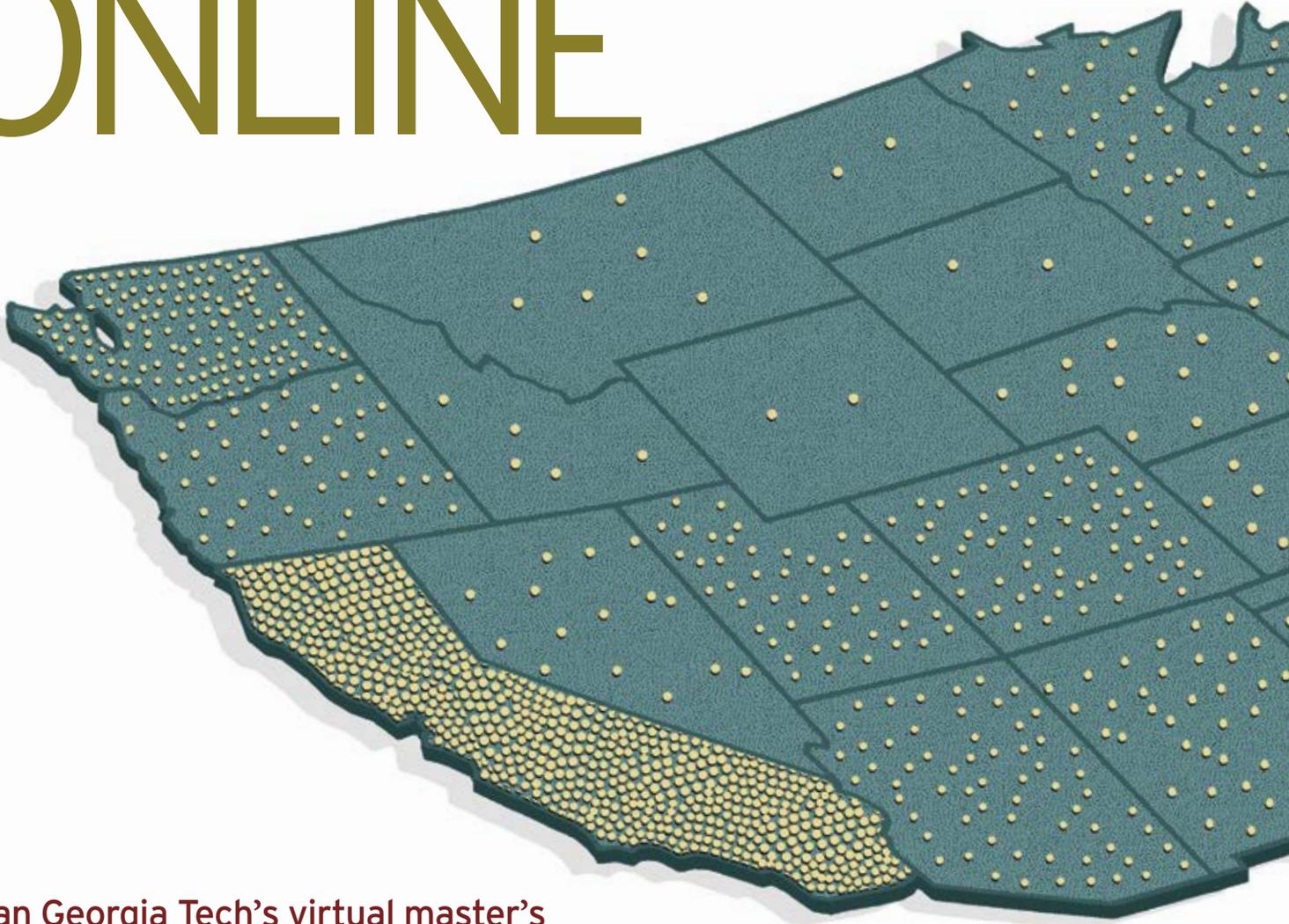


AN ELITE GRAD-SCHOOL DEGREE GOES ONLINE



Can Georgia Tech's virtual master's increase access to education?

ONLINE COURSEWORK has been heralded as potentially transformative for higher education, including by lowering the cost of delivery and increasing access for disadvantaged students. Rather than physically attending a class with peers and an instructor at a set time and location, online students can satisfy class requirements at home and on their own schedules, by logging on to a website, engaging in chat sessions, and completing assignments digitally.

