Leading by Example in Science: Evidence from a Natural Experiment in High Schools *

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ABSTRACT

Talents in science are crucial for promoting innovations, technological breakthroughs, and economic growth. Early exposure to talented students in scientific subjects may have substantial spillover effects on their peers. Awards in scientific subjects is a way to publicly recognize outstanding performance in school, influencing subsequent outcomes of others by shaping their beliefs, interests, or behaviors. In this study, we explore whether the public recognition of students for scientific achievements affects their peers' test scores and university choices. We leverage unique data from the Hellenic Mathematical Society on award winners and merge them with administrative data on their peers' outcomes in school to study the causal effect of having a science award winner in one's environment. For identification, we exploit two strategies. First, we exploit variation across cohorts and within schools, comparing cohorts with an award winner to those without. Second, we exploit the quasi-random assignment of students to classrooms, comparing classrooms that were randomly assigned a science award winner with those that, by chance, were not. We find that the presence of a science award winner improves the future educational outcomes of male schoolmates and classmates, but not of females. These effects are economically meaningful: having a science award winner in the peer group enhances performance by 5% of a standard deviation in standardized exams and leads to a 4.7 percentage point increase in university enrollment. These effects are more pronounced in smaller groups in which winners are more salient and interactions are likely to be more intense.

JEL Codes: J24, J21, J16, I24
Keywords: science awards, spillover effects, random classroom assignment, STEM degrees

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1 Introduction

Recognizing academic excellence is an important part of education. Recognition often takes the form of prizes and awards, and much research has examined how the recognition affects the recognized individual's outcomes (Angrist and Lavy, 2009; Kremer, Miguel, and Thornton, 2009). However, the goal of recognizing an exemplary individual is not only to acknowledge their achievements but also to inspire and influence a wider audience. Despite this intention, recognition can sometimes lead to unintended consequences, such as feelings of shame or decreased motivation (Butera, Metcalfe, Morrison, and Taubinsky, 2022). This line of reasoning prompts our research question: Does recognizing an individual's accomplishments also affect the larger peer group that observes this success by shaping their beliefs, norms, and interests?

We examine the effects of exposure to students who receive public recognition for their scientific achievements in school and the spill-over effects on their peers' educational outcomes. We exploit quasi-experimental variation in exposure to these awarded students generated by two sources. First, we exploit within school and across-cohort variation in award winners, as the assignment of an award winner to a particular cohort can be considered random. Second, within a school-cohort, students are lexicographically assigned to classrooms based on their surnames, and thus, it is quasi-random if a student ends up in the same classroom as an award winner or in another. The public recognition that awarded students receive takes several forms, including public announcements from the teacher and principal. This recognition is likely to affect students in their peer groups who witness their success. These conditions provide a unique opportunity to evaluate the impacts of exposure to these talented students in scientific subjects in school on their peer's short and longer-term outcomes.

This paper is the first to present such a comprehensive analysis of spill-over effects to other students' outcomes in their class and school. In addition, our data allow us to highlight heterogeneous effects of those effects by gender and intensity of exposure. This is relevant, since in line with studies that show that males are more willing to enter competitive settings, the majority of award winners in our setting are boys (Buser and Yuan, 2019; Croson and Gneezy, 2009; Niederle and Vesterlund, 2010). Our quasi-experimental research design allows us to present causal evidence on the impact of the recognition of someone's accomplishments in science, providing important insights for policies aimed at targeting the gender gap in performance and enrollments in scientific fields. We use unique data on the award winners from the Hellenic Mathematical Society, which, to the best of our knowledge, have not been utilized before. We combine this dataset with student-level administrative datasets from the Ministry of Education to trace their peers' performance and choices in school and college. We examine outcomes from a wide range of administrative datasets linking high school performance and admission to tertiary education. Our baseline analysis focuses on students' performance in exams in high school, which are high-stakes and standardized. We also examine longer-term outcomes related to postsecondary admission and the quality of their enrolled university degree.

