Hard Problems: Young Math Talents in the U.S. and Their Choices of Higher Education

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November 2, 2025

Abstract Mathematics competitions like the USA Mathematical Olympiad (USAMO) and the William Lowell Putnam Mathematical Competition (Putnam) are seen as early-stage talent selections, providing winners access to prestigious institutions and career advantages. However, their long-term impact on academic trajectories remains unclear. This study examines whether such competitions effectively predict future academic decisions and how receiving different levels of honors varies in these effects. Using a self-built dataset of USAMO and Putnam awardees from 1985 to 2010, collected through both manual research and automated matching, we are able to analyze their higher education and career paths. Nearly half of the USAMO awardees obtained a Ph.D. in mathematics-related STEM fields such as Pure Math, Applied Math, Physics, Computer Science, and Economics, compared to 58.49% of the Putnam awardees. Besides, 42.86% of the USAMO awardees' current profession positions are professors in colleges, and 20.31% of the Putnam awardees have won at least once NSF research funding, which recognizes their academic performances, relatively. Furthermore, USAMO gold medalists were significantly more likely than Honorable Mention recipients to pursue higher degrees in these fields and remain in academia. While the pattern remains in Putnam awardees, that of the relative rankings within colleges is ambiguous. These results contribute to discussions on talent screening through competitive challenges, suggesting that while high-level mathematics competitions identify strong academic candidates, psychological factors and institutional influences shape long-term career outcomes.

Decades later, after he had acquired a worldwide reputation in pure mathematics and had won a Nobel Prize in economics, Nash hinted in his Nobel autobiography that the Putnam still rankled and implied that the failure played a pivotal role in his graduate career. Today, Nash still tends to identify mathematicians by saying, "Oh, So and So, he won the Putnam three times."

—-Sylvia Nasar, 'A Beautiful Mind'

1 Introduction

Math competitions among the youth are regarded as a selection of talents in the early stage, which makes use of challenging mathematics questions to check whether the participants could deeply master the advanced knowledge. The awardees of these competitions are usually seen as students with beyond-the-average ability to work on hard problems and given chances to more abundant research resources. For example, the students ranking among the top in The USA Mathematical Olympiad (USAMO for short below) will be very likely to be admitted to prestigious institutions like Harvard University (Harvard for short), Massachusetts Institute of Technology (MIT for short below), Princeton University (Princeton for short below), etc. Many awardees of The William Lowell Putnam Mathematical Competition (Putnam for short below) list their honors on CVs/Resumes, which also shows that the awards serve to be a persuasive proof of their ability.

Could these math competitions effectively serve to select real young talents? And how does the experience of receiving such honors affect their choices of career paths, especially the academic paths given their ability and education background? The questions are yet to be answered. In common sense, students who show their talents in high school or undergraduate will be given much attention and are encouraged to pursue higher degrees as well as create breakthroughs in science. The taste of early success could also build their self-belief in their academic capacity.

However, on the other hand, the nationwide math competitions also shape the participants' beliefs by making some of them realize they are no longer the most talented one. Many students chose to participate the competitions with confidence of their ability compared with their classmates, while not everyone of them would receive a satisfied result. For the students who got listed as Honorable Mention (HM for short) in USAMO, despite of having a chance to study mathematics at Harvard or MIT just as those gold medal winners, will they be less confident

in being mathematicians? And for a student of Swarthmore College who ranked 25th place in Putnam, yet still the best performer in her or his college, will s/he be more confident than the former ones?

In this project, we manage to collect the education details after high school of the awardees in USAMO and Putnam between 1985 and 2010 to answer the above questions. By both manual collection and automatic matching, we build a dataset containing the awardees' choices of academic paths, such as whether having a doctorate degree, and if so, the fields of the degree.

We find that there exists an obvious gap between USAMO's gold medal and HM winners in their choices of major in undergraduate, graduate degrees, mathematics-related majors, and whether to stay in the academia after obtaining a Ph.D. degree. Nearly half of these high school awardees chose to pursue a doctorate degree in STEM fields, yet that of Putnam only results in around 26%.

The paper relates to three strands of literature. First, it adds to a series of discussions on the screening of talents through specially-designed challenges (Agarwal and Gaule, 2020; Agarwal et al., 2023) and guarantee them enough attention for success in academia (Borjas and Doran, 2015). Previous papers are focusing on worldwide award winners in the International Mathematical Olympiad (IMO for short below), which guarantees them to include the affect of social and economics background into consideration. Even though the economics status would restrict them, the young talents who proved their ability in IMO still performed a higher inclination to be successful both in scientific research and innovation development. Following the project on the awardees of the International Olympiad (Agarwal et al., 2024), the paper focuses on the math talents in the stage of high school and undergraduate in the U.S. (and Canada). These competitions are designed beyond the average difficulty in math education in high school or college students, which guarantees us to confidently conclude that the participants, especially the awardees, are among the most talented young people in math.The data collected in this paper generate similar conclusions that these young talents distinguished themselves in the competitions would show a stronger inclination to higher education and academia than the average.

Second, the paper also contributes to papers related to factors that matter in pushing knowledge frontiers forward and motivating scientists. There have been many important things shap-

ing the development of innovation, such as immigration and high mobility of scientists, collaboration among researchers, role of superstars, the direction of fundings and support, etc (Borjas and Doran, 2012; Azoulay et al., 2011; Azoulay et al., 2019). While from the perspective of knowledge production, it requires abundant smart minds to generate new ideas and dedicate to scientific research for breakthroughs. In this way, this paper suggests that nationwide competitions could be effective to screen talents in their early stage of study and make sure they are provided with enough support.

Third, the property of Putnam also allows us to check the effect of peer spillover effect and self-belief on choices of higher education among undergraduates. (Non)monetary awards could let the winners enjoy psychological self interests compared with their peers. The experience of being recognized as "standing out" of the others could help the winners build confidence and increase their probability of success in study and work performances (Bradler et al., 2016; Sequeira et al., 2016). This also refers to the "big fish in a little pond" effect (BFLPE for short), first introduced and developed by psychologists (Marsh, 1987), that high achievers in a low-ability environment tend to perform higher academic self-concept and henceforth invest more in human capital (Elsner and Isphording, 2017). In other words, the ordinal rank of academic performances of students matter in their late-life choices of education and career, besides the overall test scores (Murphy and Weinhardt, 2020; Elsner et al., 2021; Denning et al., 2023).

On the other hand, there also exists spillover effects among crowds with heterogeneous abilities and outputs. By collaborating with high-achieved peers and getting motivated by them, even the less-achieved ones could still increase their performances in academia (Calvó-Armengol et al., 2009; Borjas and Doran, 2015; Moreira, 2016). In this paper, Putnam, which includes students from highly research universities and teaching-oriented colleges, could serve as a natural experiment that enable us to observe the two effects by looking at the awardees' absolute and relative rankings. We roughly find that, despite the possible positive effect of self-recognition on potential in higher education, the peer effect plays a more significant role. A student who ranked 5th in MIT still has a higher chance to complete doctorate's study than the top scorer in Swarthmore College.

