the situation in junior high schools. A student in high school may join the Atuda program even if they did not participate in the program in junior high schools (this phenomenon became marginal after the program was administered in six-year high schools).

exam following a summer preparatory course for participating students whose grades are below the transition requirements). In 2018, total annual costs for the Atuda program were approx. NIS 107 million,[11] and according to our calculations, the total cost of the additional study hours from seventh to twelfth grade per Atuda participant was approx. NIS 10.3 thousand.[12]

The Atuda program was launched as a pilot program in 2010, and from 2011 was operated as a regular curriculum. Consequently, the first twelfth-grade students who completed three years in the program in high school graduated in 2013. Therefore the year 2012 serves as the base year for descriptive statistics and for the estimations presented below. Notably, twelfth-graders who graduated in 2016 were the first students who completed the entire sequence of the program from seventh to twelfth grade.

In 2018, 32 independent junior high schools and 239 high schools (including six-year junior/high schools) participated in the program, represented 23% of all high schools (excluding special education high schools or high schools in the Haredi education system). See Figure 2 for the number of participating schools by year. In 2018, approx. 7.1 thousand seventh-grade students and approx. 7.1 twelfth-grade students participated in the program, representing approx. 6.0% and 6.7% of all students in their respective grade years (excluding special education high schools or high schools in the Haredi education system).

Figure 2. Participating schools in the Technology-Science Reserve ("Atuda") program[1]



Source: Ministry of Education, and data processing by the authors.
(1) Excluding 2 schools that participated in the pilot program and left the program in a year that is not known.

[11] Source: Economics and Budgets Administration, MOE.
[12] Based on the cost of one classroom hour in junior high school (senior high school), which was approx. NIS 4.7 thousand (NIS 10.0 thousand) in 2018, and assuming 30 students in an Atuda classroom in junior high school and 25 Atuda students per grade in senior high school.

Give Five, the National Program to Promote Mathematics (which was initially named "Math First" or "5times2", after a project that was incorporated into the program), was designed to increase the number of students who sit for a 5-unit matriculation exam in mathematics, enhance the status of the subject and its image among all students, and improve the standard of teaching[13] (For additional information see Ministry of Education, 2015; National Authority for Measurement and Evaluation in Education, 2016, 2018a, 2018b). According to the Ministry of Education, the program's goal was to double the number of students sitting for 5-unit matriculation exams in mathematics within four years, from approx. 9.7 thousand students in 2014 (in 2017, the number of these students was approx. 16.1 thousand); According to the 5times2 project, the aim was to have 18% of all students sit for 5-unit matriculation exams in mathematics within 10 years (figures in 2014 and 2017 were approx. 10.8% and 16.1%, respectively), with emphasis on female students, Arab students, and students from weak socioeconomic backgrounds.

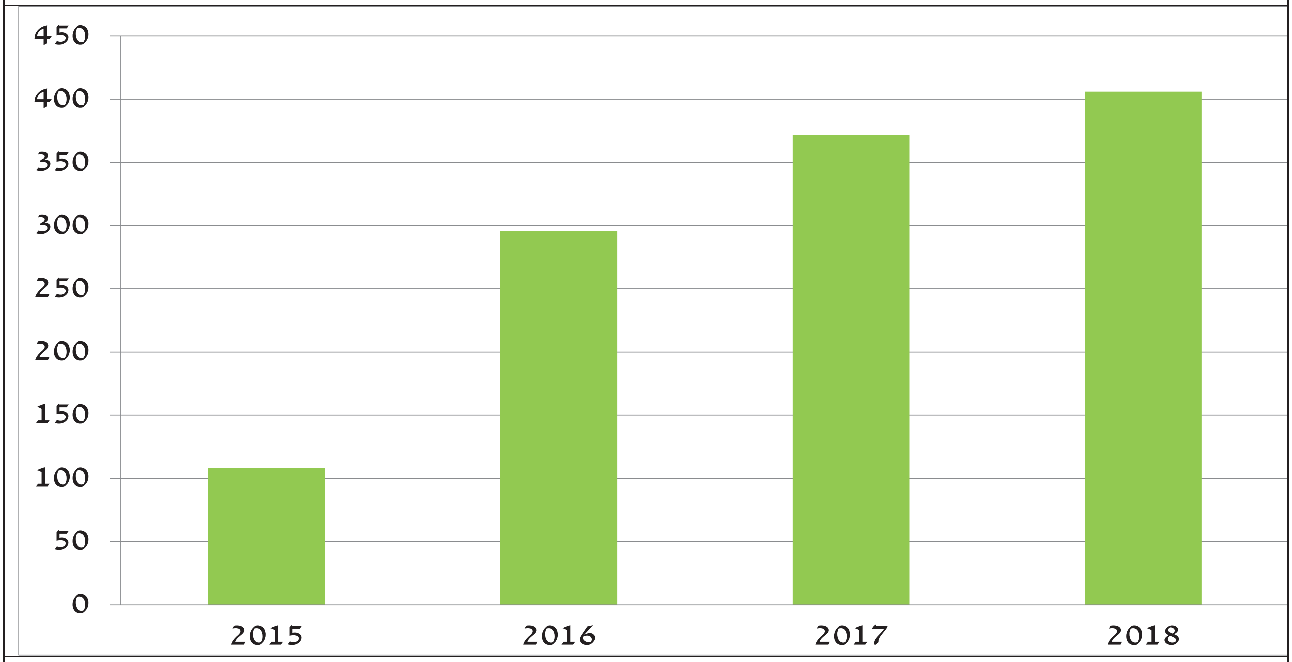
Participating schools in the program received a budget for 15 weekly teaching hours that were supposed to be directed to twelfth-grade students but in practice were distributed among tenth-, eleventh-, and twelfth-grade classes in many schools, and were also used to open small classes for 5-unit mathematics studies and for tutoring sessions.[14] The entire school system held marathons in advance of the matriculation exams and conducted training sessions for principals and teachers, and additional measures were taken to increase the quality of the teachers (certification of teachers in mathematics, scholarships to students of mathematics in higher education and to college graduates in other disciplines that pursue studies in mathematics, to college and university graduates from other disciplines who pursued a job as teachers in mathematics, etc.).[15] In addition, high-tech companies operated volunteer programs in which employees taught in high schools or gave support to teachers and students.

Give Five is operated in schools that do not participate in the Atuda program. Give Five was launched in 2015 in 108 high schools and was quickly expanded (see Figure 3). In 2018, the program had 406 participating high schools, which represent approx. 39% of all high schools (excluding special education high schools and high schools in the Haredi education system). That year, costs of the Give Five program totaled approx. NIS 33 million.[11]

The program's follow-up studies provide indications of the challenges encountered in the program's implementation (National Authority for Measurement and Evaluation in Education, 2018b), including the challenges of teaching heterogeneous groups of students; adverse effects on students who were unsuitable or uninterested in participating, and especially students who dropped out of the program; a depreciation of the status of 3- and 4-unit mathematics tracks; and the sense that liberal arts subjects are being neglected.

[13] Shaviv (2018) points to the shortage of qualified mathematics teachers (Most mathematics teachers have a B.Ed. degree and do not hold an academic degree in mathematics). A similar shortage for science teachers exists.
[14] Approx. 5 thousand teaching hours were also added in the entire education system for tutoring in mathematics in ninth grade, to provide learning support to students entering 5-unit mathematics studies in tenth grade.
[15] In addition, in 2016, institutions of higher education increased the bonus granted to a passing grade in a 5-unit matriculation exam in mathematics (from 25 to 30 points), and created a "safety net" that allows students to sit for a 4-unit exam in mathematics in the event that they fail a 5-unit exam.

Figure 3. Participating schools in the Give Five program



Source :Ministry of Education and data processing by authors.

C. Database, Study Population, and Profile of Students in Participating Schools

The database used in this study is based on a combination of administrative files of the Central Bureau of Statistics that refer to students, their parents, and the schools; demographic information taken from the Population Registry; Students' paths in the education system is based on files of students, educational institutions, and teachers; academic achievements based on eighth-grade Meitzav exam scores and matriculation exam scores; information on academic admissions was taken from files on students in institutions of higher education; parents' years of education and income were taken from the Education Registry of the Central Bureau of Statistics and from files of the Tax Authority, respectively. The Ministry of Education granted us access to information on the dates the schools joined and terminated their participation in the Atuda and Give Five programs.[16]

The study population comprised the high schools in Israel that operated continuously between 2006 and 2017,[17] excluding high schools in the Haredi education system and special education high schools, agricultural high schools, and small high schools.[18] The following students were excluded

[16] The MOE has no records of the students who participated in the programs. Therefore, the estimations described below refer only to the programs' average effects on all the students in participating schools (intention to treat) rather than their direct effects on participating students. Therefore it is possible that the results of the estimations presented below represent underestimations of the programs' effects on participating students.

[17] On the date the study was conducted, 2018, matriculation exam results were not available from the Central Bureau of Statistics. Focusing on the permanent population of schools forgoes the need to address the effect of the change over time in the composition of the education system and the schools on outcome variables.

[18] These schools were excluded from the study for the following reasons: A small percentage of students in Haredi and special education schools, if any, sit for matriculation exams; Agricultural schools (and boarding schools) have unique features. Also eliminated high schools that had fewer than 30 students in tenth grade in one or more years between 2006 and 2017, because of the challenge of performing panel estimations with a small number of students per school, and also due to the desire to include the same schools in the estimations of all years (balanced panel).

from the study: education students in regular schools, high school drop-outs (because they are not relevant to the programs' target population), and students who transferred schools between tenth and twelfth grade (because of the difficulty of identifying students' participation in a program). Table A-1 in the Appendix presents data on the high schools and students that were excluded from the study.

In total, the study population included 404 high schools that operated continuously from 2006 to 2017, which had approx. 718 thousand twelfth-grade students, who constituted approx. 88% of all the students in the participating schools. In 2017, 174 high schools that participated in the Atuda program (142 in the Jewish education sector and 32 in the Arab education sector), which constitute approx. 70% of all participating schools that year, were included in our study. The study population included 134 high schools that participated in the Give Five program (78 in the Jewish education system and 56 in the Arab education system), which constitute approx. 36% of all participating schools at the time.[19]

Schools that joined the Atuda and Give Five programs differed from non-participating schools. Table 1 shows the socioeconomic profiles of the students of participating schools, before and after joining the programs. Participating schools were relatively large or had a technology track (not shown in the Table). Students of the participating schools (including the students who did not participate in the programs) were on average from a much stronger socioeconomic background and had higher eighth-grade Meitzav scores in mathematics than students of non-participating schools. Participating schools had a higher percentage of students who sat for 5-unit matriculation exams in mathematics and a higher percentage of students who were eligible for a matriculation certificate. These differences are not surprising as both programs target students who have a good chance of being successful in accelerated studies in mathematics and other science/technology subjects. Students in schools participating in the Atuda program come from a slightly stronger socioeconomic background compared to students in schools participating in the Give Five program.