We find that male students exposed to male award winners in their school and class perform better in all short and longer-term outcomes relative to male students exposed to females award winners. In particular, boys randomly exposed to male winners increase their performance in the national exams by 4% of a standard deviation (SD). We also find that the probability of enrollment in a University degree program increases by 4.7 percentage points, relative to a 59.5% average. The results for females are very small and statistically insignificant. We also study whether our results vary by the size of the school cohort. Our intuition here is that ties and imitation tendencies among students might be larger in schools or classes of smaller size. Indeed, we find that the effects on boys are much larger in smaller peer groups, while for women there is not much of a difference. For instance, for boys the effect size is equal to 13% of a SD. improvement in their test scores in small schools, while it is much smaller and imprecise in large schools. The baseline effect that we find on boys' performance in standardized exams is meaningful, and non-negligible. The effects is of comparable magnitude to those in the literature on improving school inputs. For instance, our effect size is comparable to students being taught by a teacher between 1.5 and 2 SDs above the average (Hanushek, Kain, O'Brien, and Rivkin, 2005; Lavy and Megalokonomou, 2024a) or to reducing the class size by 20% (Angrist and Lavy, 1999).

We assess the robustness of these results by excluding some sub-groups that may render the identification assumption ambiguous. In particular, we exclude private schools that have a lot of autonomy and to some extend may operate in a different way than public schools. Then, we exclude schools that have no awarding students in any of the relevant years. The results from these extended models and samples show clearly that our effects remain very robust to those sample adjustments. Our results hold against this rich set of additional robustness checks that address some possible confounders.

Our paper contributes to several strands of the literature. There is a very large literature on peer effects in education, see Epple and Romano (2011) and Sacerdote (2011, 2014) for excellent overviews. Within this large literature, a subset of studies how focused on the impact of high-achieving students on the educational outcomes and choices of their peers: (Balestra, Sallin, and Wolter, 2023; Cools, Fernández, and Patacchini, 2022; Feld and Zölitz, 2022; Fischer, 2017; Lavy, Silva, and Weinhardt, 2012; Modena, Rettore, and Tanzi, 2022; Mouganie and Wang, 2020). We contribute to this literature by examining the influence of a particular group of high-achieving peers who have received public recognition for their excellence in a science competition.

Our paper also connects to the literature on role models in education. Most of the studies focus on teachers as role models.[1] However, to the best of our knowledge, little is known about the causal effect of peer role models on the education outcomes of peers. Only a recent paper examines the causal effect of peer role models and focuses on top performers across all subjects who receive the recognition of being in charge of the class attendance book (Goulas,

[1] For a recent survey see de Gendre, Feld, Salamanca, and Zölitz (2023).

Gunawardena, and Megalokonomou, 2024). In this paper, we focus on winners of a national mathematical competition, which is male dominated.

Our paper also contributes to the literature that examines the gender gaps in STEM (Buffington, Cerf, Jones, and Weinberg, 2016; Cimpian, Kim, and McDermott, 2020; Goulas, Griselda, and Megalokonomou, 2022; Lavy and Megalokonomou, 2024b; Lavy and Sand, 2018). Despite the recent increase in girls' mathematics advancements in school, there exists a persistent gender gap in students' propensity to choose a STEM field of study. In our data, girls outperform boys in test scores in school. Nevertheless, we observe fewer girls earning an award in the mathematical competition. Our analysis highlights that the woman under representation, also has important downstream implications for other students, as male winners spur other boys to perform better in the national exam, thereby contributing to the STEM gender gap.

2 Institutional Setting

The national mathematical competition is the largest national annual competition that targets all schools in Greece. It is organized by the Hellenic Mathematical Society and takes place once a year. The competition is conducted in 3 stages and the Society's objective is to examine and advance overall mathematical thinking in the student population. The Hellenic Mathematical Society organizes the national competition in three annual national student competitions: Thales, Euclides, Archimedes. The competitions are sequential and are held in three rounds in October, January and February. Only the top performers in the Thales competition can participate in the Euclides competition and only the top performers in the Euclides competition can participate in the Archimedes competition. Each year after the top performers of the Archimedes competition are announced, the Hellenic Mathematical Society selects the team members that form the national team that represents Greece in the Balkans and the International Mathematical Olympiad.

Teachers promote the competition in the class during lessons, so that all students receive the related information. The principals also advertise the competitions during school events. Participating students in the different regions of Greece take the same exams on the same days. The duration of the exam is 3 hours. Two graders are assigned to each examination sheet. The Hellenic Mathematical Society selects the examiners for all competitions and decides on the examinable topics. A student's final grade is the average score submitted by the two independent examiners. Students are compared with each other across all regions in Greece and the best performing students in the country proceed to the next competition. Students participate in the Balkan, European, or International math competitions, and as a form of appreciation for their advanced skills and talent in mathematics, gain automatically admission to university departments without taking a national exam in mathematics (while everyone else does).