The remaining of the paper is organized as follows. Section 2 introduces two competitions that are considered in the project; Section 3 shows the data collection and process. Section 4

shows a few patterns we found based on the data, and Section 5 concludes the paper.

2 USAMO and Putnam

2.1 USA Mathematical Olympiad

Starting in the year of 1972, USAMO is served as the final round of the American Mathematics Competitions to select top students into the United States National Team to compete in International Mathematical Olympiad (IMO). The competition lasts for nine hours with 6 questions in Number Theory, Geometry, Combinatorics, and Algebra respectively. Every year it invites around 500 eligible U.S. citizens or legal residents in the U.S. or Canada based on their performances in AMC competitions such as AMC 12 and AMC 10.

Before 2022, the 12 students with the highest rankings will be awarded with gold medals, and next approximately 12 performers will be listed in Honorable Mention lists. The top performers will then be invited to Mathematical Olympiad Program (MOP) for the further training and selection, among whom 6 National Team members will be chosen to represent the country in IMO.

Once get listed as an awardee of USAMO, no matter gold medal or HM winner, the student will receive opportunities to study at a high-ranking university. For example, among 121 awardees whose undergraduate placements could be searched, 27 students graduated from Harvard, 44 from MIT, 8 from California Institute of Technology (CalTech for short below), and 6 from Duke University (Duke for short below). For 39 students who never won gold medals and only got listed as HM, there are still 16 of them graduated from MIT, 3 from Harvard, and 4 from Princeton.

2.2 William Lowell Putnam Mathematical Competition

Putnam competition was founded in 1927 and then organized annually from 1938 by the Mathematical Association of America. Now it serves as one of the most important and famous math competitions among university students in the U.S. and Canada. The competition lasts for three hours and contains 12 questions that require specific knowledge and talents in mathematics. Any undergraduates at a participating college could enroll the competition as they wish, while the official team of the college is by selection. The top performers of Putnam will

be awarded with multi-level scholarship depending on their rankings. The top five teams win 25,000, 20,000, 15,000, 10,000, and 5,000 dollars respectively, and the individual awardees will be divided as the following levels: Top 5, Next 5, Next 6, Next 8, and Honorable Mention (HM for short).

Although a majority of the individual winners are undergraduates from prestigious universities famous for their math departments, such as Harvard, MIT, CalTech, and Princeton, there are also students from small LACs and other schools, like Carleton College and St. Lawrence University. In this way, we could not only observe an individual's overall ranking among all the participants in the same year, but also her or his relative one within college.

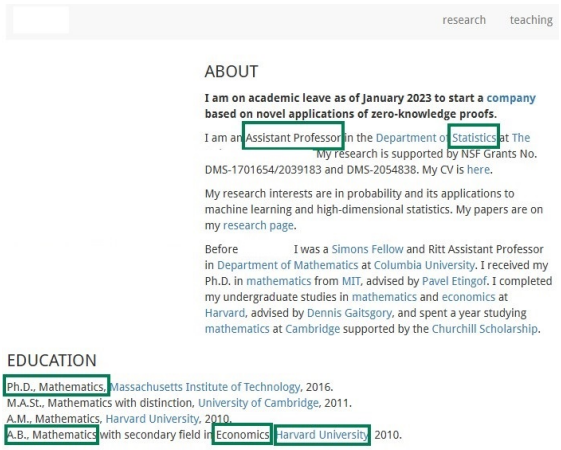
3 Construction of Data

3.1 USAMO

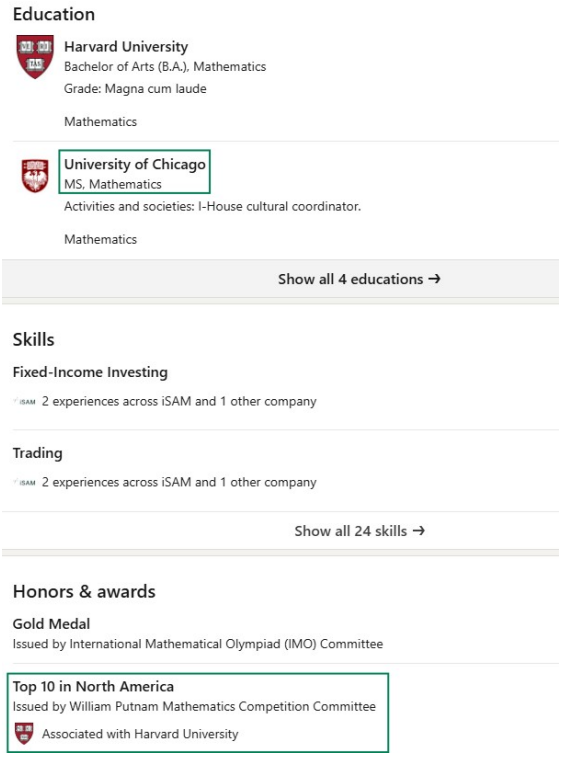
We first collect a list of students of USAMO in the year of 1989, 1994-1998, and 2003-2010 who ranked top among the participants, including National Team members, the remaining Gold Awardees (top 6%), and Honorable Mentioned receivers (not winners yet finished in the top 24) [1]. For each student, we record their times of winning the three honors respectively. We also keep the record of the year they got listed as awardees for the first time. The names of awardees after 2010 is available as well, but these observations are not very likely to obtain a Ph.D. degree before 2025 and be tracked.

Then we manually search and collect personal information of the names, including their undergraduate universities and majors, the highest degree they obtained, current positions and fields, and personal websites (either self-built websites or LinkedIn profiles) if exist. However, the work requires a large bulk of time and efforts. An example is given in Figure 9, where the awardees' public education and career information is collected from their personal website or LinkedIn profile.

[1] The names are collected at https://artofproblemsolving.com/wiki/index.php/USAMO_historical_results?srsltid=AfmBOopYlu30GUVoya4ElGoypY3h4gpENaSB89amORTwckpDgAz-zpTA#USAMO_Gold_Awardees, and some years are missing.