Students' backgrounds show an improvement between 2009 (the year the programs were launched) and 2017, and improvements were of the same order of magnitude (in absolute terms) in Give Five, Atuda and other schools. A sharp rise of 5.5 percentage points was also recorded in the percentage of students who sat for 5-unit matriculation exams in mathematics in participating Atuda schools.[20]

The socioeconomic background (measured as the mother's years of education) of students in schools that joined the programs at their launch are much stronger than of students in schools that joined at a later stage, especially in Give Five schools, and are also much stronger than the socioeconomic background of students in non-participating schools (see Figure A-2 in the Appendix).

The programs' effective implementation and expansion require qualified teachers, such as math teachers with an academic degree in mathematics or a closely related discipline (in addition to teacher

[19] The main reasons for the limited representation of Give Five schools in this study are that many of these schools did not operate continuously since 2006 or had fewer than 30 twelfth-grade students in some years.

[20] The rise in eligibility for a matriculation certificate in non-participating schools was, in absolute terms, lower than in Atuda or Give Five schools, and the reverse phenomenon occurred with respect to standardized scores on eighth-grade Meitzav exams in mathematics. However, when estimating the probability of twelfth-grade students to become eligible for a matriculation certificate or the standardized score on eighth-grade Meitzav exams in mathematics, controlling for their background and schools and teachers characteristics (following the method described below), we find no differences between the three groups of schools in the development of these outcome variables.

training). Table 1 (bottom row) indicates that in 2009, one-half to two-thirds of the math hours in Atuda and Give Five schools were taught by qualified teachers, and this fraction declined slightly over time.[21]

The programs were expected, among other things, to lead to an inflow of students from a weak socioeconomic background to 5-unit studies in mathematics and Atuda cluster subjects, relative to backgrounds of students in such study tracks previously. A comparison of Tables 1 and 2 shows, as expected, that students who sit for 5-unit matriculation exams in mathematics have a much stronger background than other students in the same school. Students in participating schools who sign up for 5-unit math studies do not come from a weaker socioeconomic background compared to the students who did so before the program was initiated, even after controlling for changes in the socioeconomic backgrounds of students in 5-unit mathematics studies in non-participating schools (see DID column), which may reflect an overall increase in parents' education and income over time, among other changes. Students in the Atuda cluster tracks come from a similar socioeconomic background as students in 5-unit mathematics studies, and Atuda cluster tracks do not show an increase in students from weak socioeconomic backgrounds after participating in the programs compared to students in non-participating schools (not shown).

[21] Apparently the percentage of qualified teachers of 5-unit mathematics studies is higher (Many-Iken & Rosen, 2015; National Authority for Measurement and Evaluation in Education, 2016).

Table 1. Socioeconomic characteristics of students in schools participating in the Atuda and Give Five programs and in non-participating schools,[1] before and after program launch

Socioeconomic characteristics	Atuda program schools		Give Five schools		Non-participating schools	
(Year of matriculation exam)	Before (2009)	After (2017)	Before (2009)	After (2017)	(2009)	(2017)
Mother's years of education	12.5	12.9	12.4	12.9	11.2	11.9
Father's years of education	12.6	12.8	12.3	12.7	11.5	11.9
Number of siblings	2.5	2.4	2.8	2.5	3.3	3.2
Parents' standardized income per capita[2] (NIS thousands per month)	4.9	5.9	4.1	5.5	3.0	3.9
Eighth-grade Meitzav math z-score (SD)	0.21	0.16	0.17	0.11	-0.17	-0.03
Students sitting for 5-unit matriculation exams in math (%)	16.2	21.7	16.5	19.8	11.0	13.0
Students eligible for matriculation certificate (%)	71.9	86.1	66.9	83.3	63.5	74.6
Students per school[3]	239	227	251	239	200	177
Math teachers with an academic degree in mathematics or closely related discipline (%)[4]	55.7	55.1	70.9	66.9	54.5	51.6

Source: Ministry of Education, Central Bureau of Statistics, and data processing by authors.

(1) Schools in the study population. Atuda and Give Five schools – only schools in which the programs were operated continuously at least between 2015 and 2017; Non-participating schools – schools that did not operate either program before end 2017.

(2) The difference between Atuda/Give Five values in 2017 and 2009.

(3) Tenth-grade students.

(4) Percentage of teaching hours of teachers of mathematics with an academic degree in mathematics or related field (physical sciences, statistics, computer science, engineering) of total teaching hours of mathematics. We included only teachers for which information on academic degrees earned in Israel was available. As a result, older teachers and teachers who earned a degree overseas were not included.

Table 2. Socioeconomic characteristics of twelfth-grade students who sat for a-5 unit matriculation exam in mathematics in participating and non-participating schools,[1] by program, before and after program launch

	Atuda program schools		**Give Five schools**		**Non-participating schools**		**DID[2]**	
(Year of matriculation exam)	Before (2009)	After (2017)	Before (2009)	After (2017)	(2009)	(2017)	Atuda *minus* Non	Give Five *minus* Non
Mother's years of education	14.5	14.6	14.1	14.7	14.1	14.5	-0.2	0.2
Father's years of education	14.6	14.5	14.1	14.6	14.3	14.4	-0.2	0.4
Number of siblings	2.2	2.1	2.6	2.3	2.3	2.4	-0.2	-0.4
Parents' standardized per capita income[3] (NIS thousands per month)	7.1	8.3	6.1	8.1	6.0	7.5	-0.2	0.5
Eighth-grade Meitzav math z-core (SD)	0.97	1.02	0.89	0.96	0.87	0.97	-0.1	0.0

Source: Ministry of Education, Central Bureau of Statistics, and data analysis by authors.

(1) Schools in the study population. Atuda and Give Five schools – only schools in which the programs were operated continuously at least between 2015 and 2017; Non-participating schools – schools that did not operate either program before end 2017.

(2) The difference between Atuda/Give Five values in 2017 and 2009.

(3) Parents' income (or mother's income if mother is unmarried) from salaried and self-employed work, in 2015 prices.

D. Descriptive Statistics

Figure 1 indicates that all schools in the study population (both participating and non-participating schools) show an increase in the percentage of students sitting for a 5-unit matriculation exam in mathematics after the launch of the Atuda program; This increase continued after the launch of the Give Five program, reflecting an increase from 11.1% of all twelfth-graders in 2012 (the last year before twelfth-graders could be exposed to the Atuda program) to 18.3% in 2017.[22] During this period, the percentage of students sitting for 4-unit matriculation exams in mathematics dropped slightly, while the percentage of students sitting for 3-unit exams dropped more sharply. Apparently, some students who would have studied mathematics at the 4-unit level in the absence of the program chose to study at the 5-unit level, and some who would have otherwise studied at the 3-unit level chose to study at the 4-unit level, taking into account that the number of students who sat for matriculation exams in mathematics at the 3-5-unit levels increased by 5 percentage points since 2012. The percentage of students sitting for Atuda Cluster subjects also shows a considerable increase from 6.3% in 2012 to 10.0% in 2017. The percentage of students sitting for each Atuda Cluster subject increased in that period by less than 4 percentage points (not shown) and therefore the major share of the increase in students sitting for Atuda Cluster subject apparently stems from the rise in the number of students sitting for 5-unit exams in mathematics.

Figure 4A shows the development in the percentage of students sitting for 5-unit exams in mathematics in (a) participating schools that joined the Atuda program in the pilot year or in 2011 and operated the program until end 2017, (b) participating schools that joined the Give Five program in 2015, its launch year, and operated the program until end 2017, and (c) non-participating schools. Before the launch of the two programs, figures show a steady decline in the percentage of students sitting for 5-unit exams in mathematics in all three groups of schools, and this trend reversed after the programs were launched. The increase in the percentage of students sitting for 5-unit exams in mathematics in non-participating schools may have stemmed from several factors, including the effects of specific parts of the Give Five program that were implemented throughout the education system (see Chapter B). Figure 4B shows the difference in the percentage of students sitting for 5-unit exams in mathematics in Atuda schools and non-participating schools compared to the difference in 2012 (the last year before the Atuda program was launched in twelfth grades in Atuda schools). In the years immediately before and after the launch of the Atuda program, the difference was not significant, but in the subsequent period figures show a sharp, statistically significant, rise of over 5 percentage points in the difference between those schools, compared to the difference in 2012. The fact that the absolute and relative increases are gradual apparently stems from two factors: junior high school students who entered the Atuda program reached twelfth grade, and the program's integration in the participating schools' curricula.

Figure 4C shows the difference in the percentage of students sitting for 5-unit exams in mathematics between Give Five schools and non-participating schools, compared to the difference in 2014, prior

[22] Furthermore, the percentage of schools in which students sit for 5-unit matriculation exams in mathematics, which declined steadily from approx. 86% in 2009 to approx. 79% in 2014, has since returned to its 2009 level.

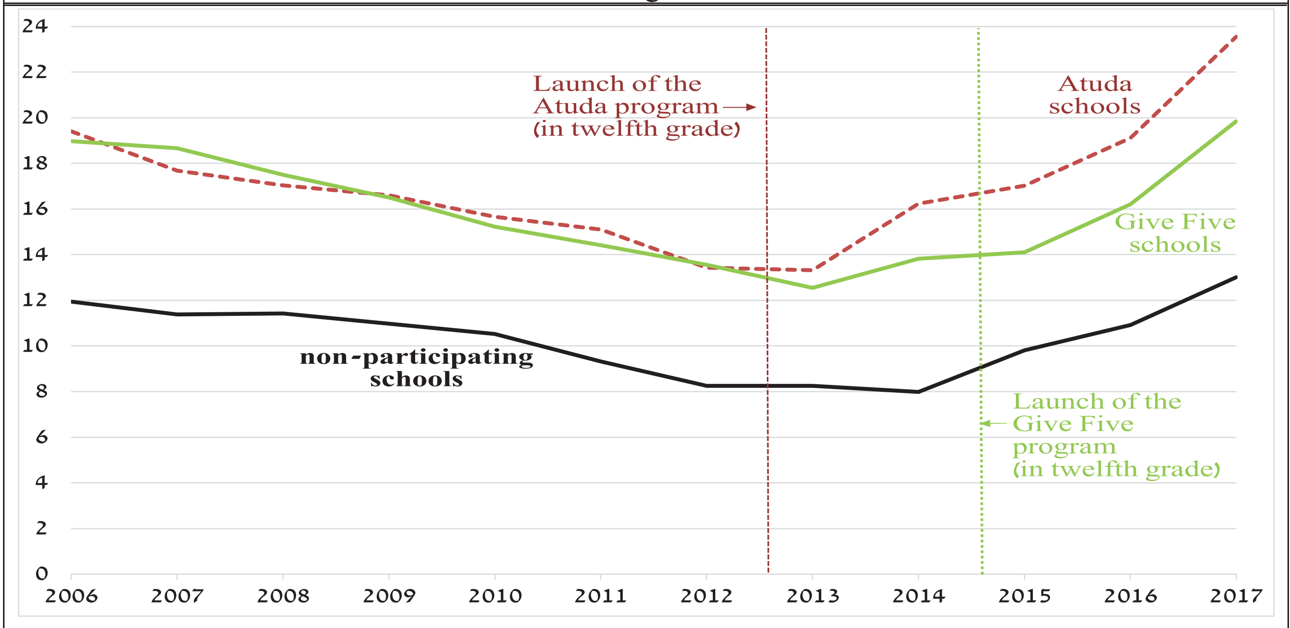
to the program's launch. In the years immediately before the launch of the Give Five program, the difference was relatively stable, and thereafter showed a slight, close to significant increase.