Teachers and classmates are highly likely to know who the award winners are. Teachers and principals publicly congratulate the award winners and the school usually advertises this

achievement on their website. Interested individuals can also check the Hellenic Mathematical Society website as well as learn about the award winner in school. Schools usually also share this information on their announcement board at the entrance of the school. Classrooms usually consist of around 25 students and the average number of classrooms is 3 per school. Students in a given classroom take all core educational subjects together. Classmates in the core education classes remain together for several years until the end of senior high school.

3 Data

We combine several data sources to construct the sample of award winners and their peers. The Hellenic Mathematical Society publicly announces the winners of the mathematical national competition every year and maintains an online archive. We tracked down the archives and constructed lists with the following information on the winners: first name, surname, grade and year in which they participate in the competition, school they attend and the district to which the school belongs. The district indicates which local school authority is in charge of the school the winner attends. From students' first names we deduce their gender. The data ranges from 2008 to 2011. In Appendix Table A.1 we show a list of award winners for grade 12 for the year 2010-2011. Table 1 displays the number of final year science award winners by gender and graduation year for grade 12. There are a total of 635 winners, of which 483 (76.1%) are boys. We do not have information on the total number of students (and their gender) entering the competition.

Table 1: Science Award Winners

Graduation Year	Girl Winners	Boy Winners	Total Winners
2009	32	125	157
2010	50	181	231
2011	70	177	247
Total	152	483	635

We also use student-level administrative data obtained from the Ministry of Education with test scores on students' performance in national examinations that all high school students take in twelfth grade (Bizopoulou, Megalokonomou, and Simion, 2022; Dinerstein, Megalokonomou, and Yannelis, 2022). Our data span the universe of students taking the university entry exam in 2008-2011 and include each student's exam score and high school attended. Performance in these exams is the most important determinant for university admission. The exams are externally graded and are blind, i.e., the name of the student is hidden (Lavy and Megalokonomou, 2024b). We convert the test scores to student standard deviation units by normalizing scores to have mean zero and standard deviation one in each year. This dataset also included information about students' postsecondary choices and outcomes. In particular,

we have information of students' enrolled degree (university and department) in tertiary education.[2] Each student receives an offer from a unique degree and thus, the majority of students accept this offer and enroll to their offered postsecondary degree.

Tables 2 and 3 provide some basic summary statistics about the student population and the award winners. Overall, our school sample includes 188,997 students, 56% of which are girls. The average age in graduation from high school is 18, and the average number of students in each school/cohort (we refer to it as school-cohort size) is 75.4. Note that there is considerable variation in school-cohort size, which we are going to exploit in our heterogeneity analysis. The raw test score varies from 0 to 20 and is increasing in student performance. The average test score is 13.2, while 63.3% of students earn admission to an academic university program.

Table 2: Number of Students by Cohort, Population of Students

Graduation Year	Freq.	Percent	Cum.
2009	49,733	26.31	26.31
2010	70,320	37.21	63.52
2011	68,944	36.48	100.00
Total	188,997	100.00	

Table 3: Summary Statistics about Award Winners

Variable	Mean	Std. dev.	Min	Max
Girl (1=yes)	0.561	0.495	0	1
Age (in years)	18.04	0.25	17	23
School-cohort Size	75.4	37.3	1	202
Test score	13.2	4.3	0.37	19.96
Admission to University (1=yes)	0.634	0.478	0	1

We are planning on using data from a smaller sample of schools in which there is a math competition award winner and exploit a unique institutional feature to obtain identification. In particular, students in Greece are lexicographically assigned to classrooms based on their surnames. This assignment occurs in grade 10 and students remain in the same group of peers throughout senior high school (grades 10-12). This dataset includes student-level data on test scores in every subject and exam they take during senior high school as well as information about all educational choices students make (such as choice of STEM or Classics track in grades 11 and 12). The idea is that it quasi-random if a student ends up in the classroom of the award winner or not. This dataset and identification will allow us not only to examine the short and longer term effects of math competition award winners on the performance and choices of their peers and complement the existing analysis.

[2]Each university department offers a unique degree.

4 Empirical Strategy

Our goal is to estimate the effect of a high-school math competition winner on the performance of students in the same school, measured using a variety of outcomes, including national exams scores in various subjects and whether a student secures admission to University.