Such courses have grown in popularity. In 2015, 14 percent of U.S. college students were enrolled in online-only

programs, and another 15 percent of students took at least one class online. Most of that growth has been at large public institutions, with for-profit colleges accounting for about one-third of online students nationwide.

Those numbers raise a question: who takes online classes? Does online education simply substitute for in-person education or does it serve students who would not otherwise enroll in an educational program? While existing research has compared academic performance between in-person and online students, little is known about the differences among the students themselves.



In 2014, Georgia Tech started enrolling students from across the country in a fully online version of its highly regarded Master of Science in Computer Science degree.

Do online programs attract additional students and thereby increase the number of people obtaining education?

An innovative program at the Georgia Institute of Technology provides an opportunity to study this question. In 2014, Georgia Tech's College of Computing, which is regularly ranked in the top 10 in the United States, started enrolling students in a fully online version of its highly regarded Master of Science in Computer Science degree—the earliest educational model

to combine the inexpensive nature of online education with a degree program from a highly ranked institution. The online degree costs about \$7,000, less than one-sixth of the \$45,000 that out-of-state students pay to enroll in the same program in person. The classes were designed by faculty to mirror the in-person courses, are graded to the same standards, and lead to the identical degree without any “online” distinction. It is now the nation's largest master's-degree program in computer science.

by JOSHUA GOODMAN, JULIA MELKERS, and AMANDA PALLAIS

We first compare the online and in-person applicant pools and find there is nearly no overlap between these two programs. Unlike the in-person master's, the online program attracts older employed students. Next, we rigorously estimate whether this online option expands access to education for students. We find that students admitted to the program are more likely to pursue postsecondary education than those who are not admitted. In other words, access to the online program does not appear to substitute for other educational options. Those not admitted to the online program do not find appealing alternatives in the current higher-education landscape and thus do not pursue further education.

These findings indicate that the higher education market has been failing to meet demand for mid-career online options. Our analysis does not directly address the question of whether the quality of the online program is as high as that of the in-person program, but it does put that question in a new light. For the vast majority of online students, the alternative is not an in-person degree program but rather no degree at all. Even so, we find that a majority of enrollees in the online program are on track to complete their degrees and perform as well as or better academically than students who enroll on campus.

The Georgia Tech program confirms that, when done well, online coursework can substantially increase overall educational attainment and expand access to students who would not otherwise enroll.

An Elite Online Program

The Georgia Tech computer-science master's degree was the first large-scale online program of its kind: it is offered by a highly ranked department, priced much lower than its

now offers a fully online version of its highly regarded MBA for about one-third of the cost of the in-person program, Yale University is currently developing a fully online version of its Master of Medical Science degree for physician assistants, and the University of Colorado at Boulder has just started an online Master of Science in Electrical Engineering.

The Georgia Tech program was developed by the university and AT&T and is offered through a platform designed by Udacity, one of the largest providers of MOOCs. To earn their degree, students must complete 10 courses, specializing in computational perception and robotics, computing systems, interactive intelligence, or machine learning. The typical student takes one or two courses each semester and the expected time to graduation is six to seven semesters. In order to maintain educational quality, the online courses use similar assignments and grading standards as their in-person counterparts.

Though deadlines for submitting assignments are the same as the in-person courses, one major difference is that all lecture-watching and other learning experiences are asynchronous, meaning that there is no fixed time during which a student must be online. All content is posted at the start of the semester so that students may proceed at a pace of their choosing. Students schedule their exams within a specified window and are monitored to guard against cheating. Most interaction happens in online forums where students post questions and receive answers from fellow students, teaching assistants, or faculty members. Faculty members interact with students in online office hours, though online forums are typically run by the head teaching assistant.

To make the online program accessible to a wider range of applicants than its in-person counterpart, Georgia Tech's admissions website describes as "preferred qualifications" having a BA in computer science or a related field with an



Each year nearly 1,700 students begin a computer-science master's degree through Georgia Tech's online program, making it the largest computer-science master's degree program in the United States, and possibly the world.

in-person equivalent, and culminates in a prestigious graduate degree. It stands in contrast to the models of online education that preceded it, which involved either highly ranked institutions offering online degrees that cost as much as their in-person equivalents, lower-ranked institutions offering inexpensive online degrees with low labor-market returns, or a variety of institutions offering free massive open online courses (MOOCs), with unclear returns and very high attrition rates.