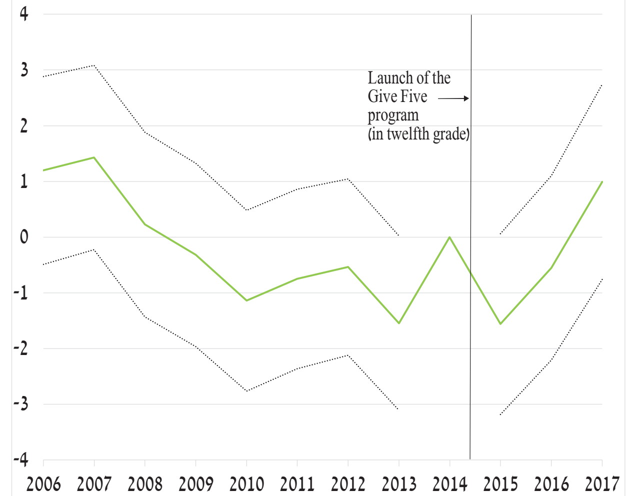
Figure 5 presents the percentage of students sitting for Atuda Cluster subjects, and indicates similar developments to the trends in the percentage of students sitting for 5-unit mathematics exams. Before the launch of the Atuda program, the percentage of students sitting for Atuda Cluster subjects in participating schools was stable, and increased by a total of approx. 6 percentage points in the following years after the launch of the program (Figure 5A), also compared to the percentage in other schools (Figure 5B), which is similar to the cumulative increase in the percentage of students sitting for 5-unit exams in mathematics (Figure 4B). Give Five schools recorded a relative total increase of over 2 percentage points in the share of students sitting for Atuda Cluster subjects (Figure 5C). The explanation for this increase is twofold: First, as a result of the increase in the percentage of students sitting for 5-unit exams in mathematics, students who previously studied two science-technology subjects at the 5-unit level (but not mathematics) were automatically counted in the Atuda Cluster group; Second, the decision to study mathematics at the 5-unit level apparently motivated some students to also choose to study two science-technology subject at this level as well.

Raw data thus show that the percentage of students who studied mathematics and Atuda Cluster subjects at a 5-unit level in Atuda and Give Five schools increased after the schools joined these programs, compared with the percentage in other schools. However, a more accurate assessment of the programs' effect on these outcome variables calls for consideration of the socioeconomic backgrounds of the students', and schools' and teachers' characteristics in that period, as changes in these factors (e.g., transfer of students from a strong socioeconomic background to participating schools) may have affected the outcome variables. We examine this in the next chapter.

Figure 4. Percentage of twelfth-grade students sitting for-5 unit matriculation exams in mathematics in participating and non-participating schools[1]

A. Percentage of examinees



B. Difference between Atuda schools and others[2] (compared to the difference in 2012, in percentage points)	C. Difference between Give Five schools and others[2] (compared to the difference in 2014, in percentage points)
	

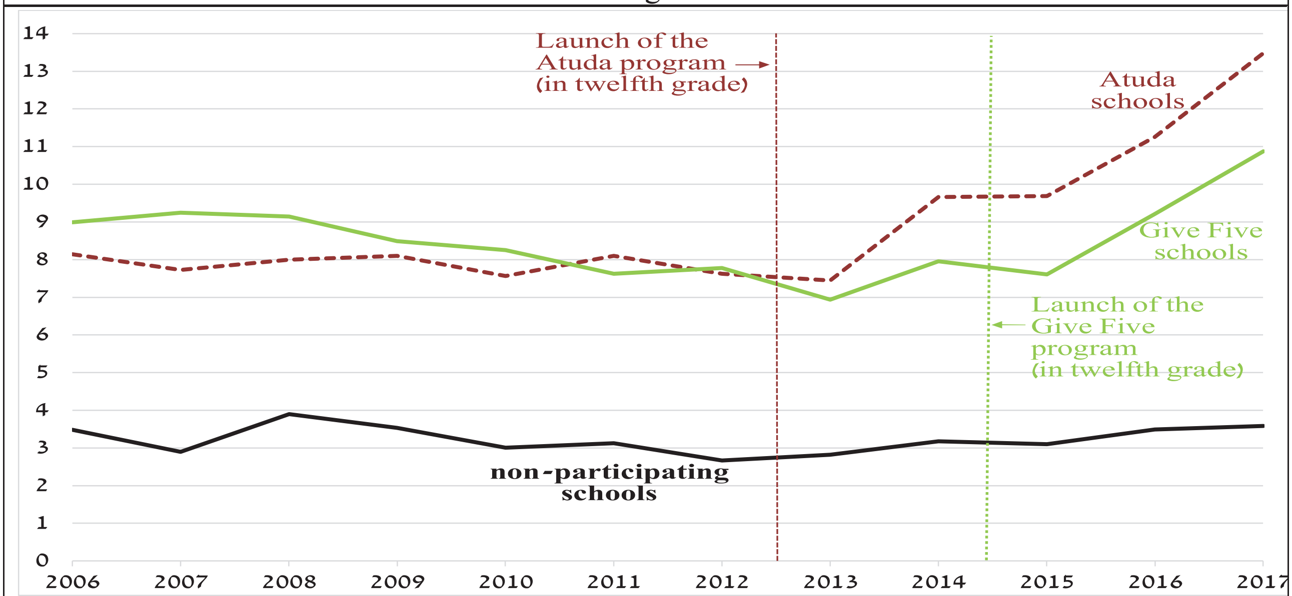
Source: Ministry of Education and data processing by authors.

(1) Schools in the study population .Atuda schools – only schools in which the program operated continuously from 2011 (or from the pilot program in 2010) to end 2017. Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

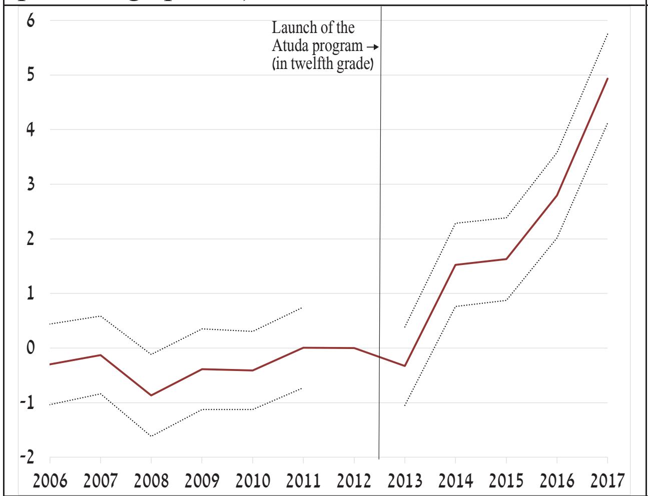
(2) Based on estimates of the interaction variables of the dummy variable for program × the dummy variable for year, in the LPM estimations of the dummy variable for 5-unit mathematics examinees, as a function of the dummy variable for program, years, and interaction variables. The dashed lines are confidence intervals (at a confidence level of 95%). The year 2012 is the last year in which twelfth graders had not completed three years in the Atuda program, and 2014 is the last year before Give Five was launched.

Figure 5. Percentage of twelfth-grade students sitting for Atuda Cluster exams,[1] participating and non-participating schools[2]

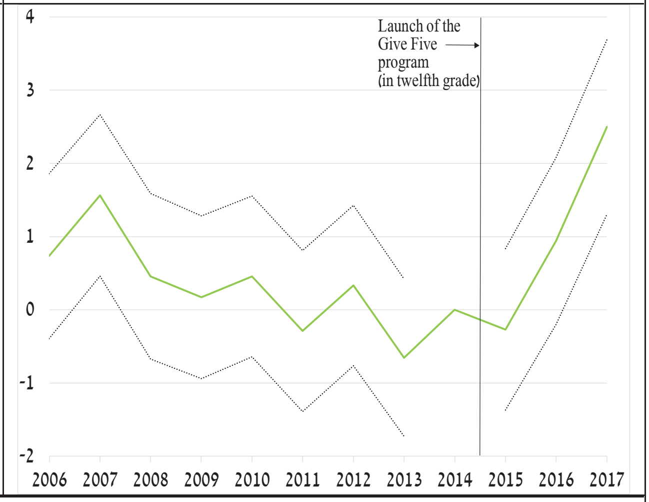
A. Percentage of examinees



B. Difference between Atuda schools and others[3] (compared to the difference in 2012, in percentage points)



C. Difference between Give Five schools and others[3] (compared to the difference in 2014, in percentage points)



Source: Ministry of Education and data processing by authors.

(1) Schools in the study population. Atuda schools – only schools in which the program operated continuously from 2011 (or from the pilot program in 2010) to end 2017. Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

(2) Based on estimates of the interaction variables of the dummy variable for program × the dummy variable for year, in the LPM estimations of the dummy variable for Atuda Cluster examinees, as a function of the dummy variable for program, years, and interaction variables. The dashed lines are confidence intervals (at a confidence level of 95%). The year 2012 is the last year in which twelfth graders had not completed three years in the Atuda program, and 2014 is the last year before Give Five was launched.

E .The Estimation Method and Findings

The effects of the Atuda and the Give Five programs on the outcome variables were estimated using the Difference-in-Differences method :In the participating schools (treatment) we examined the difference between the outcome variables before and after the program's launch and the difference between the before and after outcome variables in non-participating schools (comparison) in the same period. As we showed earlier in Figures 4 and 5 (bottom panels), the outcome variables in the treatment and comparison schools shortly before the program's launch show a common trend. The assumption underlying this method is that in the absence of the program's launch, the difference in outcome variables in the treatment schools and in the comparison schools after the program's launch would be similar.[23] The estimations were performed controlling for background factors of students and schools, and for schools fixed effects, capturing educational stream, school location etc. Because background factors also included students' scores on eighth-grade Meitzav exam in mathematics, the

[23] Although Give Five schools received an addition of mainly teaching hours, all schools received additional resources. Moreover, the media coverage of the program may have encouraged students in non-participating schools to study mathematics at a higher level. Furthermore, teachers who participated in the programs may have also taught in non-participating schools. One possible indication of Give Five's potential positive impact on non-participating schools is the increase in the percentage of students sitting for 5-unit matriculation exams in mathematics (see Figure 4A above). We therefore state that we are estimating only the effect of the allocation of specific teaching hours to these programs (and specifically to Give Five) on the outcome variables.

estimated equation can also be considered a quasi-model of added value.[24] A detailed description of the estimated equation is presented in the Appendix. The LPM method was used to estimate the effects, unless stated otherwise.[25]

Effects were measured for 114 Atuda schools that joined the program in 2011 (or joined the pilot program in 2010) and operated it until 2017, 38 Give Five schools that joined the program in 2015 and operated it continuously until 2017, and 85 schools that participated in neither program until 2017 (see Table A-1 in the Appendix). Schools that joined a program after the launch year were eliminated from the estimations, as were a small number of schools that joined a program in its launch year but left the program before the end of 2017.