We estimate specifications of the form:

$$Y_{i,s,t} = \theta_s + \theta_t + \beta D_{s,t} + \gamma X_{i,s,t} + \epsilon_{i,s,t}, \tag{1}$$

where $Y_{i,s,t}$ is the outcome of student i in school s and year $_t$. θ_s and θ_t are school and year (cohort) fixed effects, respectively. $D_{s,t}$ is an indicator variable that takes the value of 1 if the school s was treated in year t. A school is treated if a final year student attending the school wins a mathematical competition. $X_{i,s,t}$ is a vector of student characteristics. We cluster the standard errors at the school level.

In a variation of equation 1, we estimate a differential effect of the treatment on the basis of whether the award winner was a boy or a girl:

$$Y_{i,s,t} = \theta_s + \theta_t + \beta_b D^b_{s,t} + \beta_g D^g_{s,t} + \gamma X_{i,s,t} + \epsilon_{i,s,t}, \tag{2}$$

where $D^b_{s,t}$ is an indicator variable for whether there was a boy winner in school s at time t, and $D^g_{s,t}$ is an indicator for a girl winner. This specification allows us to differentiate between the influence of boy high-achievers and girl high-achievers. In our baseline results, we will run separate regressions for boys and girls.

We examine whether cohort-to-cohort changes in male and female outcomes within the same school-cohort are systematically associated with having an award winner in the school in that year. The basic idea is to compare the outcomes of students from adjacent cohorts who have similar characteristics and face the same school environment, except for the fact that one cohort had a competition award winner to purely random factors

Using repeated cross-sectional data, we will estimate the above reduced-form equation separately for boys and girls. Note that we have a panel of schools and repeated cross-sections of year 12 students, as for the same school we observe the outcomes of different cohorts of students who are in their final year of high-school. For each specific student we only observe their outcomes once. Therefore, we rely on within-school across cohort variation for identification: we compare outcomes of students who had a winner in their cohort to students in the same school who did not have a winner in their cohort. The main threat for identification are time varying confounders that operate at the school level and might influence both the probability of a school having a winner in the math competition and the educational performance of the other students in the school.

Table 4: Impact of Award Winners on Peers' Test Scores in University Entry Exams

	Outcome: Standardized Exam Score					
	All		Boys		Girls	
	(1)	(2)	(3)	(4)	(5)	(6)
Winner	0.017		0.038**		-0.001	
	(0.011)		(0.016)		(0.013)	
Boy Winner		0.020*		0.047***		-0.004
		(0.011)		(0.017)		(0.013)
Girl Winner		0.009		0.004		0.013
		(0.017)		(0.023)		(0.020)
Observations	188,996	188,996	82,932	82,932	106,054	106,054
R^2	0.125	0.125	0.135	0.135	0.121	0.121

Notes: This table presents estimation results from different regressions. Each column corresponds to a different regression. The outcome is standardized and have a mean of zero and a standard deviation of one. In all regressions, we control for school fixed effects, year fixed effects, age (in years), and a binary indicator that takes the value 1 if the student is born in the first quarter of the calendar year. Standard errors are clustered at the school level.

5 Results

Baseline results We begin by presenting baseline estimates on the performance of students in grade 12 national university entry exams obtained from estimating equations 1 and 2 in Table 4. We show the estimated effects for the entire sample in columns 1-2, only for boys in columns 3-4, and only for girls in columns 5-6. In column 1, we observe that the effect of a winner is positive (0.017 SD), but small, and not statistically significant. When we differentiate by the gender of the winner (column 2), we find that boy winners have a stronger effect (0.020 SD) than girl winners (0.009 SD), with only the former being statistically significant at 10%.

We next consider whether there are gender differences in these effects, examining whether boys or girls might be more susceptible to the influence of winners. Results presented in columns 3-6, indicate that this is indeed the case. We find that for boys there is a positive and larger than that of girls effect of a winner (0.038 SD versus -0.01), with the effect on boys being statistically significant at 5%. When we examine the impact of a winner by their gender, we find that for boys the effect of a boy winner is large (0.047 SD) and statistically significant at 1%, while that of a girl winner is essentially zero. For girls, on the other hand, we find that a boy winner has a zero effect, while a girl has a small positive effect (0.013 SD) that is not statistically significant. Overall, the pattern that emerges from these findings, is that there is a significant impact of boy winners on the scores of their same-gender classmates. Girls, on the other hand, do not appear to be affected by the presence of a winner in their year in school.