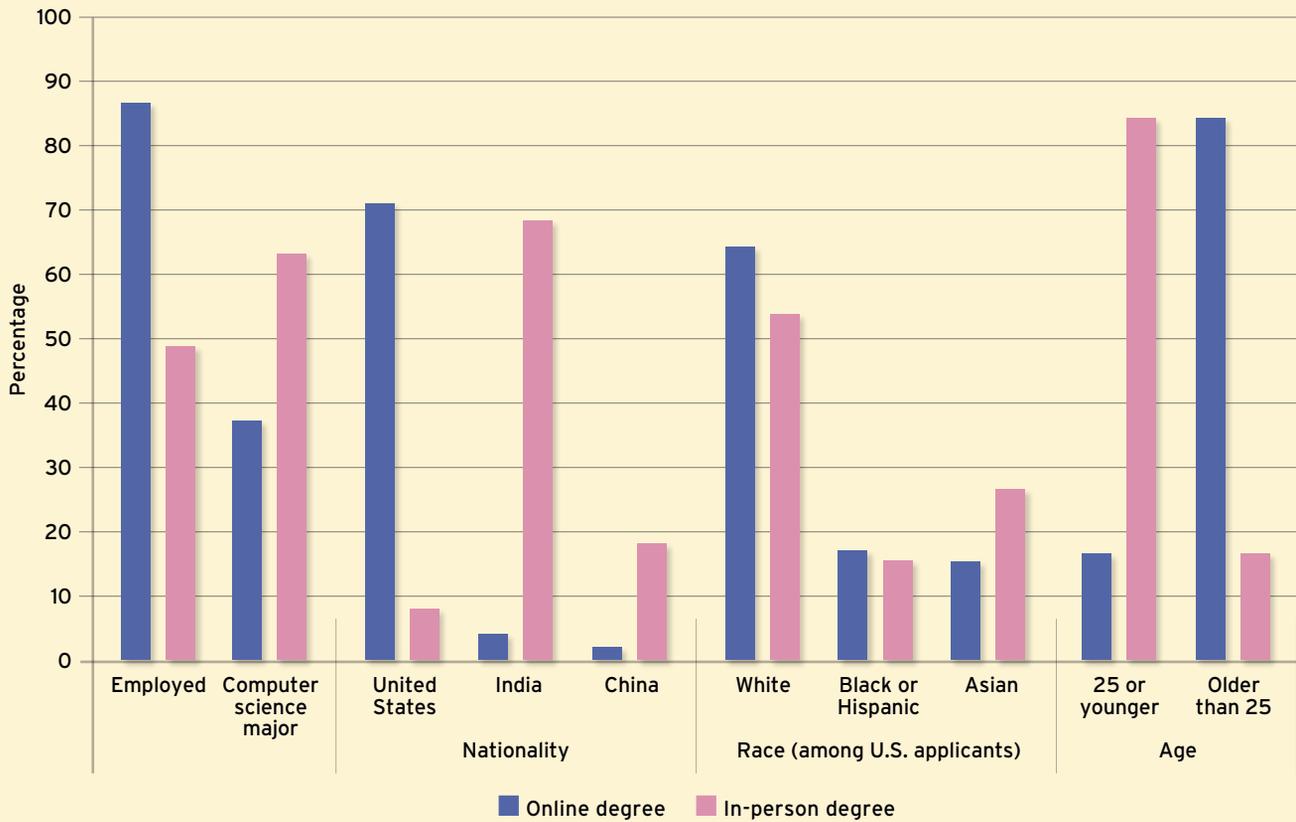
Since the founding of the Georgia Tech program, similar efforts have taken root at other prestigious institutions. For example, the University of Illinois at Urbana-Champaign

undergraduate GPA of 3.0 or higher. Applicants to the online program are not required to submit GRE scores, while those applying to the in-person program must. Online students can apply and start the program in either the spring or fall semester; students in the in-person program may only begin in the fall.