1. Sitting for 5-unit matriculation exams in mathematics and Atuda Cluster subjects

We now proceed to describe the results of the programs' estimated effects on the probability of the following outcome variables: sitting for 5-unit matriculation exams in mathematics, sitting for matriculation exams in Atuda cluster subjects, sitting for 5-unit matriculation exams in each of the science-technology subjects in the Atuda Cluster, passing the 5-unit matriculation exam in mathematics, and the grade in the 5-unit matriculation exam in mathematics.

Table 3 (left-hand columns) presents the results of the estimations of the probability of sitting for 5-unit matriculation exams in mathematics in Atuda schools compared to non-participating schools. A control for exposure to the program in junior high school is included in Model 2 but not in Model 1. Before the Atuda program was launched, the difference between the probability of a student in an Atuda school to sit for a 5-unit matriculation exam in mathematics and the probability of a student in a non-participating school to do so was not significantly different from the difference in 2012 (the last year before twelfth graders were introduced to the program); That is to say, the trends in the probability of sitting for such exams were similar in both groups of schools .The results of Model 1 show that this probability increased in 2014-2016 by approx. 2 percentage points in Atuda schools' favor, and in 2017 this probability surged by approx. 5 percentage points (in 2012 more than 13% of Atuda school students sat for-5 unit matriculation exams in mathematics). We posit that the Atuda program's growing influence in 2017 stemmed from the fact that the twelfth graders who completed the program after 2016 had been in the program since seventh grade, and from the program's integration in the participating schools. The estimate of the Atuda variable is negative, which implies that the probability of Atuda school students of sitting for a 5-unit matriculation exam in mathematics before the program's launch was lower than the probability of students in non-participating schools , controlling for the differences in the background factors of students, teachers, and schools. Consequently ,the Atuda program led to a more effective realization of the potential of students able to sit for a 5-unit matriculation exam in mathematics. Each standard deviation in eighth-grade Meitzav exam scores in mathematics (equal to 100 points) increased the probability of sitting for a 5-unit matriculation exam in mathematics by 16 percentage points.

[24] The Atuda program begins in seventh grade and the Meitzav exam takes place in eighth grade. Therefore the program may have some effect on Meitzav scores.
[25] Estimating logistic regression models (GLIMMIX in SAS) generated similar results.

Adding a variable that represents participation in the Atuda program in junior high school (Model 2) has little impact on the results ,and the estimate of this variable is not statistically significant . Ostensibly, this shows that participation in the Atuda program in junior high school (which is only relevant for twelfth grade students in the years 2015-2017) does not increase the probability of sitting for a-5 unit matriculation exam in mathematics in twelfth grade .This finding should however be qualified because the vast majority of students in Atuda schools attended six-year high schools in which the program operates concurrently in junior and senior high school, which precludes an effort to separate the contribution of the program's operations in each cluster of grades to the probability of sitting for a 5-unit matriculation exam in mathematics.

Separate estimations by gender, ethnicity, mother's years of education, and student's score on the eighth-grade Meitzav exam in mathematics led to the following insights (Table A-2 in the Appendix): The Atuda program contributed to an increase by 1-2 percentage points in the share of students sitting for a 5-unit matriculation exam in mathematics for female students and students who achieved a higher than average score on their eighth-grade Meitzav exam in mathematics, compared to other student groups. No notable differences were found between students in the Jewish vs. the Arab education system. In the Jewish education system, no notable differences were found by mother's years of education (more/less than 12 years of schooling).

By 2017, the Atuda program increased the probability of sitting for matriculation exams in Atuda Cluster subjects by approx. 4 percentage points (Table 3, right-hand columns). Before the program's launch, approx. 8% of students sat for matriculation exams in Atuda Cluster subjects, and therefore the probability increased by half. A portion of this increase stemmed from the increase in the percentage of students sitting for a 5-unit matriculation exam in mathematics in Atuda schools compared to non-participating schools, as shown above; However, even the percentage of students in Atuda schools sitting for 5-unit matriculation exams in physics and computer sciences increased by 2-3 percentage points compared to the percentage in non-participating schools, while the percentage of students sitting for 5-unit matriculation exams in other Atuda Cluster subjects remained relatively stable (not shown). The relative increase in the probability of Atuda school students of sitting for matriculation exams in Atuda Cluster subjects, by students' background factors, is similar to the relative increase in the probability of sitting for-5 unit exams in mathematics.

Up until now we estimated the effect of the Atuda program on the percentage of students sitting for 5-unit exams in mathematics and Atuda Cluster subjects, by comparing these outcome variables for Atuda students (the treatment group) and students of non-participating schools (the comparison group) .Although the trends in these outcome variables were similar in these two groups before the program's launch, as we showed above, students in non-participating schools came from a relatively weak socioeconomic background, and these schools had a low percentage of students who sat for these exams at the 5-unit level. We therefore repeated our estimations using students in Give Five schools as the comparison group. Note that in 2013-2014 the Atuda program was already in operation but the Give Five program was not in operation in those years. Therefore, for those years we only measured the effect of the Atuda program and in the subsequent years we compared the effects of both programs.

Table 4 presents the results of these estimations. Already in 2014, Atuda schools showed an increase of approx. 3 percentage points in the percentage of students sitting for a 5-unit matriculation exam in mathematics, and an increase of approx. 2 percentage points in the percentage of students sitting for a 5-unit matriculation exam in Atuda Cluster subjects compared to Give Five schools .These disparities remained even after the Give Five program was launched .The potential heterogeneous effects of the Atuda program (not shown) included a contribution to female students (an increase of over 4 percentage points), but no statistically significant contribution to male students, and also contributed to students with above-average Meitzav scores in mathematics (approx. 5 percentage points) compared to students whose Meitzav scores in mathematics were below average (approx. 2 percentage points). These findings are consistent with the results obtained when the comparison group was non-participating schools. The Atuda program had no statistically significant effect on the probability of studying any science/technology subject in the Atuda Cluster (not shown).

We also studied the differences in the Atuda program's effects on high-achieving and low-achieving schools. High-achieving schools were classified as such if in 2009 (the last year before the program's launch), the percentage of students sitting for a 5-unit matriculation exam in mathematics or Atuda Cluster subjects was higher than expected on the basis of the background characteristics of their students, teachers, and the school.[26] Slight differences were found in the Atuda program's effect in favor of high-achieving schools (not shown). Consequently, the program helped students with relatively high abilities to realize their potential in low-achieving schools.

The estimated effects of the Give Five program on the probability of sitting for 5-unit matriculation exams in mathematics and Atuda Cluster subjects compared to students in non-participating schools are presented in Table 5. In 2017, the first year in which twelfth-graders had participated in the program for three years, the program increased the relative probability of sitting for a 5-unit matriculation exam in mathematics by close to 3 percentage points (up from approx. 13% in 2014, before the launch of the program). The program's effect focused on boys (approx. 4 percentage points) and no effects were experienced by girls; In the Arab education system the program's effects were slightly higher than in the Jewish education system (see Table A-3 in the Appendix). The relative probability of sitting for matriculation exams in Atuda Cluster subjects increased by close to 4 percentage points) up from 8% in 2014, before the launch of the program), primarily due to the increase in the percentage of students sitting for a 5-unit matriculation exam in mathematics.

The integration into 5-unit mathematics studies of students from a weak socioeconomic background and relatively poor prior academic achievements might have decreased the percentage of students who passed their exams (achieved a score of 55 points or higher) and depressed scores (also see National Authority for Measurement and Evaluation in Education, 2018b). Based on a computation (not shown), the percentage of students who passed the 5-point matriculation exam was relatively stable before the launch of the program (over 98% of students passing), yet declined by 1-2 percentage

[26] For Atuda schools in 2009 we estimated the probability of sitting for a 5-unit matriculation exam in mathematics / Atuda Cluster subjects using the equation presented in the Appendix, excluding a dummy variable for school. We then calculated the difference between the school average of the predicted probability and the actual percentage of students who sat for these exams. Schools in which the difference was positive and greater than 0.1 standard deviation from the actual percentage of students who sat for the exams were defined as high-achieving schools; Schools in which the difference was negative and smaller than -0.1. were defined as low-achieving schools.

points after the program's launch. However, a similar phenomenon was recorded in the non-participating schools as well. Therefore the decline in the percentage of passing students cannot be necessarily attributed to the programs. One possible explanation for this finding is that some high schools students (approx. 29%, based on a survey conducted in 2012-2014) drooped out of 5-unit mathematics studies before sitting for their matriculation exams, mainly due to poor achievements (Manny-Ikan and Rozen, 2015).

The Atuda program led to a decline of 2-3 percentage points in students' scores on 5-unit matriculation exams in mathematics relative to the scores of students in non-participating schools (Table 6), especially in the sores of girls (not shown) – an unsurprising result, as the percentage of girls sitting for 5-unit matriculation exams in mathematics increased as a result of the Atuda program more than did the percentage of male students. In any case, the overall decline was small because in 2012, the average grade in-5 unit matriculation exams in mathematics in Atuda schools was 84. Moreover, this score shows no decline when compared to Give Five schools (including when scores are segmented by gender). The average score of Give Five students did not change relative to the average score of non-participating schools.

Finally ,we examined if the Atuda program had an effect on the percentage of students in 3- and 4-unit mathematics studies. Table A 4-in the Appendix shows no change in the percentage of students sitting for 4-unit matriculation exams in mathematics in Atuda schools compared to non-participating schools and Give Five schools. The percentage of students sitting for 3-unit matriculation exams in mathematics declined by 6 percentage points compared to non-participating schools (but not in comparison with Give Five schools). We can therefore hypothesize that the figures reflect students' transition from 3-unit mathematics studies to 4-unit mathematics studies, and from 4-unit to 5-unit mathematics studies.

Table .3 Probability of sitting for 5-unit matriculation exams in mathematics and Atuda Cluster subjects:[1] Atuda schools vs. non-participating schools[2]

Explanatory variables[3]	5-unit matriculation exam in mathematics		5-unit matriculation exam in Atuda Cluster subjects	
	Model 1	**Model 2**	**Model 3**	**Model 4**
Atuda	-0.048***	-0.048***	0.013	0.013
Atuda × 2006[4]	-0.006	-0.007	-0.017	-0.017
Atuda × 2007[4]	0.003	0.003	-0.026**	-0.026
Atuda × 2008[4]	-0.008	-0.009	-0.019*	-0.019**
Atuda × 2009[4]	0.002	0.002	-0.013	-0.013*
Atuda × 20010[4]	-0.007	-0.007	-0.008	-0.008
Atuda × 20011[4]	-0.003	-0.003	-0.001	-0.001
Atuda × 20013[4]	**-0.004**	**-0.004**	**-0.003**	**-0.003**
Atuda × 20014[4]	**0.026***	**0.026***	**0.008**	**0.008**
Atuda × 20015[4]	**0.020***	**0.020***	**0.013**	**0.013**
Atuda × 20016[4]	**0.022***	**0.018**	**0.020****	**0.015**
Atuda × 20017[4]	**0.052*****	**0.048*****	**0.045*****	**0.040*****
Participation in the program in junior high school[5]		0.005		0.007
Standardized eighth-grade Meitzav score in mathematics	0.162***	0.162***	0.090***	0.090***
Background factors of the student and their parents	V	V	V	V
Background factors of the school and teachers	V	V	V	V
Time trend by district	V	V	V	V
School F.E.	V	V	V	V
No. of observations	213,889	213,889	213,889	213,889
No. of schools (No. of Atuda schools)	199 (114)	199 (114)	199 (114)	199 (114)
Adjusted R^2	0.207	0.207	0.135	0.135

*** ,** ,* statistically significant at ,5% ,10% and ,1% respectively .

(1) Mathematics at the 5-unit level, one subject in natural sciences (physics, chemistry, biology) at the 5-unit level, and one additional science subject (physics, chemistry, biology, computer sciences) or a studies in 5-unit technology track subject (software engineering, electronics, mechanical engineering, biotechnology, etc.).