Table 5: Impact of Award Winners on Peers' Likelihood to Enroll to Academic University

	Outcome: Binary Indicator for Enrolling to Academic University					
	All		Boys		Girls	
Winner	0.008		0.015**		0.001	
	(0.005)		(0.008)		(0.006)	
Boy Winner		0.009*		0.018**		0.001
		(0.005)		(0.006)		(0.008)
Girl Winner		0.003		-0.002		0.006
		(0.007)		(0.010)		(0.011)
Observations	158,585	158,585	70,626	70,626	87,944	87,944
R^2	0.061	0.061	0.078	0.078	0.058	0.058

Notes: This table presents estimation results from different regressions. Each column corresponds to a different regression. In all regressions, we control for school fixed effects, year fixed effects, age (in years), and a binary indicator that takes the value 1 if the student is born in the first quarter of the calendar year. Standard errors are clustered at the school level.

University Admission We then examine the impact of having a math competition award winner in one's school-cohort on the likelihood of peers' enrolling to some academic university. Students enroll into vocational institutions otherwise. The estimated reuslts are shown in Table 5. Each degree program has a set number of positions, and admission is decided on the basis of the student's test scores and students' list of preferred programs. As we saw earlier in Table 3, about 63% of students achieve this outcome. The evidence here is consistent with what we obtained above for test scores: for boys, having a boy winner in one's cohort leads to an increase of 4.7 percentage points in the likelihood of entering an academic university program, whereas for girls we find no statistically significant effects.

Intensity Note that in our analysis so far, we have considered the causal effect of having a winner classmate. In practice, there is some variation in the number of winning classmates that a student experiences. That is, 82% of students do not experience a winner, 11.5% experience exactly one winner, and 6.5% experience multiple winners (up to 6). We next examine whether the data reveal any intensity of treatment, that is, effects vary by the number of winners in one's school-cohort. We thus estimate a specification in which we differentiate the impact of being exposed to a unique winner from being exposed to multiple winners. These results are presented in Table 6.

We find that effects are stronger when there are multiple winners, and this is true for the entire sample and for boy winners (columns 1 and 3). When we consider the effect on boys in column 4, this pattern emerges again: one winner has a smaller effect (0.024 SD) than multiple winners (0.070 SD). These effects seem to be driven by boy winners, where the effect of multiple winners is more than double that of a single winner (0.082 versus 0.034 SD). For girls, none of

Table 6: Intensity Effects: Impact of Multiple Award Winners on Peers' Test Scores

	Outcome: Standardized Exam Score					
	All		Boys		Girls	
	(1)	(2)	(3)	(4)	(5)	(6)
One Winner	0.011		0.024		0.007	
	(0.013)		(0.018)		(0.015)	
Multiple Winners	0.033**		0.070***		0.005	
	(0.016)		(0.022)		(0.020)	
One Boy Winner		0.011		0.034*		-0.008
		(0.013)		(0.019)		(0.014)
Multiple Boy Winners		0.044**		0.082***		0.008
		(0.017)		(0.026)		(0.021)
One Girl Winner		0.005		-0.004		0.012
		(0.018)		(0.025)		(0.022)
Multiple Girls Winners		0.008		0.013		0.006
		(0.043)		(0.061)		(0.044)
Observations	188996	188996	82932	82932	106054	106054
R^2	0.125	0.125	0.135	0.135	0.120	0.121

Notes: This table presents estimation results from different regressions. Each column corresponds to a different regression. In all regressions, we control for school fixed effects, year fixed effects, age (in years), and a binary indicator that takes the value 1 if the student is born in the first quarter of the calendar year. Standard errors are clustered at the school level.

the effects are statistically significant. This is a consistent finding across tables and specifications; girls are not affected by having a math competition winner in their school cohort.

School-Cohort Size Heterogeneity We next turn attention to whether the estimated results in the overall sample might mask significant heterogeneity by school-cohort size. The idea we explore is that the impact of a winner might be stronger in smaller schools, because in these schools winners are more likely to be salient and interactions between winners and their peers are likely to be more intense. Table 7 presents these results where we split the sample by the median school-cohort size (the median cutoff is 71).

Starting with the case of boys, we see that in small schools estimated effects are substantially larger than in small schools. Specifically, we find that the impact of a winner of any gender is 0.076 SD ($p < 0.05$). Interestingly, the gender of the winner has quite different effects. A boy winner increases the scores of their same gender classmates by 0.134 SD, an effect that is statistically significant at 1%. On the other hand, a girl winner, seems to have a negative effect, which is however not statistically significant. For girls, the school cohort heterogeneity analysis also reveals some interesting patterns. In small schools, we find a positive, yet not statistically significant effect (0.026 SD). The effect is also stronger when the winner is a girl (0.050 SD) than a boy (0.021 SD), although neither of these coefficients are statistically significant.