Demand for the online program is large: it attracts over 3,400 applicants annually, about twice as many as its in-person equivalent. Some 61 percent of applicants are admitted, almost five times the 13 percent admission rate for the in-person program, and 80 percent of those admitted enroll. As a result, each year nearly 1,700 students begin a computer-science master's

Online Master’s Program Attracts a Different Kind of Applicant (Figure 1)

There is nearly no overlap in the populations applying to Georgia Tech’s online and in-person master’s degree programs in computer science. The typical applicant to the online degree program is a 34-year-old employed American while the typical applicant to the in-person degree program is a 24-year-old recent college graduate from India.



SOURCE: Authors’ calculations

degree through Georgia Tech’s online program, making it the largest computer-science master’s degree program in the United States, and possibly the world.

Who Applies to an Online Master’s Program?

We examine data for all applicants to the online program’s first six cohorts, from spring 2014 to fall 2016, and for all applicants to four cohorts of the in-person program, from fall 2013 through fall 2016. For each applicant, we have basic self-reported demographic information, including age, gender, race/ethnicity, and citizenship. Applicants also report their employer, postsecondary education history, undergraduate GPA, and the field and type of any degree earned. In our data, less than 0.2 percent of the nearly 18,000 applicants to either program applied to both programs.

In order to track all applicants’ enrollment at any postsecondary institution in the United States, we merge their data to the National Student Clearinghouse (NSC). In addition, because the NSC data contain information only on enrollment in formal higher-education degree programs, we survey all spring 2014 online applicants to capture other forms of education and training. We also ask which characteristics of Georgia Tech’s online degree program factor in their decision to apply.

The online and in-person applicant pools look fairly similar in terms of gender and race among American applicants, but the online program also attracts a much more American demographic than does the in-person program (see Figure 1). About 70 percent of the online applicants are U.S. citizens, compared to 8 percent of in-person applicants. The vast majority of in-person applicants are citizens of India (nearly

70 percent) or China (nearly 20 percent); less than 10 percent of applicants to the online program are Indian or Chinese citizens. That more than 70 percent of online program enrollees are U.S. citizens makes that pool substantially more American than the national pool of those completing computer-science master's degrees, of whom 52 percent are U.S. citizens.

The online program attracts a substantially older demographic than the in-person program, with the average age at 34 compared to 24 for in-person applicants. These older online applicants are largely in the middle of their careers: nearly 90 percent list a current employer on their applications compared to less than 50 percent of in-person applicants. And while we find that hardly anyone older than 30 applies to the in-person program, the oppo-

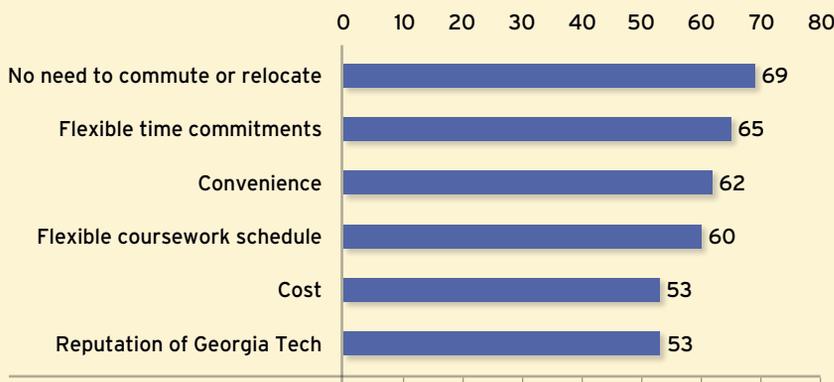
0.2 standard deviations lower than students from in-person applicants' colleges. Their colleges also have a higher proportion of low-income students, as well as a substantially lower six-year graduation rate. Online applicants are much less likely than in-person applicants to have majored in computer science, and more likely to have majored in engineering, mathematics, physical sciences, and even the social sciences and humanities.

In our survey, online applicants are asked to rate the importance of various features of the online master's-degree program to their decision to apply. The top four characteristics all relate to the geographic or temporal flexibility that an asynchronous, fully online program provides, with 69 percent valuing not needing to commute or relocate and 65 percent citing the program's flexible time commitments (see Figure 2). The cost and Georgia Tech's reputation are also valued characteristics, with 53 percent of respondents describing them as "extremely important" and 85 to 90 percent citing them as either "important" or "extremely important." Skill development is cited as "extremely important" by slightly less than half of applicants.

Why Do Students Apply for an Online Master's Program? (Figure 2)

When applicants were surveyed about how important various program characteristics were in their decision to apply to the online program, the features cited as most important were those that related to the geographic and temporal flexibility that online technology makes possible.