(2) Schools in the study population. Atuda schools – only schools that operated the program continuously from 2011 (or the pilot program in 2010) to end 2017; Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

(3) See Appendix for the list of explanatory variables. Estimations also include school's exposure to the Oz Latmura reform and the number of years students were exposed to Ofek Hadash reform.

(4) Compared to the difference between Atuda and non-participating schools in the probability of sitting for a 5-unit matriculation exam in mathematics in 2012. 2012 is the last year in which twelfth-grade students had not completed three years in the Atuda program.

(5) Dummy variable that takes the value of 1 for students in Atuda schools, where the program was operated during the student attended seventh, eighth, and ninth grades.

Table 4. Probability of sitting for 5-unit matriculation exams in mathematics and Atuda Cluster subjects:[1] **Atuda schools vs. Give Five schools**[2]

Explanatory variables[3]	**5-unit matriculation exam in mathematics**	**5-unit matriculation exam in Atuda Cluster subjects**
Atuda	-0.039***	-0.008
Atuda × 2006[4]	0.004	-0.012
Atuda × 2007[4]	-0.016	-0.003
Atuda × 2008[4]	-0.007	-0.019
Atuda × 2009[4]	0.010	0.000
Atuda × 20010[4]	0.001	-0.007
Atuda × 20011[4]	0.029**	0.014
Atuda × 20013[4]	**0.018**	**0.011**
Atuda × 20014[4]	**0.031*** **	**0.024*** **
Atuda × 20015[4]	**0.032** **	**0.021** **
Atuda × 20016[4]	**0.019**	**0.012**
Atuda × 20017[4]	**0.035** **	**0.021* **
Participation in the program in junior high school[5]	V	V
Standardized eighth-grade Meitzav score in mathematics	V	V
Background factors of the student and their parents	V	V
Background factors of the school and teachers	V	V
Time trend by district		
School F.E.		
No. of observations	221,873	221,873
No. of schools (No. of Atuda schools)	152 (114)	152 (114)
Adjusted R^2	0.211	0.133

*, **, *** statistically significant at 10%, 5%, and 1%, respectively.

(1) Mathematics at the 5-unit level, one subject in natural sciences (physics, chemistry, biology) at the 5-unit level, and one additional science subject (physics, chemistry, biology, computer sciences) or a studies in 5-unit technology track subject (software engineering, electronics, mechanical engineering, biotechnology, etc.).

(2) Schools in the study population. Atuda schools – only schools that operated the program continuously from 2011 (or the pilot program in 2010) to end 2017; Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

(3) See Appendix for the list of explanatory variables. Estimations also include school's exposure to the Oz Latmura reform and the number of years students were exposed to Ofek Hadash reform.

(4) Compared to the difference between Atuda and Give Five schools in the probability of sitting for a 5-unit matriculation exam in mathematics or Atuda Cluster subjects in 2012. 2012 is the last year in which twelfth-grade students had not completed three years in the Atuda program.

Table 5. Probability of sitting for 5-unit matriculation exams in mathematics and Atuda Cluster subjects:[1] Give Five schools vs. non-participating schools[2]

Explanatory variables[3]	5-unit matriculation exam in mathematics	5-unit matriculation exam in Atuda Cluster subjects
Atuda	0.015	0.044**
Atuda × 2006[4]	-0.009	0.007
Atuda × 2007[4]	0.031	0.002
Atuda × 2008[4]	-0.006	0.013
Atuda × 2009[4]	0.001	0.003
Atuda × 20010[4]	-0.003	0.013
Atuda × 20011[4]	-0.017	0.006
Atuda × 20013[4]	0.011	0.021**
Atuda × 20014[4]	-0.008	0.003
Atuda × 20015[4]	**-0.003**	**0.012**
Atuda × 20016[4]	**0.006**	**0.022****
Atuda × 20017[4]	**0.028***	**0.037****
Participation in the program in junior high school[5]	V	V
Standardized eighth-grade Meitzav score in mathematics	V	V
Background factors of the student and their parents	V	V
Background factors of the school and teachers	V	V
Time trend by district	V	V
School F.E.	V	V
No. of observations	98,540	98,540
No. of schools (No. of Give Five schools)	123 (38)	123 (38)
Adjusted R^2	0.206	0.144

*, **, *** statistically significant at 10%, 5%, and 1%, respectively.

(1) Mathematics at the 5-unit level, one subject in natural sciences (physics, chemistry, biology) at the 5-unit level, and one additional science subject (physics, chemistry, biology, computer sciences) or a studies in 5-unit technology track subject (software engineering, electronics, mechanical engineering, biotechnology, etc.).

(2) Schools in the study population. Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

(3) See Appendix for the list of explanatory variables. Estimations also include school's exposure to the Oz Latmura reform and the number of years students were exposed to Ofek Hadash reform.

(4) Compared to the difference between Give Five and non-participating schools in the probability of sitting for a 5-unit matriculation exam in mathematics or Atuda Cluster subjects in 2014. 2014 is the last year before the Give Five program was launched.

Table 6. Grades on 5-unit matriculation exams in mathematics[1]

Explanatory variable[2]	**Atuda vs. non-participating schools**	**Atuda vs. Give Five schools**	**Explanatory variable**[2]	**Give Five vs. non-participating schools**
Atuda	11.41***	-1.59	Give Five	7.98***
Atuda × 2006[3]	-2.62*	3.13	Give Five × 2006[4]	-2.67
Atuda × 2007[3]	-2.69	-1.78	Give Five × 2007[4]	0.84
Atuda × 2008[3]	-0.49	1.07	Give Five × 2008[4]	1.32
Atuda × 2009[3]	-1.16	0.83	Give Five × 2009[4]	0.52
Atuda × 20010[3]	1.47	0.72	Give Five × 2010[4]	3.48***
Atuda × 20011[3]	-1.47	1.62	Give Five × 2011[4]	-0.38
Atuda × 20013[3]	**-1.68**	**-0.00**	**Give Five × 2013**[4]	3.00**
Atuda × 20014[3]	**-3.56*** **	**-0.85**	**Give Five × 2014**[4]	1.17
Atuda × 20015[3]	**-3.23** **	**-1.67**	**Give Five × 2015**[4]	**0.98**
Atuda × 20016[3]	**-2.13***	**0.60**	**Give Five × 2016**[4]	**0.95**
Atuda × 20017[3]	**-1.75***	**-0.14**	**Give Five × 2017**[4]	**1.24**
Background factors of the student and their parents	V	V		V
Background factors of the school and teachers	V	V		V
Time trend by district	V	V		V
School F.E.	V	V		V
No. of observations	33,875	37,171		13,392
No. of schools (No. of Atuda schools)	199 (114)	152 (114)	No. of schools (No. of Give Five schools)	123 (38)
Adjusted R^2	0.196	0.171		0.173

*, **, *** statistically significant at 10%, 5%, and 1%, respectively.

(1) Schools in the study population. Give Five schools – only schools in which program operated continuously from 2015 to end 2017. Non-participating schools – schools that did not participate in either program until end 2017.

(2) See Appendix for the list of explanatory variables. Estimations also include school's exposure to the Oz Latmura reform and the number of years students were exposed to Ofek Hadash reform.

(3) Compared to the difference between Atuda and Give Five or non-participating schools in the score in 5-unit matriculation exam in mathematics in 2012. 2012 is the last year before twelfth-grade students had not completed three years in the Atuda program.

(4) Compared to the difference between Give Five and non-participating schools in the score in 5-unit matriculation exam in mathematics in 2014. 2014 is the last year before the Give Five program was launched.

2. Starting science program in higher education

Both programs were designed to indirectly increase the number of students starting academic science (STEM) programs in institutions of higher education, which might lead to successful integration in the labor market, specifically in the high-tech sector. Kohen (2019), for example, showed that the percentage of undergraduates in STEM disciplines among those who had sat for 5-unit matriculation exams in mathematics is relatively high; Bental et al. (2019) found that approx. one-third of high-tech employees between the ages of 30 and 37 (in 2015) have a science-oriented matriculation certificate[27] and an academic degree in STEM disciplines, and one-fifth have a science-oriented matriculation certificate with no academic degree or a non-STEM academic degree.[28] The 2018 Higher Education Survey (Central Bureau of Statistics, 2019) conducted among students who had commenced undergraduates studies in the 2010/2011 academic year indicates that approx. one-half of those employed in the high-tech sector had studied in academic engineering institutions, and one-quarter had studied mathematics, statistics, or computer sciences. As expected, more than one-half of the graduates in these fields benefited from high wages (over NIS 13 thousand net per month on average).

We therefore estimated the probability of entering (by 2018) the first year of an undergraduate degree program in the sciences, which include one or more of the following fields: mathematics, statistics, and computer sciences; physical sciences (including chemistry); biology and agriculture; engineering. We also estimated the probability of studying in fields related to the high-tech sector: mathematics, statistics, and computer sciences; physics and engineering.

The first graduates of the Atuda program completed twelfth grade in 2013 and were only 23 years old in 2018. A large part of this cohort – those who served in the IDF and were interested in pursuing academic studies – had not yet had the opportunity to do so by 2018. We therefore limited our estimations to the graduates in the Arab education sector (excluding Druze males) who completed twelfth grade before or in 2016. Figure A-3 in the Appendix presents the percentage of twelfth-grade high school graduates who began undergraduate studies in the science disciplines. This figure shows that more than two thirds of them begin their studies within two years of graduating from high school (and an additional one quarter did so in the third year after their high school graduation); Therefore, limiting the estimations to students who completed twelfth grade by 2016 is appropriate (and in any case, the year of completing twelfth grade is controlled for in these estimations). This figure also indicates that within a period of 2-3 years after their high school graduation in 2015-2016, the percentage of twelfth-grade graduates who began studies in the science disciplines increased by one percentage point among graduates of the Atuda program, compared to students who completed high school in previous years; The percentage of twelfth-grade graduates of Give Five and non-participating schools who commenced studies in the science disciplines remained more or less stable in those years. Notably, only 5.3% of the twelfth-graders who graduated from high school in 2012 (before the launch of Atuda) and were eligible for a matriculation certificate, began to study for an undergraduate degree in the sciences by 2018; yet this percentage reached 43.2% of students who sat for a 5-unit matriculation exam in mathematics and 44.3% of students who sat for matriculation exams in Atuda Cluster subjects.