Table 7: Heterogeneity Effects by School-Cohort Size

	Standardized Exam Score							
	Boys				Girls			
	Small schools		Large Schools		Small schools		Large Schools	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Winner	0.060***		0.023		0.019		-0.011	
	(0.020)		(0.017)		(0.018)		(0.013)	
Boy Winner		0.099***		0.023		0.029		
		(0.021)		(0.017)		(0.019)		
Girl Winner		-0.048		0.021		0.016		
		(0.029)		(0.025)		(0.029)		
Observations	27764	27764	28297	28297	35276	35276	34317	
R^2	0.169	0.169	0.155	0.155	0.133	0.133	0.115	

Notes: This table presents estimation results from different regressions for boys and girls in schools of different cohort-size. Small schools have a school-cohort size smaller than 71, and large schools have a school-cohort size larger than 71. Each column corresponds to a different regression. In all regressions, we control for school fixed effects, year fixed effects, age (in years), and a binary indicator that takes the value 1 if the student is born in the first quarter of the calendar year. Standard errors are clustered at the school level.

Robustness To explore the robustness of our results, we perform two additional analyses. First, we exclude from the sample students in private and experimental schools, as the students that are admitted to these schools might be different. Second, we exclude schools from the sample that did not have a winner in the years that span our sample (2009-11). Comparing results in Table 8 to those in Panel B of Table 4 indicates that for boys the impact of a same-gender winner is slightly smaller in these sub-samples but clearly robust. For girls, comparison of Table 9 to those in Panel C of Table 4 also indicates that the estimated coefficients of interest are very similar in sign, magnitude, and statistical significance. These findings provide reassurance as to the robustness of our main results.

Table 8: Robustness of Baseline Results for Boys

	Exam score			
	Excluding private schools		Excluding no-awards schools	
Winner	0.030*		0.035**	
	(0.017)		(0.016)	
Boy Winner		0.042**		0.045***
		(0.018)		(0.017)
Girl Winner		-0.013		0.001
		(0.027)		(0.023)
Observations	74324	74324	56084	56084
R^2	0.112	0.112	0.099	0.099

Table 9: Robustness of Baseline Results for Girls

	Exam score			
	Excluding Private schools		Excluding no-Awards Schools	
Winner	-0.006		-0.002	
	(0.014)		(0.013)	
Boy Winner		-0.006		-0.005
		(0.014)		(0.013)
Girl Winner		-0.001		0.011
		(0.023)		(0.020)
Observations	96613	96613	69626	69626
R^2	0.104	0.104	0.089	0.089

6 Conceptual Framework

To understand our results, let us develop a simple network model. We assume that two students i and j in the same classroom are directly connected by a network $\mathbf{g}$ if and only if $g_{ij} = 1$; otherwise, $g_{ij} = 0$. The degree or the number of direct neighbors of individual i is defined by $d_i := \sum_{j=1}^{n} g_{ij}$. Finally, we define $\widetilde{g}_{ij} := g_{ij}/d_i$ if $d_i > 0$ and $\widetilde{g}_{ij} := 0$ otherwise.

Following Boucher, Rendall, Ushchev, and Zenou (2024), define $\mathbf{y}_{-i} := (y_1, \ldots, y_{i-1}, y_{i+1}, \ldots, y_n)^T$ the vector of study effort or outcome in GPA without the effort of agent i. The utility function for each student i is given by:

$$U_i(y_i, \mathbf{y}_{-i}, \mathbf{g}) = \alpha_i y_i - \frac{1}{2} y_i^2 + \lambda y_i \widetilde{y}_{-i}(\beta), \tag{3}$$

where $\alpha_i = \mathbf{x}_i \boldsymbol{\gamma} + \epsilon_i$ is a vector of individual characteristics that includes both the observable $(\mathbf{x}_i)$[3] and unobservable (ϵ_i) characteristics of individual i, λ is the peer-effect propagation rate (common for all individuals in the group) and $\widetilde{y}_{-i}(\beta)$ is the social norm defined by

$$\widetilde{y}_{-i}(\beta) = \left(\sum_{j=1}^{n} \widetilde{g}_{ij} y_j^{\beta} \right)^{\frac{1}{\beta}}. \tag{4}$$