Percentage of respondents describing program feature as extremely important in their decision to apply



SOURCE: Authors' survey sent in July 2017 by e-mail to all Spring 2014 online program applicants, N=2,419, response rate=38%

site is true of the online program. Only 16 percent of online applicants are 25 or younger and less than 30 percent are between 25 and 30. The majority of applicants are over 30, with substantial representation of students in their 40s and 50s.

To learn more about applicants' family backgrounds and academic skills, we look at their undergraduate institutions using data from the Integrated Postsecondary Education Data System (IPEDS), which we are able to do for 88 percent of U.S. citizen applicants. We find that online applicants come from colleges where the average student's SAT math score is 30 points or about

program, and those denied. This analysis includes all students who applied to the Georgia Tech online master's program in spring 2014 and uses NSC data to track whether they were enrolled in any graduate program as of fall 2016.

We focus on spring 2014, the program's first semester, to exploit a one-time admissions practice that makes it possible to study the causal effect of being admitted. When the program began, Georgia Tech initially opted to constrain the number of students accepted, which officials did by sorting applications by undergraduate GPA, reading them in descending order, and

Does an Online Master's Program Expand the Pool of Students?

A key goal of our study is to determine whether the existence of an online option alters applicants' educational trajectories. If not for access to such an option, would its applicants pursue other educational options? Or does the online option lack close substitutes in the current higher-education market?

We compare the educational outcomes of two groups of students with similar academic qualifications but with one important difference: those offered admission to the online program, and those denied.

offering immediate entry only to the first 500 or so applications deemed admissible. As a result, only applicants with an undergraduate GPA of 3.26 or higher were eligible for admission in spring 2014. Eventually, all of the applications were reviewed and some students both below and above the 3.26 threshold were made offers of deferred admission.

The threshold provides an opportunity to compare similar students' trajectories, focusing on the impact of an offer of admission to the online program. Applicants just above and below the threshold should differ only in their access to the online option and be nearly identical in terms of academic skills, as measured by GPA as well as other characteristics. We obtain more precise results by controlling for gender, race/ethnicity, citizenship, age, employment, and college major, but we obtain similar findings without these controls.

This method allows us to measure the causal effect of admission to the online program as long as students could not manipulate whether their GPA was just above or below the cutoff. We believe this is the case because applicants' GPAs appeared on official transcripts not provided by the student and applicants had no knowledge that a GPA of 3.26 would play any role in the process. Additionally, we find no differential sorting across the threshold in terms of gender, race, citizenship, age, employment, or college major.

online programs from institutions such as DeVry University or Arizona State University.

This stands in contrast to applicants to the in-person program, about half of whom eventually enroll in alternative U.S. degree programs, including at prestigious competitors such as Carnegie Mellon or the University of Southern California. In addition, looking at the full applicant pool, we see no falloff in enrollment to the online Georgia Tech program among students with much higher GPAs. This suggests the market is not providing appealing alternatives for a wide range of students for whom the online master's degree is appealing.

Finally, survey data on students' informal, non-degree training produces no evidence that access to the online degree program reduces hours spent on non-degree training—and, in fact, our estimates, while statistically insignificant, suggest that access to the online program may actually increase informal education, such as time spent on professional certification programs and coding boot camps.

An Underserved Student Market

Our study finds the first rigorous evidence that we know of showing that an online degree program can increase educational attainment. We see significant demand for the first



Georgia Tech blindly graded final exams for online and in-person students taking the same course from the same instructor, and found the online students slightly outperformed the in-person students.

Using NSC data, we track whether students were enrolled in any graduate program as of fall 2016, well beyond the point at which all spring 2014 applicants would have had to enroll if admitted or would have had time to apply to and enroll in other institutions if rejected. We focus on the likelihood that a given student received any admission offer, regardless of its timing.

We find that students just above the GPA threshold were about 21 percentage points more likely both to be admitted and to enroll in the online program than students just below the threshold (see Figure 3). This implies that roughly all of the marginal applicants admitted because of the GPA threshold accepted the offer of admission, and that they appear not to have competing options that would cause them to decline their offer.