(a) Information collection from an awardee's personal website

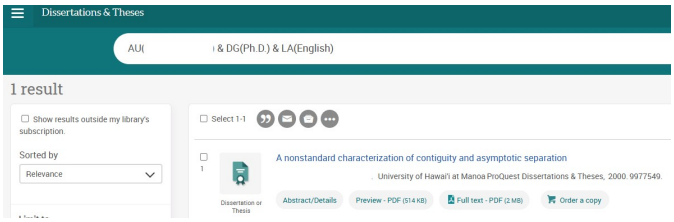


(b) Information collection from an awardee's LinkedIn profile

Figure 1: An example of manual information collection

Based on the list, we searched each of the names on ProQuest Dissertations & Theses database,

one of the largest and comprehensive dissertation database. To make the process easier, we specify the searching strategy as “Author(name) & Degree(Ph.D.) & Language(English)", that we focus on the dissertations written by the names in English to the application of a Ph.D. degree. Then for every search result, we scrape its Title, Author (this might be slightly different with the input of the names, because of fuzzy matching mechanism, and possible middle names and nicknames), Degree year, Subjects, Advisor, Institution, and Document URL. An example is shown in Figure 2.



(a) Search result of an awardee's name

Details

Subject	Mathematics; Statistics
Classification	0405: Mathematics 0463: Statistics
Identifier / keyword	Pure sciences; Asymptotic separation; Contiguity; Dichotomy; Nonstandard characterization
Title	A nonstandard characterization of contiguity and asymptotic separation
Author	
Number of pages	62
Degree date	2000
School code	0085
Source	DAI-B 61/07, Dissertation Abstracts International
ISBN	978-0-599-83455-2
Advisor	Ross, David A.
University/institution	University of Hawai'i at Manoa
University location	United States -- Hawaii
Degree	Ph.D
Source type	Dissertation or Thesis
Language	English
Document type	Dissertation/Thesis

(b) Details of the dissertation result

Figure 2: An example of automatic information collection

Then we attempt to match the Ph.D. dissertations with the awardees, with the following rules:

- The difference of the year of an awardee partipating USAMO as a high school student and

that of obtaining a Ph.D. degree should be more than 7 years;

- The subjects of the Ph.D. dissertations should be related to math, applied math, statistics, computer science, economics (economic theory) and social sciences. This is because in the process of data collection manually, we find the pattern that these awardees are very likely to choose these fields as their majors, both in undergraduate and graduate periods.

After the matching, there still exists a few cases that an awardee's name matches with multiple dissertations. For these cases, we manually search the awardee's information and match her/him with the most appropriate results.

In this way, we manage to build a small dataset of 172 observations, including the award winners of USAMO between 1989 and 2010, with their undergraduate and graduate paths, as well as career choices. Comparing the two ways of data construction, the manual collection finds 100 Ph.D.s (which takes up 58.14% of the sample), while the automatic matching finds 97 (56.4% of the sample). Among 172 observations, 157 of them (91.28%) show the same result in both measures. 91 observations (52.91% of the sample) are double-checked to have a Ph.D. degree in math-related fields under both measures, and they are considered as doctorate-degree holders in the analysis below.

3.2 Putnam

The construction of Putnam data is following similar ways of USAMO dataset. However, there are two main differences. The first is that the list of Putnam awardees provides both their names and affiliations, which makes it easier to search their information online [2]. However, the second is that the observations of Putnam awardees are much more than that of USAMO, so it will be very time consuming to manually collect the data. Currently, we only consider looking at the pattern of winning a Putnam award and the choice of pursuing a Doctor's degree.

We repeat the coarse scraping of the awardees' Ph.D. dissertations and match them with the name list. The matching rule is the same as before, with the difference being that we narrow down the year difference of Putnam and Ph.D. degree to more than 5 years. Another difference is that Putnam data includes the full names of most awardees, which include the initial letter of their middle names (for example, "John F. Nash"). So we search both "Author (John F. Nash)"

[2] https://kskedlaya.org/putnam-archive/

and “Author (John Nash)", to collect all the possible Mr. John Nashs' dissertations. The details of these dissertations enable us to collect the writers' full name (usually it takes the form of “Nash, John Forbes") as well. So we could delete all the dissertations with writers named “John James Nash".

What we going to do the next is to successfully match the names with multiple dissertations, and construct variables describing the relative ranking of the participants in their universities.

3.2.1 Linking NSF awards to Putnam data

Given the enormous amount of samples in Putnam data, it is too time-consuming to manually collect the career paths of each observation. Instead, we design an indicator: the experience of winning NSF awards, to represent whether these observations become great scientists after graduation.

Established in 1950 by U.S. Congress, the U.S. National Science Foundation (NSF for short) is an independent federal agency that supports science and engineering in all 50 states and U.S. territories. Every year, NSF could assign 11,000 awards to 1,900 institutions to support their research and education activities on average[3]. In 2025, the budget for NSF reaches to $10.183 billion, covering 10,900 awards among all 40,800 proposals submitted. Among them, only 24% of the Research Grant Proposals got approved, with an average funding amount of $207,900 [4]. Obviously, winning a NSF award, especially a research-based one, serve as a sign of the Principal Investigator (PI for short)'s recognized ability in her/his research.

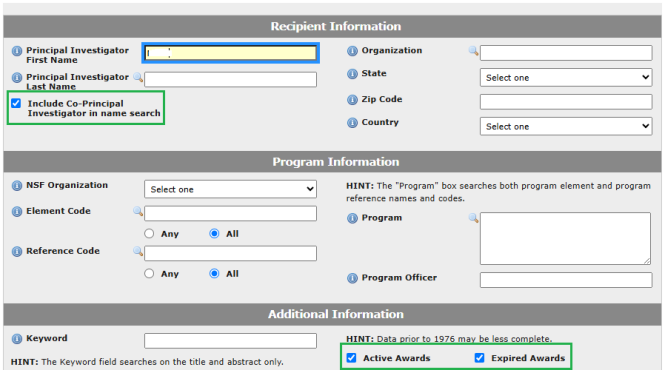
NSF official website provides a database to search for approved awards, including both active and expired ones. This enables us to automatically search for each Putnam awardees' name and scrape their history of NSF awards.

Figure 3 provides an example of our initial collection of NSF data. We search for PI's first name and last name, including Co-PI, for their active and expired awards. If our request returns to some results, we collect the Title, Recipient (usually PI's institutions), Start and End date, Total Intended Award Amount, PI/Co-PIs' names and email addresses, and NSF Program of the

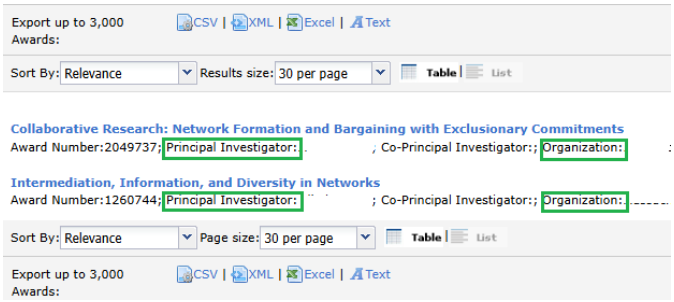
[3]https://www.nsf.gov/about.