First, observe that the social norm defined in the linear-in-means (LIM) model is a special case of (4) when $\beta = 1$, that is, students only care about the average outcome of their peers; formally, $\overline{y}_{-i} \equiv \widetilde{y}_{-i}(1) = \sum_{j=1}^{n} \widetilde{g}_{ij} y_j$. Our social norm is general, since (4) allows for any β, that is, $\beta \in [-\infty, +\infty]$. It is easily shown that

$$\lim_{\beta \to +\infty} \widetilde{y}_{-i}(\beta) = \max_{j \in \mathcal{N}_i} \{y_j\},$$

[3] $\mathbf{x}_i$ is a $(1 \times k)$ vector of k observable characteristics, and $\boldsymbol{\gamma}$ is a $(k \times 1)$ vector, so that $\mathbf{x}_i \boldsymbol{\gamma} = \sum_{l=1}^{k} x_l \gamma_l$.

that is, the social norm is defined with respect to the *most studious* students in the network. Under $\beta = -\infty$, (4) becomes

$$\lim_{\beta \to -\infty} \widetilde{y}_{-i}(\beta) = \min_{j \in \mathcal{N}_i} \{y_j\},$$

that is, the social norm is defined with respect to the *least studious* students.

The first-order condition with respect to y_i is equal to

$$y_i = \mathbf{x}_i \boldsymbol{\gamma} + \lambda \widetilde{y}_{-i}(\beta) + \epsilon_i. \tag{5}$$

What we showed in Section 5 is that, for boys, λ is positive and significant when the social norm is equal to $\max_{j \in \mathcal{N}_i} \{y_j\}$, that is, when β is very large, while, for girls, there is no significant effect of this social norm.

We plan to test further this model and to see which type of social norm matters for girls; in particular, if it is not the the max maybe it could be that girls are more influenced by the average test scores of girls in the classroom.

7 Mechanisms

We are currently in the process of designing a survey to investigate what are the channels though which boys react positively to science award winners and girls are not. Our initial hypothesis is that the dominant channels for boys are a desire to catch up with the winners (competition channel) or the transmission of information from the award winners (information channel).

8 Conclusion

In this study, we estimate the spillover effect of having a science award winner in one's class on performance in a high-stake exam that determines access to higher education. For causal identification, we rely on within schools and across cohorts variations in the presence of science award winners. We find significant gender differences in the spillover effects. The presence of a same-gender science award winner improves the future educational outcomes of males but not those of females. Effects are economically meaningful—having a winner in the peer group improves performance by 5% of a standard deviation in standardized exams—and have long-term implications: enrollment to University degrees of peers of science award winners increase by 4.7 percentage points. Effects are stronger in smaller groups in which winners are more salient and interactions are likely to be more intense. These findings suggest that male award winners act as a significant motivating factor for their male peers.

9 New Tables

Table 10: Impact of Award Winners on Peers' Test Scores in University Entry Exams

	Outcome: Standardized Exam Score					
	All		Boys		Girls	
	(1)	(2)	(3)	(4)	(5)	(6)
	Exam score	Exam score	Exam score	Exam score	Exam score	Exam score
Winner	0.015		0.035**		-0.002	
	(0.011)		(0.016)		(0.013)	
Boy Winner		0.018		0.044***		-0.005
		(0.011)		(0.017)		(0.013)
Girl Winner		0.007		0.001		0.011
		(0.017)		(0.023)		(0.020)
Observations	125654	125654	56061	56061	69593	69593
R^2	0.092	0.092	0.098	0.098	0.089	0.089

Table 11: Impact of Award Winners on Peers' Likelihood to Enroll to University

	Outcome: Indicator for Enrolling to University					
	All		Boys		Girls	
	(1)	(2)	(3)	(4)	(5)	(6)
Winner	0.007		0.015*		0.000	
	(0.005)		(0.008)		(0.006)	
Boy Winner		0.009*		0.017**		0.001
		(0.005)		(0.008)		(0.006)
Girl Winner		0.001		-0.003		0.004
		(0.007)		(0.011)		(0.010)
Observations	108084	108084	48896	48896	59187	59187
R^2	0.055	0.055	0.068	0.068	0.052	0.052

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Appendix

A Figures and Tables

Figure A.1: Example of a List of Science Award Winners



Σύνδεσμοι | Επικοινωνία

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ

Βάση ασκήσεων | Ψηφιακή βιβλιοθήκη

Αρχική | Νέα | Διαγωνισμοί | Συνέδρια | Κατασκηνώσεις | Εκδόσεις | i JME | Bulletin