We then look at the NSC data to determine whether applicants just below the threshold who were denied admission to Georgia Tech enrolled in a different degree program, in any field of study. The overall levels of such enrollment are quite low, with less than 20 percent enrolling elsewhere. The few alternatives chosen by such applicants are generally lower-ranked

low-cost online degree offered by a highly ranked institution, and our analysis shows that demand is from students who would not otherwise pursue a master's degree.

We also find that this online option expands access to education and does not substitute for other informal training, and that students denied admission do not pursue any other formal education. Further, unlike the younger, predominantly international applicants to the in-person equivalent, applicants to the online program are largely mid-career Americans. Taken together, this implies that the higher-education market had previously been failing to meet demand for a program like Georgia Tech's online computer-science master's degree.

Demand aside, can the online program produce computer-science graduates of sufficient quality? Early evidence from Georgia Tech suggests that it can. To test whether online students were finishing their courses with as much knowledge as in-person students, Georgia Tech blindly graded final exams for online and in-person students taking the same course from the same instructor, and found the online students slightly



We see significant demand for the first low-cost online degree offered by a highly ranked institution, and our analysis shows that demand is from students who would not otherwise pursue a master's degree.

outperformed the in-person students. Online students are also highly likely to continue their studies: among those who started in 2014, at least 62 percent remained enrolled two years later, apparently on track to complete their degrees. (The actual percentage is likely higher, since many students

take a semester off and then re-enroll the following semester.)

Given the nearly 1,200 Americans enrolling each year in Georgia Tech's online computer-science master's program and conservatively assuming only 62 percent graduate, we would expect at least 725 new American computer-science master's degrees to be awarded annually. Nationwide, about 11,000 Americans earn their master's degree in computer science each year, implying that this single program will boost the annual national production of American computer-science master's by about 7 percent.

We conclude with two questions raised by this research. First, to what extent will the conclusions drawn from this particular online program apply to other populations and subjects? It seems likely, for example, that mid-career training in other fields might be amenable to this model, and moves by other institutions suggest they believe there are untapped markets in such training. Whether such low-cost, high-quality models can make inroads in undergraduate or secondary education remains to be seen, however.

Second, how large are the learning and labor market impacts of this online degree and how do they compare to that of the in-person equivalent? Looking at the undergraduate colleges attended by both types of computer-science students at Georgia Tech suggests that online students are, on average, somewhat weaker academically than their in-person counterparts. Nonetheless, comparisons of student achievement across the online and in-person formats suggests that online students finish their courses with at least as much knowledge as their in-person counterparts.

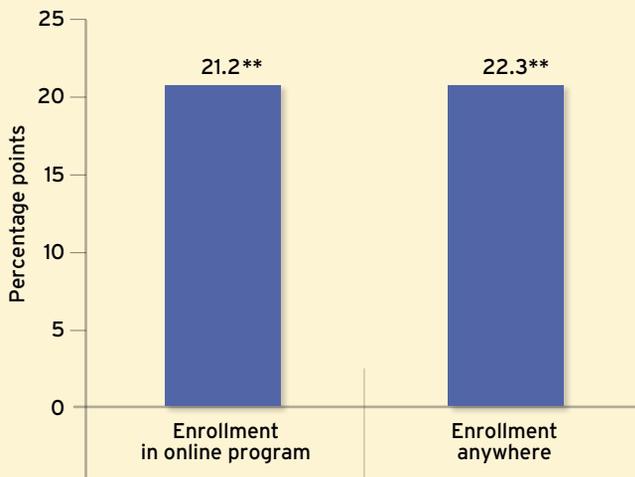
We hope to explore in subsequent work the extent to which the online degree is valued by the labor market, and whether and how it affects career advancement. Whether students who earn their computer-science master's degree online are perceived as similar in quality to their in-person counterparts will have broad implications for the evolving role of online coursework in the postsecondary sector.

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Online Degree Option Expands Educational Access (Figure 3)

As compared to their counterparts with slightly lower GPAs, those just above the GPA threshold for admissions to the online program were about 21 percentage points more likely to enroll. Those just below the GPA threshold were no more likely to enroll in other programs. This implies that access to the online program does not substitute for other educational options and instead substantially increases the number of students enrolling at all: admissibility to the online program increased enrollment in any formal higher education by about 22 percentage points.

Percentage point difference in probability, at the GPA threshold for admissions



** Statistically significant at 99% confidence level

SOURCE: Authors' calculations