[4]See in Fiscal Year 2025 Budget Request to Congress.

award.



(a) Search for Putnam awardees' name in NSF database



(b) Result of the search

Figure 3: Collecting Putnam awardees' NSF experiences

Then we match the search results with the Putnam dataset, with the following rules:

- If one PI's name refers to different topics and/or institutions, we manually search for the Putnam awardee's name and match the name with the best one;
- We check fundings with keywords like "education", "students", "teachers", as well as "symposium", "meeting", "conference" and "workshop", since these observations are very likely to be related to support education and an activity instead of pure research. We then delete all the fundings that are not research-based.
- We also delete fundings without a math-related topic.

In this way, we manage to collect 601 NSF awards to promote research in mathematics, computer science, economics, etc.

4 Results

4.1 USAMO

More than half of the USAMO awardees are matched with a record of Ph.D. dissertation in math-related fields, while 58.49% (458 out of 783 observations) of the Putnam awardees are matched.

The undergraduate university and doctorate university lists are also provided in Table 1 and Table 2 respectively. More than half of the awardees whose education background could be searched ended up obtaining a bachelor's degree from an Ivy League university, and the same pattern exists for their choice of a doctorate degree.

The USAMO awardees in our sample finished their undergraduate studies from 20 different colleges as shown in Table 1, varying from Ivy League members such as Harvard and MIT, to distinguished public colleges and UIUC and UMich, as well as LACs like Swarthmore and Harvey Mudd College. However, the majority of these awardees chose top-ranked private colleges, which indicates that attending USAMO could provide a possible access to elite education. There are also 2 observations that skipped from college, which are also listed. As shown in Table 3 and 4, 98 out of 113 awardees selected Mathematics as their majors, and 17 out of 30 selected Computer Science as their minors. Even given enough freedom to choose their majors, these awardees who showed math talents in high school still showed a very strong inclination towards STEM-related majors.

In the first decade of 21st century, the inclination towards higher degrees after undergraduate is less obvious. However, 2013-2021 witnessed a small peak in USAMO awardees obtaining a Ph.D. degree as described in Figure 4. The choices of universities among those doctorate degree holders show an even more imbalance tendency in Table 2, that the top 5 universities (MIT, Stanford, Princeton, Harvard, and UC Berkeley) attracting the most students take up 79.12% of all 19 counterparts listed. A large majority of students from Harvard and MIT chose to continue their way into academia after finishing undergraduate studies. As in 9, a majority of students who entered Ph.D. programs chose mathematics as their dissertation subjects.

Table 6 provides a few summary statistics for USAMO awardees to describe their general

experiences. On average, it takes 10.833 years for them to obtain a Ph.D. degree after getting listed in USAMO for the first time in high school, and the number varies from 7 to 21 years. For all the 172 awardees in our sample, they participated USAMO for 1.395 times on average, and were selected into National Team for 0.436 times, won a National Gold Medal for 0.831 times, and won Honorable Mention for 0.564 times.

Among the USAMO awardees, the choices of academic paths among different awardees are also slightly different. Compared with those gold medalists, HMs are the least likely to pursue a graduate degree in math and enter the academia even though 50% of them selected math as their undergraduate major. The general result is shown in Table 7. For those Gold Medal winners, whether selected to represent the country in IMO, perform a roughly 30% likelihood to become a tenured-track professor in colleges after doctorate studies, which surpasses the average 20% among Ph.D. students among all fields and 10% among Science fields[5].

4.2 Putnam

The undergraduate education background of Putnam awardees in our sample is more varied, coming from 117 different universities in the U.S. and Canada. However, a majority of these colleges only had less than 5 historical awardees, while MIT and Harvard enjoyed a good reputation for their performances in Putnam, with 152 and 109 awardees in total, respectively. Colleges famous for their STEM-related research like CalTech, Princeton, and Stanford are also performing actively in the competition with over 45 awardees.

Despite of their heterogenous and scattered undergraduate experiences, the records indicate that the pattern of obtaining a doctorate degree from an Ivy League institution still holds as shown in Table 8. The top 5 universities that chosen by these Putnam awardees as their last stage of higher education remain MIT, Princeton, UC Berkeley, Harvard, and Stanford, and takes up 68.56% of all the Ph.D. degree-holders.

One difference between USAMO and Putnam is that undergraduate students have more chances to enroll in Putnam and get an award than high school students. The 783 Putnam

[5]According to https://www.theatlantic.com/business/archive/2013/02/how-many-phds-actually-get-to-become-college-professors/273434/, 19.4% of Ph.D. students become a tenured professor and only 9.1% of Physical Sciences make it in year of 2011.

awardees participated Putnam 1.701 times on average, and won Top 5 for 0.143 times, ranked 6-16 for 0.24 times, ranked 17-25 for 0.211 times, and won Honorable Mention for 1.107 times even. However, Table 9 also indicates that compared with those high school math talents, it takes longer (9.083 years) to finish a Ph.D. after winning an award in Putnam as an undergraduate student.

Table 10 presents an overview of the doctorate degree attainment choices among different groups of Putnam awardees. Similar to USAMO, higher-ranked awardees tend to pursue Ph.D. degrees at a slightly higher rate. Among the Top 5 finishers, 78.08% went on to obtain a Ph.D. And the rate is 66.44% for Top 6-16 group, and 71.62% for Top 17-25. Honorable Mention recipients have the lowest Ph.D. attainment rate. Considering that some participants would attend Putnam in different years and won different awards, the second part of the table also takes a full investigation to people who never got listed in Top 5, Top 16, and Top 25. Still, the top 25 awardees pursue a Ph.D. degree with similar rates of around 55%, while 52.43% of the students who only won HM would obtain a doctorate degree.

We also apply a logit model to test whether this effect is statically significant. The main regression equation is as follows:

$$PHD_i = \alpha + \beta_0 Count_i + \sum_{i=1}^{4} \beta_i HonorCount_i + X_i\delta + \epsilon_i$$

where PHD_i is the dummy variable indicating whether the observation i holds a Ph.D. degree, $Count_i$ counts for total times of Putnam participation, and $HonorCount_i$ counts for awardee i's counts of 4 different tiers of rankings respectively. Time and undergraduate college fixed effect are also controlled.

Table 13 shows the basic result. There exists no significant correlation with how many times of participation in total with the awardees' choices of higher education, and only those ranking at Top 5 or 17-25 would significantly be motivated to finish their doctorates' studies.

Does the relative ranking within the same college matter? We also manage to construct these awardees' school rankings that if in year t, a student i won an Honorable Mention, but s/he is the only one who got listed in her/his college c, then the school ranking R^s_{tic} will be 1. If in college c at year t, there are two students j, k ranked 17-25, and one student n won an Honorable

Mention, then the school ranking in this case is $R^s_{tjc} = R^s_{tkc} = 1, R^s_{tnc} = 3$. For the awardees who performed well in more than one competitions, we only keep the highest ranking. The relative rankings taking year and college into consideration vary between 1 and 14, and most of the students have won 1st place in their colleges. And there is no obvious pattern that higher relative rankings could motivate the students to pursue a Ph.D. degree under constriction of observations.