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  - Θέματα & Λύσεις
  - Επιτυχόντες
    - Β' Γυμ.
    - Γ' Γυμ.
    - Α' Λυκ.
    - Β' Λυκ.
    - **Γ' Λυκ.**
- Ευκλείδης
  - Θέματα & Λύσεις
  - Επιτυχόντες
    - Β' Γυμ.
    - Γ' Γυμ.
    - Α' Λυκ.
    - Β' Λυκ.
    - Γ' Λυκ.
- Αρχιμήδης
  - Θέματα & Λύσεις
- Μικρός Ευκλείδης
  - Θέματα & Λύσεις
- Διεθνείς Ολυμπιάδες

Γ' Λυκείου 2010-2011

ΕΠΩΝΥΜΟ	ΟΝΟΜΑ	ΣΧΟΛΕΙΟ	ΝΟΜΟΣ
ΑΘΑΝΑΣΙΑΔΗΣ	ΙΩΑΝΝΗΣ	4ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΒΕΡΟΙΑΣ	ΗΜΑΘΙΑΣ
ΑΘΑΝΑΣΙΟΥ	ΓΕΩΡΓΙΟΣ	ΕΝΙΑΙΟ ΠΕΙΡΑΜΑΤΙΚΟ ΛΥΚΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟΥ ΠΑΤΡΩΝ	ΑΧΑΙΑΣ
ΑΘΑΝΑΣΙΟΥ	ΑΠΟΣΤΟΛΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΗΛΙΟΥΠΟΛΗΣ	Α' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΝΑΣΤΑΣΙΑΔΗΣ	ΧΑΡΑΛΑΜΠΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΗΡΑΚΛΕΙΟΥ	ΗΡΑΚΛΕΙΟΥ
ΑΝΤΟΥΛΙΝΑΚΗΣ	ΦΟΙΒΟΣ	1ο ΑΡΣΑΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΞΙΩΤΗΣ	ΚΥΡΙΑΚΟΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΓΕΡΑΚΑ	ΑΝΑΤΟΛΙΚΗΣ ΑΤΤΙΚΗΣ
ΑΠΟΣΤΟΛΕΡΗΣ	ΔΗΜΗΤΡΗΣ	ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΡΒΑΝΙΤΑΚΗΣ	ΣΤΑΥΡΟΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΦΛΩΡΙΝΑΣ	ΦΛΩΡΙΝΑΣ
ΑΡΦΑΡΑΣ-ΜΕΛΑΪΝΗΣ	ΑΓΓΕΛΟΣ	2ο ΑΡΣΑΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΣΗΜΑΚΟΠΟΥΛΟΥ	ΣΤΑΥΡΟΥΛΑ	-	ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ
ΑΣΤΕΡΗ	ΕΙΡΗΝΗ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΝΑΟΥΣΑΣ	ΗΜΑΘΙΑΣ
ΒΑΛΕΤΑ	ΜΑΡΙΝΑ	ΕΛΛΗΝΟΓΑΛΛΙΚΗ ΣΧΟΛΗ ΚΑΛΑΜΑΡΙ	Α' ΘΕΣΣΑΛΟΝΙΚΗΣ
ΒΑΛΛΙΟΥ	ΜΑΡΙΑ	3ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΘΗΒΑΣ	ΒΟΙΩΤΙΑΣ
ΒΑΡΒΕΛΗΣ	ΒΑΓΓΕΛΗΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΕΥΟΣΜΟΥ ΘΕΣΣΑΛΟΝΙΚΗΣ	Β' ΘΕΣΣΑΛΟΝΙΚΗΣ
ΒΑΡΔΑΚΑΣ	ΝΙΚΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΤΡΙΚΑΛΩΝ	ΤΡΙΚΑΛΩΝ
ΒΑΣΔΕΚΗΣ	ΓΕΩΡΓΙΟΣ	ΛΕΟΝΤΕΙΟ ΛΥΚΕΙΟ	Α' ΑΘΗΝΑΣ ΑΤΤΙΚΗ

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Νέος πρωτότυπος διαγωνισμός

100 χρόνια ΕΜΕ

100 χρόνια ΕΜΕ, 2018 έτος Μαθηματικών

SCGM-2022

Notes: This list shows how the science award winners for a specific competition (Thalis), grade (12) and year (2010-2011) appear on the website of the Hellenic Mathematical Society. First names of winners appears in the first column, surnames of winners appears in the second column, the name of the high school winners attended appears in the third column, and the district in which the high school is located in reported in the forth column. The district also indicates with local school authority is each winner assigned.