The results of the estimations are presented in Table 7. The probability of students who graduated from Atuda schools in the Arab education system in 2015-2016 to commence undergraduate studies in the sciences by 2018 increased at an order of 2 percentage points (compared to approx. 4.7% of students of Atuda schools in the Arab education system who graduated in 2012), compared to graduates of non-participating high schools in the Arab education system. A similar picture also

[27] 5 units in mathematics, physics, or computer science.

[28] The above findings do not necessarily indicate a causal effect of mathematics and science studies in high school on the selection of a study program in higher education institutions (or an occupation): The findings are merely correlations, and individual aptitudes and preferences affect both decisions.

emerges in comparison to graduates of Give Five schools. Additional estimations (not shown) reveal that boys and girls were similarly affected, and are evident only among students with above-average eighth-grade Meitzav scores in mathematics (2.6 percentage points). The Atuda program increased the probability of commencing undergraduate studies in disciplines related to the high-tech sector by approx. 1 percentage point (In 2012, approx. 3.7% of Atuda high school graduates commenced undergraduate studies in high-tech-related disciplines).

These findings have several limitations: The number of schools in the Arab education system that were included in the estimations is small, and there are not many students who completed three years in high school in the Atuda program (that is, graduated from high school in 2013-2016); It is therefore clear that the total number of high school graduates who participated in the Atuda program in junior high school and senior high school is even smaller (only a part of the twelfth-grade graduates in 2016). In any case, future estimations should also include graduates of Give Five schools and graduates of Atuda schools in the Jewish education system when they reach the age at which young Israeli adults pursue academic studies.

Table 7. Probability of Graduates of the Arab Education System[1] Studying in an Undergraduate Program in Sciences[2] or High-Tech-Related Disciplines[3] by 2018: Atuda Schools vs Give Five Schools and Non-Participating Schools[4,5]

Explanatory variable[6]	Science disciplines		Of which: high-tech related disciplines	
	Atuda schools vs. non-participating schools	Atuda schools vs. Give Five schools	Atuda schools vs. non-participating schools	Atuda schools vs. Give Five schools
Atuda	-0.001	-0.011#	0.002	-0.010**
Atuda × 2006[7]	-0.009*	-0.018**	-0.005	-0.008
Atuda × 2007[7]	0.026***	0.030**	0.020**	0.023**
Atuda × 2008[7]	-0.003	-0.013	-0.002	-0.008
Atuda × 2009[7]	0.007	0.008	-0.001	0.002
Atuda × 2010[7]	-0.014	-0.011*	-0.005*	-0.008#
Atuda × 2011[7]	0.007	0.006	0.000	-0.002
Atuda × 2013[7]	**-0.001**	**-0.004**	**-0.003**	**-0.002**
Atuda × 2014[7]	**0.001**	**-0.004**	**0.000**	**-0.006**
Atuda × 2015[7]	**0.018*** **	**0.034*** **	**0.009***	**0.016*** *
Atuda × 2016[7]	**0.024*** **	**0.014#**	**0.011*** *	**0.009**
Background factors of students and parents	V	V	V	V
Background factors of schools and teachers	V	V	V	V
Time trend by district	V	V	V	V
School F.E.	V	V	V	V
No. of observations	31,888	33,750	31,888	33,750
No of schools (of which, Atuda schools)	50 (14)	29 (14)	50 (14)	29 (14)
Pseudo R^2	0.471	0.368	0.469	0.366

#, *, **, *** - statistically significant at the 15%, 10%, and 5% level, respectively.

(1) Female and male Arabs and female Druze who graduated from twelfth grade up to 2016.

(2) Mathematics, statistics, and computer sciences; physical sciences (including chemistry); biology and agricultural sciences; engineering.

(3) Mathematics, statistics, and computer sciences; physics and engineering.

(4) The number of the schools in the study population. Atuda schools – only schools that operated the program continuously from 2011 (or the pilot program in 2010) to end 2017; Give Five schools – only schools that operated the program continuously from 2015 to end 2017; Non-participating schools – schools that did not operate the Atuda program or the Give Five program until end 2017.

(5) Logistic estimations were calculated (GLIMIX on SAS). The Table shows the marginal effects on the average values of the explanatory variables.

(6) The list of explanatory variables is presented in the Appendix. The estimations also include the percentage of junior high school students who participated in Atuda program, the percentage of junior high school students who participated in Give Five program, and the number of years in which students participated in Ofek Hadash reform.

(7) Compared to the difference in the probability to begin undergraduate studies between graduates of Atuda schools and graduates of Give Five schools in 2012. 2012 is the last year in which twelfth graders did not complete 3 years in the Atuda program.

F. Summary

In the past decade the percentage of students sitting for 5-unit matriculation exams in mathematics and science/technology subjects recorded a constant decline. This trend, together with the poor achievements of Israel's schoolchildren on international tests in those fields, the needs of the economy and specifically knowledge-intense sectors for qualified employees in the sciences and technology, and the desire to increase the earning potential of graduates of the education system, motivated the Ministry of Education to initiate two programs that reinforce mathematics and science studies in schools: Science-Technology Reserves (Atuda) and Give Five.

The Atuda program has been in operation since 2011 in a portion of all junior and senior high schools, with the aim of increasing the percentage of students who sit for 5-unit matriculation exams in mathematics and in two science-technology subjects ("Atuda Cluster subjects"). Give Five has been in operation since 2015 with the aim of strengthening 5-unit mathematics study programs in high schools (through addition teaching hours allocated to schools that do not participate in the Atuda program). Junior high school students who participated in the Atuda program continuously from seventh to twelfth grade graduated from high school in 2016, and high school students who participated in Give Five from tenth to twelfth grade graduated from high school in 20017.

The current study indicates that, by 2017, the Atuda program led to an increase of 4-5 percentage points in the percentage of students who sat for 5-unit matriculation exams in mathematics and Atuda Cluster subjects, compared to students in non-participating schools. Before the launch of the Atuda program, the percentage of students who sat for 5-unit matriculation exams in mathematics and Atuda Cluster subjects was 13% and 8%, respectively). The Give Five program led to an increase of 3 percentage points in the percentage of students who sat for 5-unit matriculation exams in mathematics (Before the launch of the program, the percentage of students who sat for 5-unit matriculation exams in mathematics was 14%). The percentage of students who passed 5-unit matriculation exams in mathematics and their grades on the exams showed no significant decline after the launch of these programs, which implies that the rise in the number of examinees did not adversely affect students' achievement on the exams.

The Atuda program increased the probability of graduates of the Arab education system to begin (by 2018) an undergraduate degree in the sciences by 2 percentage points (before the launch of the program, 5% of the graduates of these schools did so) and increased the probability of studying a high-tech related undergraduate program by approx. 1 percentage point (4% before the launch of the program). These figures may represent underestimations, as our information on undergraduate programs was limited to the high school graduates who completed the full six years of the Atuda program (from grade seven to twelve) and commenced academic studies in the sciences in the two-year period after their high school graduation (by 2018). Future studies will be able to examine this issue with respect to Give Five graduates and graduates of Atuda schools in the Jewish education sector.

Among other aims, the two programs were designed to strengthen studies in mathematics and science-technology studies of female students and to improve the academic achievements in these fields of students from a weak socioeconomic background. The first goal was achieved only by the Atuda program (not including commencement of science-related undergraduate programs), but the second goal was not achieved by either program. Therefore the need to invest additional efforts to reinforce studies in those subjects for students from a weak socioeconomic background remains, especially in view of the fact that the achievements on the international exam of these students, and specifically students in the Arab education system, are much lower than their peers in OECD countries .

A cost-benefit analysis of the program is challenging, especially with respect to the Give Five program whose graduates have not yet begun higher education studies ;It is even more challenging to perform comparisons to other intervention programs. Nonetheless, we will perform a rough calculation for the Atuda program. The cost of the program was approx. NIS 10.3 thousand per participant. Taking into account the ratio between the average number of students in Atuda high schools and the average number of Atuda participants per high school, and the average cost per student who participated in the Atuda program from seventh to twelfth grade (approx. NIS 1.1 thousand). As noted earlier, participation in this program led to an increase of approx. 2 percentage points in the probability of a student in an Atuda school in the Arab education system of commencing undergraduate studies in the sciences (high-tech subjects). The estimation of the wage equation, following Achdut et al. (2018), shows that in 2008-2015, the gross annual wages of Arabs with an undergraduate degree in the sciences (high-tech subjects) between the ages of 23 and 37, were higher by approx. NIS 32 thousand (approx. NIS 39 thousand) in 2017 prices compared to the wages of Arabs with an undergraduate degree in social studies disciplines, all else being equal, including individual aptitudes. Therefore, an Arab with an undergraduate degree in the sciences (high-tech subjects) will earn close to NIS 700 thousand (over NIS 800 thousand) more in the course of their lifetime than an Arab with an undergraduate degree in the social sciences (in NPV terms). In view of these increased probabilities, all graduates of Atuda schools should benefit from an additional NIS 14 thousand in lifetime wages (NIS 8 thousand for graduates in high-tech subjects). Thus, the benefits of the Atuda program exceed its cost by a factor of 10. If the circle of Atuda and Give Five participants grows, and expands to include students with lower abilities than the programs’ current graduates, there almost certainly will be a need to increase the cost per participant if we want those students to reach the same level of achievements as the current participants; The benefits can also expected to be smaller.

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APPENDIXES

The estimated equation

Estimations were performed for schools and students in the study population (defined above) in the years 2006-2017 as follows: Schools that operated the Atuda program since 2011 (or since its pilot program in 2010) continuously until 2017 (inclusive), schools that participating continuously in the Give Five program from 2015 to 2017 (inclusive), and non-participating schools.