Figure 8 provides a roughly ambiguous effect of relative ranking within colleges. Most of the participants once won the 1st place in her or his college, yet the ratio of Ph.D. degree holders over the distribution of within-college ranking varies. Using a logit model examining the effect of both honor level (where "Ranking Top 5" =1, "Ranking 6-16"=2, "Ranking 17-25"=3, and "HM"=4) and relative ranking, only the former one has a significant effect on pursuing a Ph.D. degree.

We repeat the above regression by replacing the independent variables:

$$PHD_i = \alpha + \beta_0 HonorLevel_i + \beta_1 RelativeRank_i + X_i\delta + \epsilon_i$$

that $HonorLevel_i$ represents awardee i's absolute ranking (see the definition in the previous paragraph) and $RelativeRank_i$ represents his/her relative ranking in college at the same year. As it shown in Table 13, only the absolute honor level matters. The higher absolute ranking one has once achieved, the more likely the awardee will finish with a Ph.D. degree.

159 out of 783 (20.31%) awardees resulted in a researcher who won NSF awards in research at least once, varying 1 to 15 awards. Most of the NSF winners won 1-3 times, and as in Table 12, the pattern remains straightforward and consistent: the higher absolute ranking in Putnam, the more likely to become an accomplished scientist in the future.

By applying the same econometric method as in their choices of higher education, we test whether and how the Putnam experiences affect the possible outcomes in NSF funding application:

$$NSF_i = \alpha + \beta_0 Count_i + \sum_{i=1}^{4} \beta_i HonorCount_i + X_i\delta + \epsilon_i$$

$$NSF_i = \alpha + \beta_0 HonorLevel_i + \beta_1 RelativeRank_i + X_i\delta + \epsilon_i$$

Table 14 draws similar conclusions as before: only the experience of once getting listed as a “Top 5" could significantly predict a success in science, and better performances in Putnam indicate a higher chance of getting recognized by one of the most important science fundings in the future. Relative ranking within undergraduate college, on the other hand, seems no impact on the awardees' later scientific careers.

5 Conclusion

The analysis of Putnam and USAMO awardees reveals a clear correlation between competition performance and long-term academic engagement. By building a unique dataset of the top awardees in the two mathematics competitions in the U.S., we predict that individuals who attain higher ranks in these prestigious competitions are more likely to pursue advanced degrees, particularly in mathematics. IMO winners and USAMO gold medalists exhibit the highest Ph.D. attainment rates, reinforcing the idea that early mathematical excellence translates into sustained academic ambition. Furthermore, the percentage of these awardees who go on to become professors highlights the role of competitive mathematics as a prediction for academic careers. By linking the NSF funding application data and Putnam one, we also find that a better performance in math at undergraduate level also leads to obtaining a Ph.D. degree and later winning significant support and recognition in science with more probabilities. Besides, with the college information available, we are able to check the role of Big-Fish-in-Small-Pond effect in shaping the students' decisions after undergraduate. We find that only the absolute ranking within the competition matters, while there is no evidence that a good result compared with other classmates in the same year would significantly affect these awardees' future.

However, this trend is not absolute. While top-ranked competitors are more inclined to pursue Ph.D.s, a substantial fraction do not continue in academia. The lower Ph.D. attainment rates among Honorable Mention recipients observed in both USAMO and Putnam awardees suggest that beyond competition success, external factors such as personal interest, career opportunities, and institutional influences play a crucial role in shaping long-term career paths. The mechanism behind the phenomenon is yet to be discovered.

There are lots of future facts to be checked. For example, a more detailed analysis of career outcomes beyond academia would be beneficial. Many talented mathematicians may opt for

non-academic paths, and exploring their career choices could provide a better way to encourage scientific breakthroughs. Also, the role of peer pressure on these young talents' choices of academic paths also needs more attention, whether the relative ranking within the same affiliation could shape the awardees' self-beliefs, and hence force their willingness to become scientists. Currently this paper finds no such pattern linking rankings within the same college and dedication to academia, and the reasons remain undiscovered.

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6 Appendix

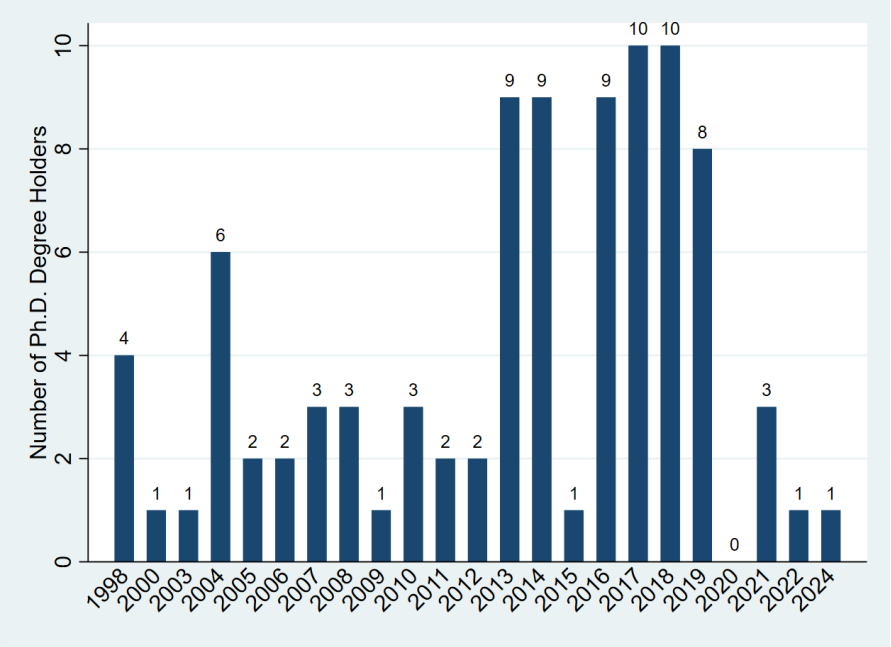


Figure 4: Annual Number of USAMO awardees obtaining a Ph.D.

