Merit Aid Scholarships and Human Capital Production in STEM: Evidence from New Mexico

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Motivation

- Science, technology, engineering, and mathematics

- Production of STEM degrees often set as policy priority at university-, state-, and national-levels

- Merit-based scholarships: do renewal requirements discourage students from pursuing more difficult majors, such as STEM?

  - If so, this is an important unintended consequence of such programs

Motivation

- Since 1991, 27 US states have launched broad-based merit scholarship programs
  - New Mexico Legislative Lottery Scholarship (NMLLS) in fall 1997
- Programs generally reward in-state students with “free” college provided they meet certain eligibility criteria
  - Results inform recent proposals to make college “free” for Americans earning under $125,000 (Cf. NY’s Excelsior Scholarship)

Background

- The most generous broad-based merit scholarship in the US (recent changes here)
  - No high school achievement requirement
  - Graduate from a NM high school, and enroll in one of the 16 qualified public institutions in the next academic year
  - Eligible after completing 12 hours in first semester with 2.5 GPA at any public college (using the Bridge to Success Scholarship)
  - Continued eligibility: 12 credit hours each term, maintain 2.5 cumulative GPA for up to 8 semesters *after* successful first semester
  - More background here

Literature

- Not in agreement; approaches are very different…
  - Cornwell *et al.* (2006) analyze GA HOPE using admin. data, finding no overall change in declaring STEM majors
  - Zhang (2011) uses IPEDS data, examining GA and FL, finding little evidence of change in majoring in STEM
  - Stater (2011) uses admin. data from three large public universities, finding that merit aid results in increased STEM major choice

Literature

- Most cited/revered paper in this literature:
  - JOLE: Sjoquist and Winters (2015) use CPS data, finding that state merit-based aid programs reduce STEM production by 6.5%
  - Examines all 27 states with broad merit-based scholarships
  - Treats state programs as homogeneous
    - Program features vary widely across states
    - Is one figure really helpful to policymakers?

Literature

- Contribution to literature:
  - Examines the effect of the broadest, lowest-bar state merit aid program on college major choice
  - First paper to disaggregate how broad-based merit scholarships affect student engagement in STEM *by academic preparation*

Preview of Findings

- No overall effect of the lottery scholarship on:
  1. Choosing first major in STEM
  2. Earning a degree in STEM

- Well-academically prepared students declare majors in STEM more often as a result of the scholarship

- Less prepared students from low-income families less likely to declare majors in STEM

- Challenges literature treating state merit-based aid programs as homogenous

Theoretical Model

- Student *i* chooses major *j* if it maximizes expected lifetime utility, $E(U_{ij})$:

$$E(U_{ij}) = p_{ij}(\boldsymbol{X})e_{ij}(\boldsymbol{Z}) + \left(1 - p_{ij}(\boldsymbol{X})\right)e_{i0}(\boldsymbol{Z}), \quad i = 1, \dots, N; j = 1, \dots, m,$$

Where:

e_{ij} : expected lifetime earnings from major *j*

p_{ij} : expected likelihood of scholarship retainment when choosing major *j*

e_{i0} : expected earnings after losing scholarship and dropping out

$\boldsymbol{X}$: factors influencing probability of scholarship retainment

$\boldsymbol{Z}$: factors affecting earnings after college

Theoretical Model

- Student chooses major *j* if

$$E(U_{ij}) \geq E(U_{ik}) \text{ for all } k \neq j$$

- After some algebraic manipulation:

$$p_{ij}(\boldsymbol{X})\left[e_{ij}(\boldsymbol{Z}) - e_{ik}(\boldsymbol{Z})\right] + \left[p_{ij}(\boldsymbol{X}) - p_{ik}(\boldsymbol{X})\right]\left[e_{ik}(\boldsymbol{Z}) - e_{i0}(\boldsymbol{Z})\right] \geq 0$$

- Theoretical implications of the model:
  - When success probabilities are roughly equal, earnings differentials drive major choice
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Theoretical Model

$$p_{ij}(\boldsymbol{X})\left[e_{ij}(\boldsymbol{Z}) - e_{ik}(\boldsymbol{Z})\right] + \left[p_{ij}(\boldsymbol{X}) - p_{ik}(\boldsymbol{X})\right]\left[e_{ik}(\boldsymbol{Z}) - e_{i0}(\boldsymbol{Z})\right] \geq 0$$