The following DID equation was estimated:

$$Y_{ist} = \alpha_0 + \alpha_2 ATUDA_s + \alpha_3 LATET5_s + \boldsymbol{\overrightarrow{\alpha_4} y_t} \times \boldsymbol{ATUDA_{is}} + \boldsymbol{\overrightarrow{\alpha_5} y_t} \times \boldsymbol{LATET5}_{is} +$$
$$\alpha_6 ATUDA\_lower\_secondary_{ist-5} + \alpha_7 REFORM_{ist} + \overrightarrow{\alpha_8} X_{it-2} + \alpha_9 M_{it-4} + \alpha_{10} NH_{it-3} +$$
$$\overrightarrow{\alpha_{11}} S_{ist-2} + \overrightarrow{\alpha_{12}} y_t \times D_s + \theta_s + \epsilon_{ist}$$

where:

Y_{ist}	Outcome variable of student i in school s in year t (the year the student attended twelfth grade).
$ATUDA_s$	Dummy variable that receives the value of 1 if the school participated in the Atuda program and 0 otherwise.
$LATET5_s$	Dummy variable that receives the value of 1 if the school participated in the Give Five program and 0 otherwise.
y_t	Dummy variable that receives the value of 1 if in the year the student attended twelfth grade and 0 otherwise
$ATUDA\_lower\_secondery_{ist-5}$	Dummy variable that receives the value of 1 if the school participated in the Atuda program when the student was in grades seven to nine, and 0 otherwise.
$REFORM_{ist}$	School's total years of participation in the Oz Latmura reform when student attended tenth through twelfth grade, in terms of teachers' hours of work.
X_{it-2}	Background factors of students and parents (when student attended tenth grade): Dummy variable for male students, number of years of schooling of mother and father, number of siblings, ethnic origin: Jew - dummy variable for student born in CSI countries, dummy variable for student born in Ethiopia (or one parent was born in the Horn of Africa), dummy for student born elsewhere outside Israel; Arab - Muslim (non Bedouin), Bedouin, Christian, Druze (Base group – Jew born in Israel); parents' gross standardized per capita wages from employed and self-employed work (mother's wages if mother is single or widowed, father's wages if father is widowed), dummy variables for student's date of birth relative to dates corresponding to tenth grade school year ("standard year"), which may reflect high or low abilities - born after December

	in the year preceding the standard year, born between October and December in the year preceding the standard year, born between January and September in the year preceding the standard year, born before January in the year preceding the standard year, and the base group is students born between January and December in the standard year.
M_{it-4}	Students' z-score on the eighth-grade Meitzav exam in mathematics (or, if none, the student's fifth-grade grade in arithmetic).
NH_{it-3}	Student's total number of years of participation in the Ofek Hadash reform in elementary school and junior high schools.
S_{t-2}	Background factors of schools and teachers (when student was in tenth grade): Percentage of male teachers, percentage of teachers with a graduate degree, average number of years of teaching experience; standardized matriculation exam grade of teachers under age 31; number of teaching hours of mathematics teachers who have an academic degree in mathematics or related field (physical sciences, statistics, computer sciences, engineering) of total number of teaching hours of mathematics, number of students in tenth grade, average number of students per teacher per school.
D_s	District (defined by the MOE).
θ_s	Fixed effects for twelfth-grade student's school (SD are clustered by school).
ϵ_{ist}	residual.

Table A-1. Number of High Schools and Students in 2017:

Total and Study Population

	Schools	**Twelfth graders**
Total high schools	1,566	121,249
Of which - high schools that were also active in 2006	[1]1,133	102,643
Of which – Haredi high schools	249	12,414
Special education schools	149	2,957
Agricultural schools	26	3,570
Small schools[2]	532	19,314
Total schools in the study population[3]	404	64,278
Of which – special education students[4]	404	[5]3,699
Students who dropped out between tenth and twelfth grade	404	[5]2,546
Students who transferred between tenth and twelfth grade	404	[5]2,488
Total schools and students in the study population[6]	404	[5]55,915
Of which – Schools included in the estimations	237	[5]33,684
Of which – Atuda schools[7]	114	[5]20,225
Give Five schools[8]	38	[5]6,102
Non-participating schools[9]	85	[5]7,357

Source: Ministry of Education, Central Bureau of Statistics, and data processing by authors.

(1) The large number of high schools that were not active in 2006 partly stems from the frequent opening and closing of special education schools (which have few students) and other registration issues.

(2) Schools with fewer than 30 students in twelfth grade in one or more years between 2006 and 2017.

(3) After excluding boarding schools (whose identification is problematic) and schools that could not associated with teacher files.

(4) Special education students in regular schools.

(5) Tenth grade students in 2015.

(6) After excluding students who died either during or one year after graduating from high school, and students who were overseas for more than one year during high school.

(7) Schools in which the program operated continuously from 2011 (or from the pilot in 2010) to end 2017.

(8) Schools in which the program operated continuously from 2015 to end 2017.

(9) Schools that did not operate the Atuda or Give Five program before end 2017.

Table A-2. Probability of Sitting for 5-Unit Matriculation Exam by Population Group: Atuda Schools vs. Non-Participating Schools[1]

Explanatory variable[2]	**Gender**		**Education system**		**Mother's education**[3] **(Jewish education)**		**Meitzav score**[4]	
	Boys	Girls	Jewish	Arab	Low	High	Low	High
Atuda × 2006[5]	-0.025	0.007	0.005	-0.050	-0.008	0.022	0.006	-0.053*
Atuda × 2007[5]	-0.022	0.027	0.000	0.023	-0.001	0.000	0.010*	-0.049*
Atuda × 2008[5]	-0.022	0.002	-0.00	-0.047	-0.016	0.020	0.005	-0.022
Atuda × 2009[5]	-0.021	0.022	0.013	0.014	0.008	0.021	0.007	-0.017
Atuda × 2010[5]	-0.018	0.002	0.006	0.009	0.012	0.004	-0.007	-0.020
Atuda × 2011[5]	-0.010	0.005	-0.005	0.031	-0.005	-0.007	0.011	-0.007
Atuda × 2013[5]	**-0.006**	**-0.003**	**-0.004**	**-0.007**	**-0.000**	**0.001**	**0.006**	**-0.026**
Atuda × 2014[5]	**0.026***	**0.027***	**0.037****	**0.019**	**0.016**	**0.060****	**0.009****	**0.043***
Atuda × 2015[5]	**0.012**	**0.026***	**0.020**	**0.008**	**0.013**	**0.032***	**0.011****	**0.015**
Atuda × 2016[5]	**0.026**	**0.012**	**0.013**	**0.022**	**0.026**	**-0.002**	**0.019*****	**0.019**
Atuda × 2017[5]	**0.041****	**0.054*****	**0.044*****	**0.034**	**0.047**	**0.048****	**0.026*****	**0.047****
No. of observations	96,236	117,653	177,588	36,301	92,396	85,192	78,257	135,632
No. of schools	172	179	148	36	148	148	184	184
Adjusted R^2	0.234	0.314	0.210	0.194	0.139	0.221	0.030	0.224

*, **, *** significant at 10%, 5%, and 1% level, respectively.

(1) Schools in the study population. Atuda schools – only schools that operated the program continuously from 2011 (or the pilot program in 2010) to end 2017; Non-participating schools – schools that did not participate in either program until end 2017.

(2) Estimations include the explanatory variables from Table 3.

(3) High education – more than 12 years of schooling.

(4) Score on eighth-grade Meitzav exam, in SD terms. high score – positive SD.

(5) Compared to the difference between the probability to sit for a 5-unit matriculation exam in mathematics for Atuda school students and non-participating school students in 2012. 2012 is the last year in which twelfth grade students had not completed three years in the Atuda program.

Table A-3. Probability of Sitting for 5-Unit Matriculation Exam by Population Group: Give Five Schools vs. Non-Participating Schools[1]

Explanatory variable[2]	**Gender**		**Population sector**		**Mother's education[3] (Jewish education)**		**Meitzav score[4]**	
	Boys	Girls	Jewish education system	Arab education system	Low	High	Girls	Jewish education system
Give Five × 2006[5]	-0.039	0.017	0.000	-0.008	-0.003	0.016	-0.004	-0.057
Give Five × 2007[5]	0.028	0.034	0.002	0.110***	0.021	-0.013	0.002	-0.006
Give Five × 2008[5]	0.005	-0.013	-0.011	-0.004	-0.017	0.006	-0.010	-0.016
Give Five × 2009[5]	0.004	0.001	-0.009	0.048**	0.007	-0.021	-0.004	-0.014
Give Five × 2010[5]	-0.010	0.002	0.005	0.028	0.005	0.010	-0.008	-0.015
Give Five × 2011[5]	-0.027	-0.008	-0.038**	0.048	-0.005	-0.060**	-0.009	-0.035
Give Five × 2013[5]	0.020	0.004	-0.003	0.052**	0.006	-0.009	0.001	0.010
Give Five × 2014[5]	0.016	-0.024	0.005	0.024	0.024*	-0.003	-0.011	-0.029
Give Five × 2015[5]	**0.004**	**-0.005**	**0.007**	**0.004**	**0.011**	**0.012**	**0.008**	**-0.018**
Give Five × 2016[5]	**0.018**	**-0.002**	**0.000**	**0.040***	**0.013**	**-0.016**	**-0.010**	**0.003**
Give Five × 2017[5]	**0.046***	**0.014**	**0.032***	**0.046****	**0.034***	**0.033**	**0.002**	**0.014**
No. of observations	42,894	55,646	57,889	40,651	29,463	28,426	42,155	56,385
No. of schools	98	105	73	36	73	73	109	109
Adjusted R^2	0.234	0.188	0.201	0.228	0.130	0.213	0.050	0.223

*, **, *** significant at 10%, 5%, and 1% level, respectively.

(1) Schools in the study population. Give Five schools – only schools that operated the program continuously from 2015 to end 2017; Non-participating schools – schools that did not operate the Atuda program or the Give Five program before end 2017.

(2) Estimations include the explanatory variables from Table 5.

(3) High education – more than 12 years of schooling.

(4) Score on eighth-grade Meitzav exam, in SD terms. high score – positive SD.

(5) Compared to the difference between the probability to sit for a 5-unit matriculation exam in mathematics for Atuda school students and non-participating school students in 2012. 2012 is the last year in which twelfth grade students had not completed three years in the Atuda program.

Table A-4. Probability of sitting for 3- and 4-unit matriculation exams by population group: Atuda schools vs. non-participating schools and Give Five schools[1]

Explanatory variable[2]	Atuda vs. non-participating schools		Atuda vs. Give Five schools	
	4 units	3 units	4 units	3 units
Atuda	0.026	-0.025	-0.107***	-0.013
Atuda × 2006[3]	0.008	-0.036	0.026	0.016
Atuda × 2007[3]	0.032**	-0.057**	0.014	0.038
Atuda × 2008[3]	0.011	-0.021	-0.004	0.059
Atuda × 2009[3]	0.002	-0.046*	-0.013	0.039*
Atuda × 2010[3]	0.006	0.013	-0.022	0.047**
Atuda × 2011[3]	0.000	0.004	-0.013	0.019
Atuda × 2013[3]	**0.022**	**-0.010**	**-0.006**	**0.006**
Atuda × 2014[3]	**-0.010**	**-0.015**	**-0.032**	**0.021**
Atuda × 2015[3]	**0.015**	**-0.022**	**-0.012**	**0.022**
Atuda × 2016[3]	**0.015**	**-0.041****	**-0.013**	**0.018**
Atuda × 2017[3]	**0.008**	**-0.061*****	**-0.007**	**-0.002**
Background factors of students and parents	V	V	V	V
Background factors of schools and teachers	V	V	V	V
Time trend by district	V	V	V	V
School F.E.	V	V	V	V
No. of observations	221,873	221,873	213,889	213,889
No. of schools (of which – Atuda schools)	142 (114)	142 (114)	199 (114)	199 (114)
Adjusted R^2	0.095	0.127	0.087	0.131