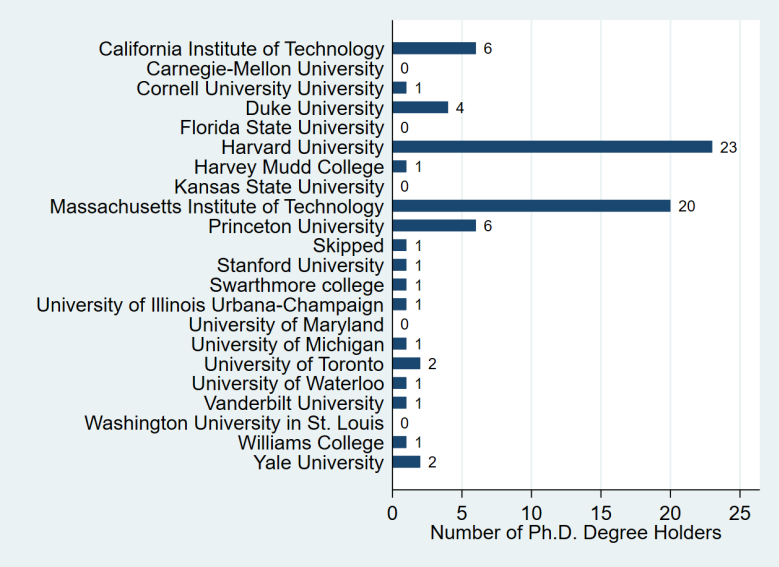


Figure 5: Number of Ph.D. degree holders among different colleges' USAMO awardees

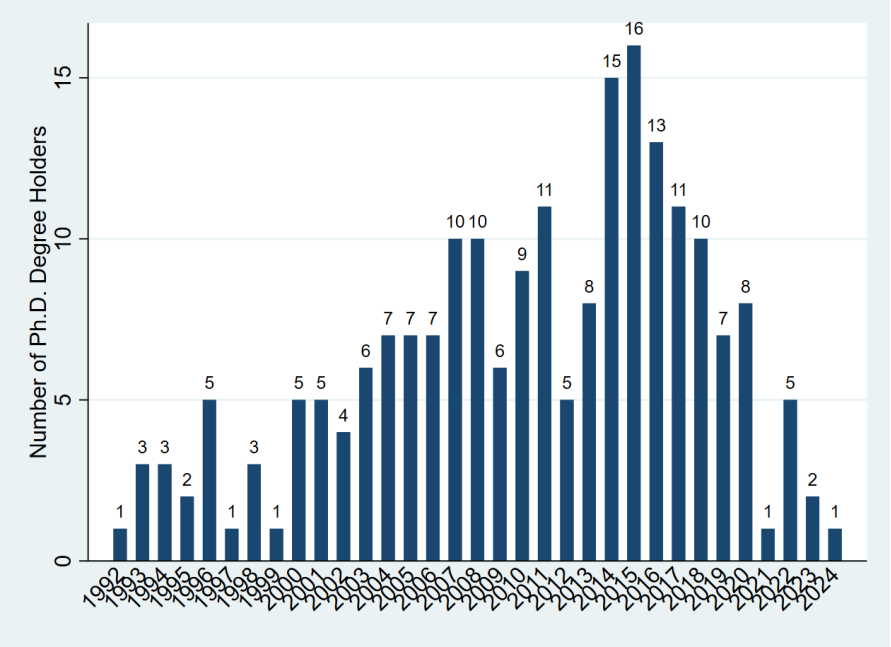


Figure 6: Annual Number of Putnam awardees obtaining a Ph.D.

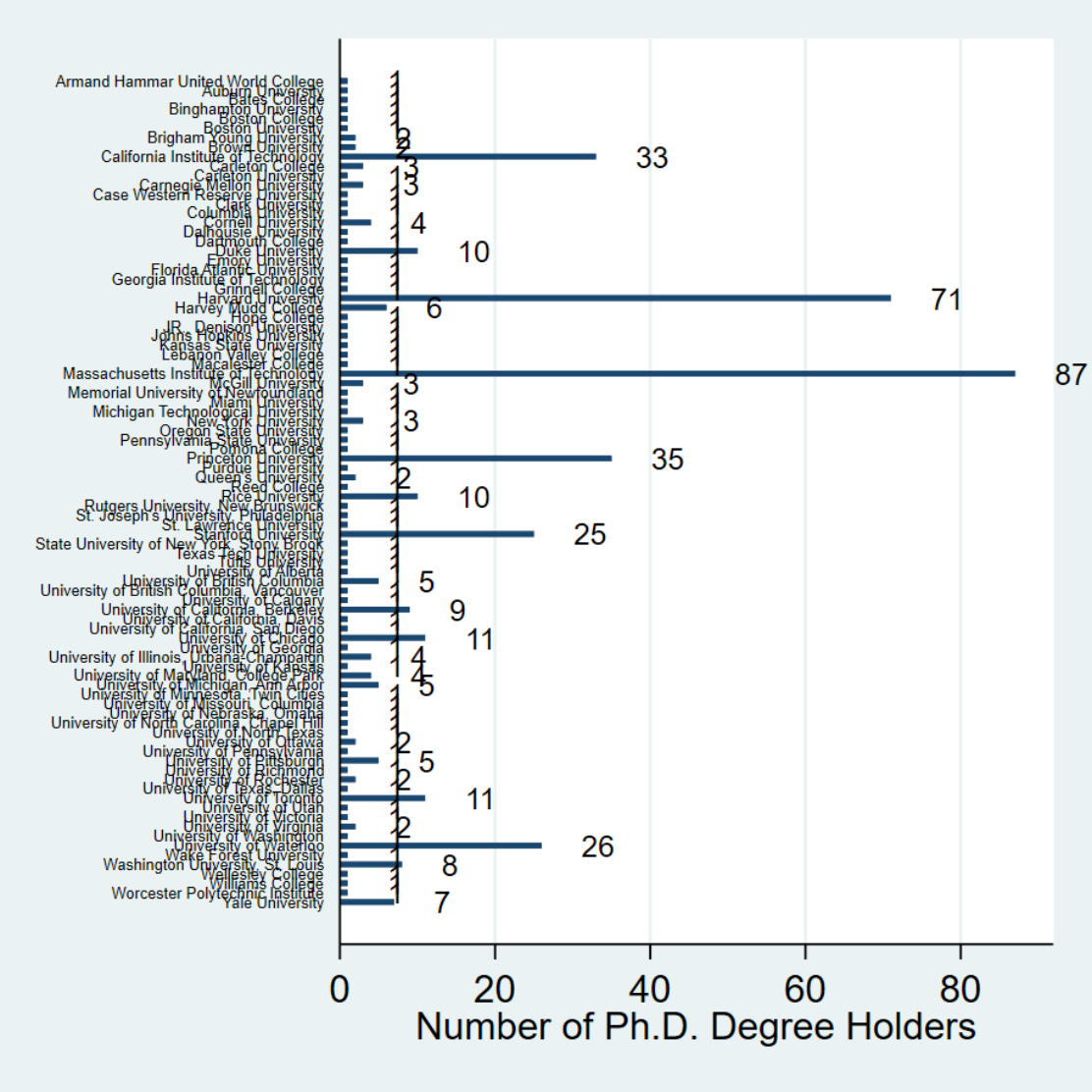


Figure 7: Number of Ph.D. degree holders among different colleges' Putnam awardees