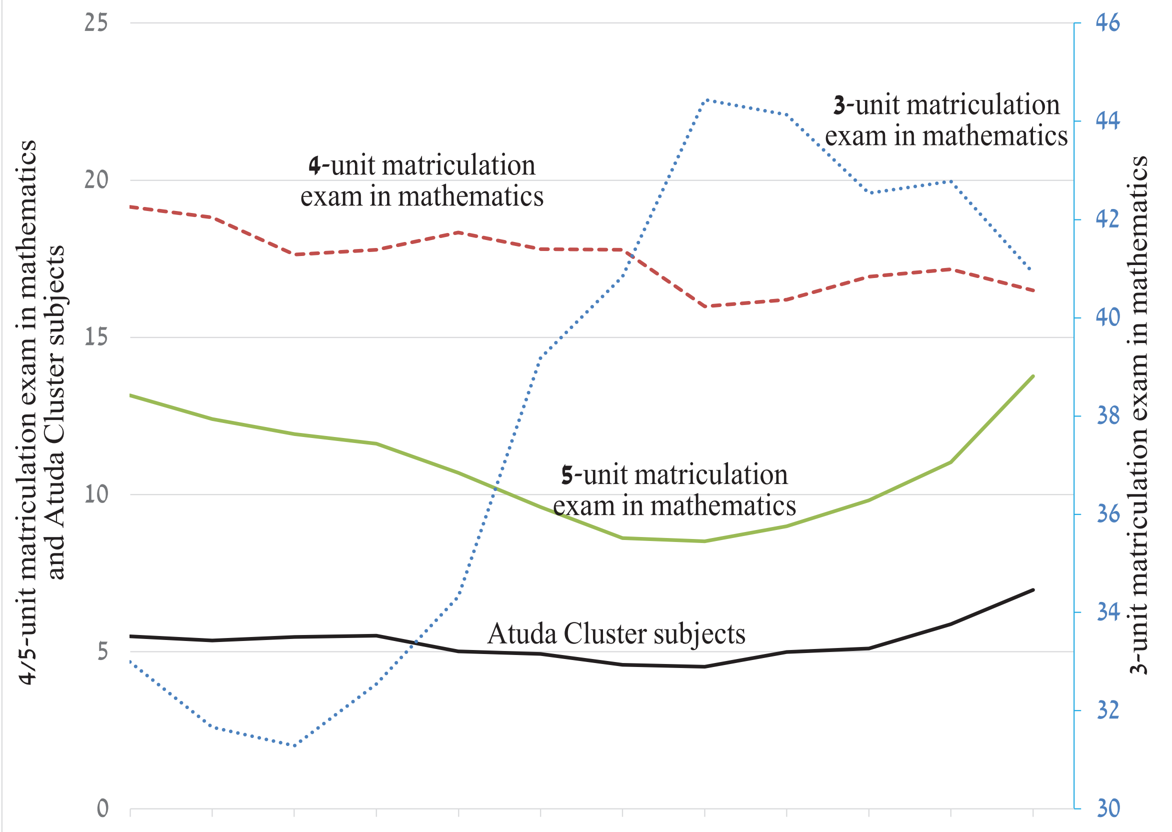
*, **, *** significant at 10%, 5%, and 1% level, respectively.

(1) Schools in the study population. Atuda schools – only schools that operated the program continuously from 2011 (or the pilot in 2010) to end 2017; Give Five schools – only schools that operated the program continuously from 2015 to end 2017; Non-participating schools – schools that did not operate the Atuda program or the Give Five program before end 2017.

(2) See Appendix for the explanatory variables. Estimations also include junior high school students' exposure to the Atuda program, percentage of schools exposed to Oz Latmura reform, and the number of years in which students were exposed to Ofek Hadash reform.

(3) Compared to the difference between the probability to sit for a 3-unit or 4-unit matriculation exam in mathematics for Atuda school students and non-participating or Give Five school students in 2012. 2012 is the last year in which twelfth grade students had not completed three years in the Atuda program.

Figure A-1. Percentage of students sitting for matriculation exams in mathematics and Atuda Cluster subjects[1] of all twelfth graders in the education system[2] (%)

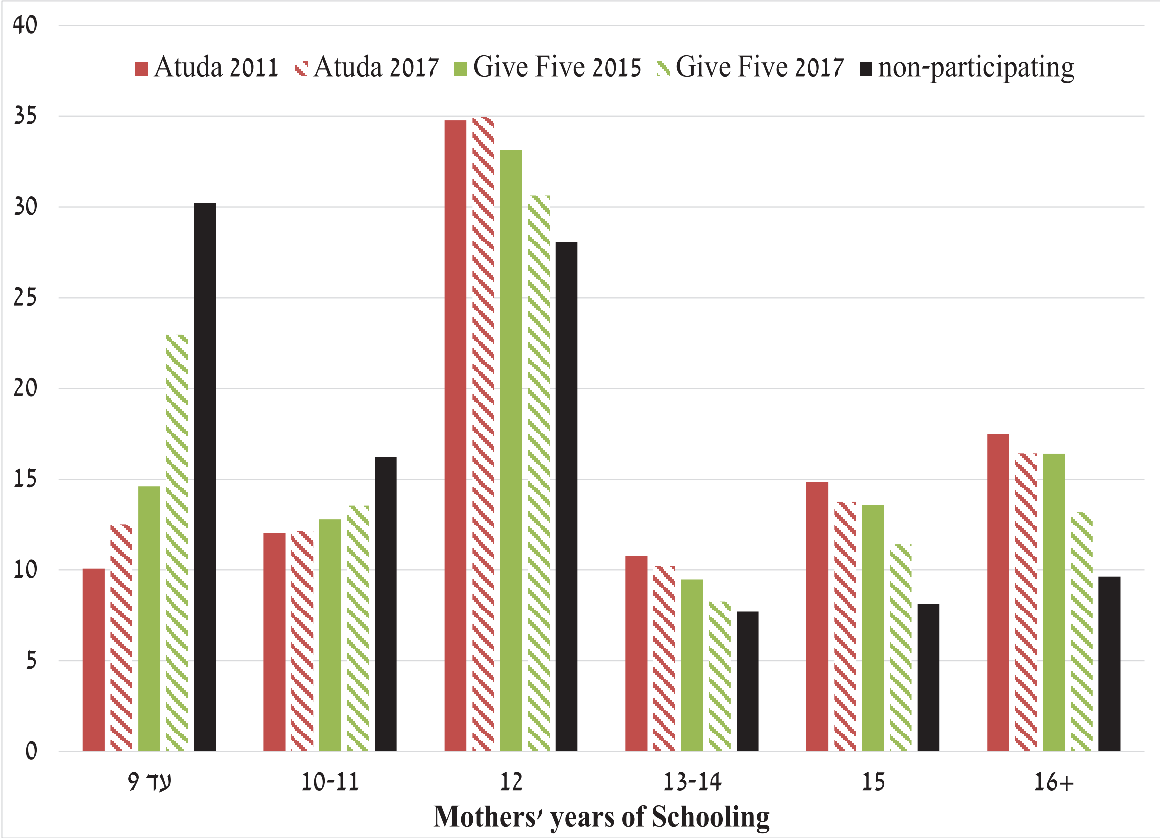


Source: Ministry of Education, Central Bureau of Statistics, data processing by authors .

(1) Students under the supervision of the MOE (excluding students in special education schools). Therefore, students in small yeshivas, vocational schools, and students in the Youth Ward Authority (the latter two are under the supervision of the Ministry of Labor, Social Affairs, and Social Services), and students in East Jerusalem who site for a summative high school exam in the territory of the Palestinian Authority or Jordan (the Tawjihi Exam).

(2) 5 units in mathematics, 5 units in physics/chemistry/biology, and an additional-5 units in physics/ chemistry/biology/computer science/electronics .

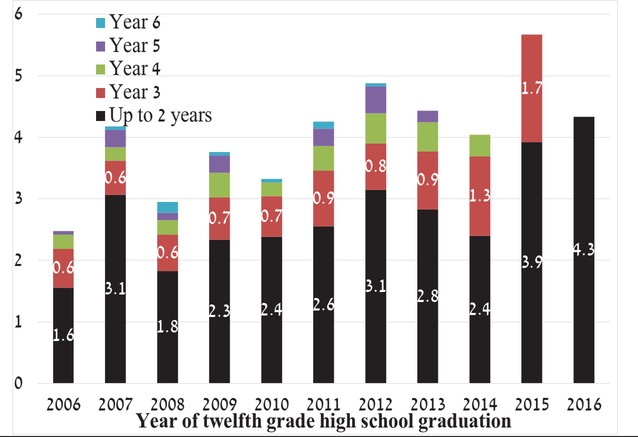
Figure A-2. Distribution of mothers' years of schooling in 2009 by year of school's participation in the program[1] (%)



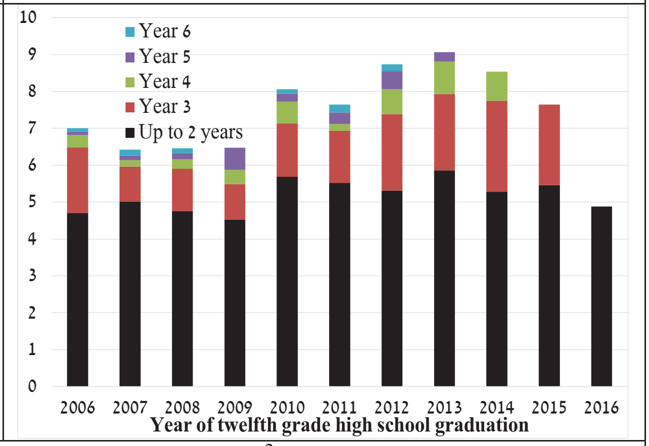
Source: Ministry of Education, Central Bureau of Statistics, data processing by authors.
(1) In the study population.

Figure A-3 .Starting of Arab[1] high school graduates an undergraduate programs in the sciences,[2] by program and years passed since high school graduation (%)

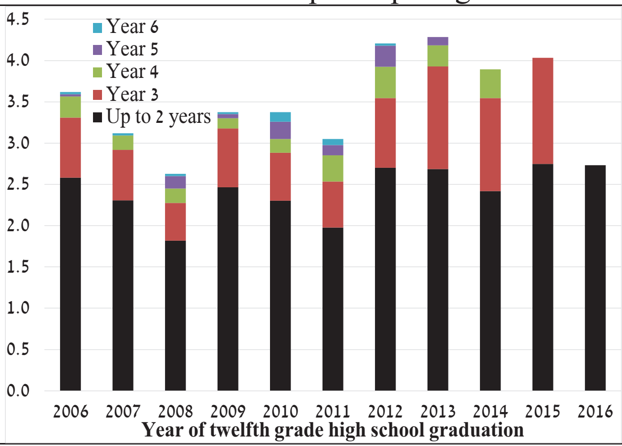
A. Graduates of Atuda schools[3]



B. Graduates of Give Five schools[3]



C. Graduates of non-participating schools[3]



Source: Ministry of Education, Central Bureau of Statistics, data processing by authors .

(1) Arab men and women (and Druze women).

(2) Mathematics, statistics, and computer science; physical sciences (including chemistry); biological and agricultural sciences; engineering.

(3) Schools in the study population .Atuda schools – only schools that operated the program continuously from 2011 (or the pilot in 2010) to end 2017; Give Five schools – only schools that operated the program continuously from 2015 to end 2017; Non-participating schools – schools that did not operate either program before end 2017.