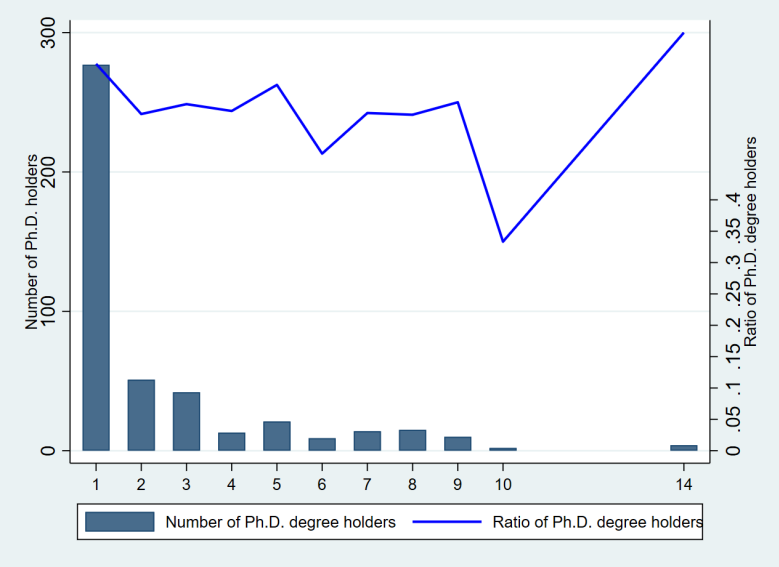
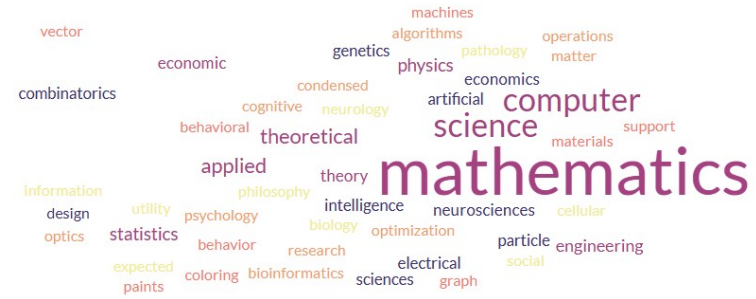
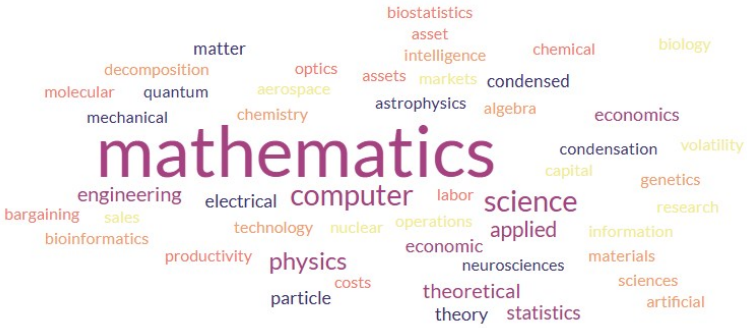


Figure 8: Overall choices of higher education by different awardees in Putnam (Relative ranking)



(a)



(b)

Figure 9: Wordcloud of doctorate dissertation subjects from USAMO (Top) and Putnam awardees (Bottom)

Table 1: The distribution of undergraduate university of USAMO awardees

UndergradSchool	Number	Percentage (%)
California Institute of Technology	8	6.61
Carnegie-Mellon University	3	2.48
Cornell University University	1	0.83
Duke University	6	4.96
Florida State University	1	0.83
Harvard University	27	22.31
Harvey Mudd College	1	0.83
Kansas State University	1	0.83
Massachusetts Institute of Technology	44	36.36
Princeton University	8	6.61
Stanford University	4	3.31
Swarthmore college	1	0.83
University of Illinois Urbana-Champaign	1	0.83
University of Maryland	1	0.83
University of Michigan	1	0.83
University of Toronto	3	2.48
University of Waterloo	1	0.83
Vanderbilt University	1	0.83
Washington University in St. Louis	1	0.83
Williams College	2	1.65
Yale University	3	2.48
Skipped	2	1.65
Total	121	100

Table 8: The distribution of doctorate university of Putnam awardees

University	Number	Percentage(%)
Arizona State University	1	0.22
Boston College	1	0.22
Brandeis University	2	0.44
Brown University	2	0.44
Budapest University of Technology and Economics (Hungary)	1	0.22
California Institute of Technology	5	1.09
Carnegie Mellon University	5	1.09
Columbia University	6	1.31
Cornell University	6	1.31
Dalhousie University (Canada)	2	0.44
Dartmouth College	1	0.22
Duke University	1	0.22
Harvard University	64	13.97
Illinois Institute of Technology	1	0.22
Imperial College London (United Kingdom)	1	0.22
Johann Wolfgang Goethe-Universitaet Frankfurt am Main (Germany)	1	0.22
Massachusetts Institute of Technology	88	19.21
Massachusetts Institute of Technology	1	0.22
McGill University (Canada)	1	0.22
Michigan State University	1	0.22
National University of Singapore (Singapore)	1	0.22
New York University	3	0.66
North Carolina State University	1	0.22
Northwestern University	1	0.22
Oregon State University	1	0.22
Princeton University	47	10.26
Rice University	2	0.44
Rutgers The State University of New Jersey, School of Graduate Studies	5	1.09
Simon Fraser University (Canada)	1	0.22

Stanford University	40	8.73
Texas A&M University	1	0.22
The Ohio State University	1	0.22
The Pennsylvania State University	1	0.22
The University of Arizona	1	0.22
The University of Chicago	17	3.71
The University of Iowa	1	0.22
The University of North Carolina at Chapel Hill	1	0.22
The University of Texas at Austin	2	0.44
The University of Utah	1	0.22
The University of Wisconsin - Madison	6	1.31
University of Alberta (Canada)	1	0.22
University of California, Berkeley	75	16.38
University of California, Davis	1	0.22
University of California, Irvine	2	0.44
University of California, Los Angeles	8	1.75
University of California, San Diego	2	0.44
University of Cambridge (United Kingdom)	1	0.22
University of Colorado at Boulder	1	0.22
University of Delaware	1	0.22
University of Illinois at Chicago	1	0.22
University of Illinois at Urbana-Champaign	2	0.44
University of Macau	1	0.22
University of Maryland, College Park	1	0.22
University of Massachusetts Amherst	1	0.22
University of Michigan	12	2.62
University of Minnesota	1	0.22
University of New Hampshire	1	0.22
University of North Texas	1	0.22
University of Ottawa (Canada)	1	0.22
University of Pennsylvania	3	0.66
University of Pittsburgh	1	0.22
University of Rochester	1	0.22

University of South Carolina	1	0.22
University of Southern California	1	0.22
University of Toronto (Canada)	2	0.44
University of Washington	3	0.66
University of Waterloo (Canada)	2	0.44
University of California, Berkeley	1	0.22
Vanderbilt University	1	0.22
Yale University	3	0.66
Total	458	100.00

Table 2: The distribution of doctorate university of USAMO awardees

University	Number	Percentage (%)
Arizona State University	1	0.96
Brown University	1	0.96
California Institute of Technology	1	0.96
Carnegie Mellon University	6	5.77
Chulalongkorn University	1	0.96
Columbia University	1	0.96
Cornell University	1	0.96
Harvard University	10	9.62
Massachusetts Institute of Technology	26	25.00
New York University	2	1.92
Princeton University	13	12.50
Rice University	1	0.96
Rutgers The State University of New Jersey, School of Graduate Studies	1	0.96
Stanford University	14	13.46
The University of Chicago	4	3.85
The University of Wisconsin - Madison	2	1.92
The University of Texas at Austin	1	0.96
University of California, Berkeley	11	10.58
University of Cambridge	1	0.96
University of Hawai'i at Manoa	1	0.96
University of Kansas	1	0.96
University of Leicester (United Kingdom)	1	0.96
University of Pennsylvania	1	0.96
University of Virginia	2	1.92
Total	104	100.00

Table 3: The distribution of undergraduate majors of USAMO awardees

Undergrad Major	Number	Percentage (%)
Biochemical	1	0.88
Chemical Engineering	2	1.77
Chemistry	1	0.88
Computer Science	7	6.19
Engineer	1	0.88
Mathematics	98	86.73
Physics	2	1.77
Statistics	1	0.88
Total	113	100.00

Table 4: The distribution of undergraduate minors of USAMO awardees

Undergrad Minor	Number	Percentage (%)
Chemistry	1	3.33
Computer Science	17	56.67
Economics	1	3.33
Engineer	1	3.33
English	1	3.33
Linguistics	1	3.33
Mathematics	2	6.67
Music	1	3.33
Physics	5	16.67
Total	30	100.00

Table 5: The distribution of current positions of USAMO awardees

Current Position	Number	Percentage (%)
Engineer	31	27.68
Entrepreneur	7	6.25
Lecturer	3	2.68
Postdoc	7	6.25
Professor	48	42.86
Psychometrician	1	0.89
Scientist	4	3.57
Streamer	1	0.89
Trader	2	1.79
Tutor	4	3.57
Writer	2	1.79
Disappear	1	0.89
Prisoned	1	0.89
Total	112	100.00

Note: Scientist here indicates the observation works in the industry or non-profit organizations other than universities as a research scientist.

Table 6: Summary statistics for USAMO awardees

Variable	Observations	Mean	Std.Dev.	Min	Max
Year difference between winning USAMO for the first time and obtaining a Ph.D.	84	10.833	2.338	7	21
Number of Participation	172	1.395	0.645	1	4
Number of being selected into National Team	172	0.436	0.641	0	3
Number of winning National Gold	172	0.831	0.773	0	3
Number of winning Honorable Mention	172	0.564	0.604	0	2

Table 7: Overall choices of higher education by different USAMO awardees

		Selecting maths as undergruaduate major		Obtaining a Ph.D. degree		Becoming a professor after graduation	
	Number	Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)
IMO winners	62	40	64.52	41	66.13	23	37.10
USAMO gold medalists	110	67	60.91	66	60	37	33.64
USAMO gold medalists without IMO	48	27	56.25	25	52.08	14	29.17
Honorable Mentions only	62	31	50	25	40.32	11	17.74

Table 9: Summary statistics for Putnam awardees

Variable	Observations	Mean	Std.Dev.	Min	Max
Year difference between winning Putnam and obtaining a Ph.D.	407	9.083	3.288	5	35
Number of Participation	783	1.701	0.942	1	4
Number of Top 5	783	0.143	0.521	0	4
Number of Rank 6-16	783	0.240	0.555	0	4
Number of Rank 17-25	783	0.211	0.458	0	2
Number of winning Honorable Mention	783	1.107	0.756	0	4

Table 10: Overall choices of doctorate degrees by different awardees in Putnam (Absolute ranking)

	Count	Ph.D. degree	Percentage (%)
Top 5	73	57	78.08
Rank 6-16	149	99	66.44
Rank 17-25	148	106	71.62
HM	648	159	55.09
Never rank Top 5	710	401	56.48
Never rank Top 16	595	329	55.29
HM only	494	259	52.43

Table 11: Distribution of NSF winners among Putnam awardees

Time of winning NSF	0	1	2	3	4	5	6	7+
Count	624	46	31	23	14	8	9	28
Percentage (%)	79.69	5.87	3.96	2.94	1.79	1.02	1.15	3.58

Table 12: NSF winners by different awardees in Putnam (Absolute ranking)

	Count	NSF winner	Percentage (%)
Top 5	73	33	45.21
Rank 6-16	149	45	30.20
Rank 17-25	148	41	27.70
HM	648	112	17.28
Never rank Top 5	710	126	17.75
Never rank Top 16	595	97	16.30
HM only	494	73	14.78

Table 13: Logit Predictors of Pursuing a Ph.D. among Putnam awardees

	(1)	(2)
	PHD	PHD
Count of Putnam Participation	0.0000209	
	(1.000)	
Number of Ranking Top 5	0.788***	
	(0.002)	
Number of Ranking 6-16	0.223	
	(0.216)	
Number of Ranking 17-25	0.718***	
	(0.001)	
Number of Honorable Mention Awards	0	
	(.)	
Honor Level (1=Best)		-0.321***
		(0.002)
Undergraduate School Relative Ranking		-0.0350
		(0.479)
Constant	0.250	1.638**
	(0.728)	(0.034)
Observations	695	695

p-values in parentheses

College and year fixed effects included but not reported.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Predictors of becoming a promising researcher

	(1)	(2)
	NSF	NSF
Count of Putnam Participation	0.142	
	(0.326)	
Number of Ranking Top 5	0.631***	
	(0.001)	
Number of Ranking 6-16	0.162	
	(0.409)	
Number of Ranking 17-25	0.319	
	(0.159)	
Number of Honorable Mention Awards	0	
	(.)	
Honor Level (1=Best)		-0.281**
		(0.018)
Undergraduate School Relative Ranking		-0.101
		(0.122)
Constant	-1.583*	-0.0877
	(0.069)	(0.922)
Observations	649	649

p-values in parentheses

College and year fixed effects included but not reported.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$