- High academic preparation:
  - Success probabilities are high for all majors, so those with highest expected earnings would be chosen (i.e., STEM)
    - Earnings by major type here
- Low academic preparation:
  - Success probabilities vary considerably across majors, as do earnings differentials, so choice of major is less clear

Theoretical Model

$$p_{ij}(\boldsymbol{X})\left[e_{ij}(\boldsymbol{Z}) - e_{ik}(\boldsymbol{Z})\right] + \left[p_{ij}(\boldsymbol{X}) - p_{ik}(\boldsymbol{X})\right]\left[e_{ik}(\boldsymbol{Z}) - e_{i0}(\boldsymbol{Z})\right] \geq 0$$

- In the context of the lottery scholarship:
  - Is the bar set so low for scholarship renewal that success probabilities will be high for most students, so that more students will choose STEM?
  - Or, are scholarship renewal constraints binding, so that students will be less engaged in STEM fields?

Data

- Administrative data on all first-time, full-time University of New Mexico (UNM) students over the period 1995 – 1999
- 10,381 students
  - 9,281 residents (89%); 1,100 nonresidents (11%)
- Socio-demographics
  - age, race, gender, ethnicity, family income
- High school performance
  - HS GPA, ACT/SAT scores, required remedial coursework
- College performance
  - Major choice, credits earned, grades, date of graduation

Table 1. Student majors before and after initiation of the NMLLS program, First Major Declared and Major of Degree Earned, ACS Major Codes, 1995-1999

	Residents			Nonresidents		
Variable	Before	After	Diff.	Before	After	Diff.
First Major Declared:						
STEM	.246	.221	-.025***	.202	.150	-.052*
Liberal Arts	.161	.184	.023***	.221	.234	.013
Education	.088	.101	.013**	.069	.088	.019
Business	.079	.094	.015**	.064	.071	.007
Social Science	.113	.101	-.012*	.126	.116	-.010
Health-Related	.151	.114	-.037***	.128	.080	-.048*
Never Declared	.161	.183	.022***	.190	.261	.071*
Degree Type Earned:						
STEM	.108	.096	-.012*	.062	.056	-.006
Liberal Arts	.115	.100	-.015**	.114	.099	-.015
Education	.042	.032	-.010**	.021	.007	-.014*
Business	.075	.076	.001	.055	.046	-.009
Social Science	.073	.071	-.002	.057	.066	.009
Health-Related	.021	.025	.004	.012	.016	.004
Observations	2,741	6,540		421	679	

Source: Freshmen Tracking System, Office of Institutional Analytics, UNM. ***, **, and * represent statistical significance at the 1, 5, and 10 percent-levels, respectively. Standard deviations are in parentheses.

Table 2. Student characteristics before and after initiation of the NMLLS program, 1995-1999

	Residents			Nonresidents		
Variable	Before	After	Diff.	Before	After	Diff.
HSGPA	3.342 (.502)	3.272 (.472)	-.070***	3.288 (.520)	3.294 (.506)	.006
ACT	22.676 (3.869)	22.203 (3.894)	-.473***	22.583 (3.986)	22.903 (4.103)	.320
Remedial	.233	.283	.050***	.140	.216	.076***
Income < $40K	.228	.203	-.025***	.164	.161	-.003
Female	.565	.563	-.002	.525	.542	.017
Hispanic	.388	.373	-.015	.183	.165	-.018
Native	.042	.045	.003	.045	.050	.005
Asian	.047	.037	-.010**	.043	.027	-.016*
Black	.023	.023	< .001	.083	.080	-.003
Observations	2,741	6,540		421	679	

Source: Freshmen Tracking System, Office of Institutional Analytics, UNM. ***, **, and * represent statistical significance at the 1, 5, and 10 percent-levels, respectively. Standard deviations are in parentheses.

Data

- Difference-in-differences (DD) models
  - Residents are treatment, nonresidents are control
- Many observable differences between residents and nonresidents
  - Not problematic as long as common trends assumption holds
- This is supported both visually and empirically
  - Empirical tests of common trends assumption (here)

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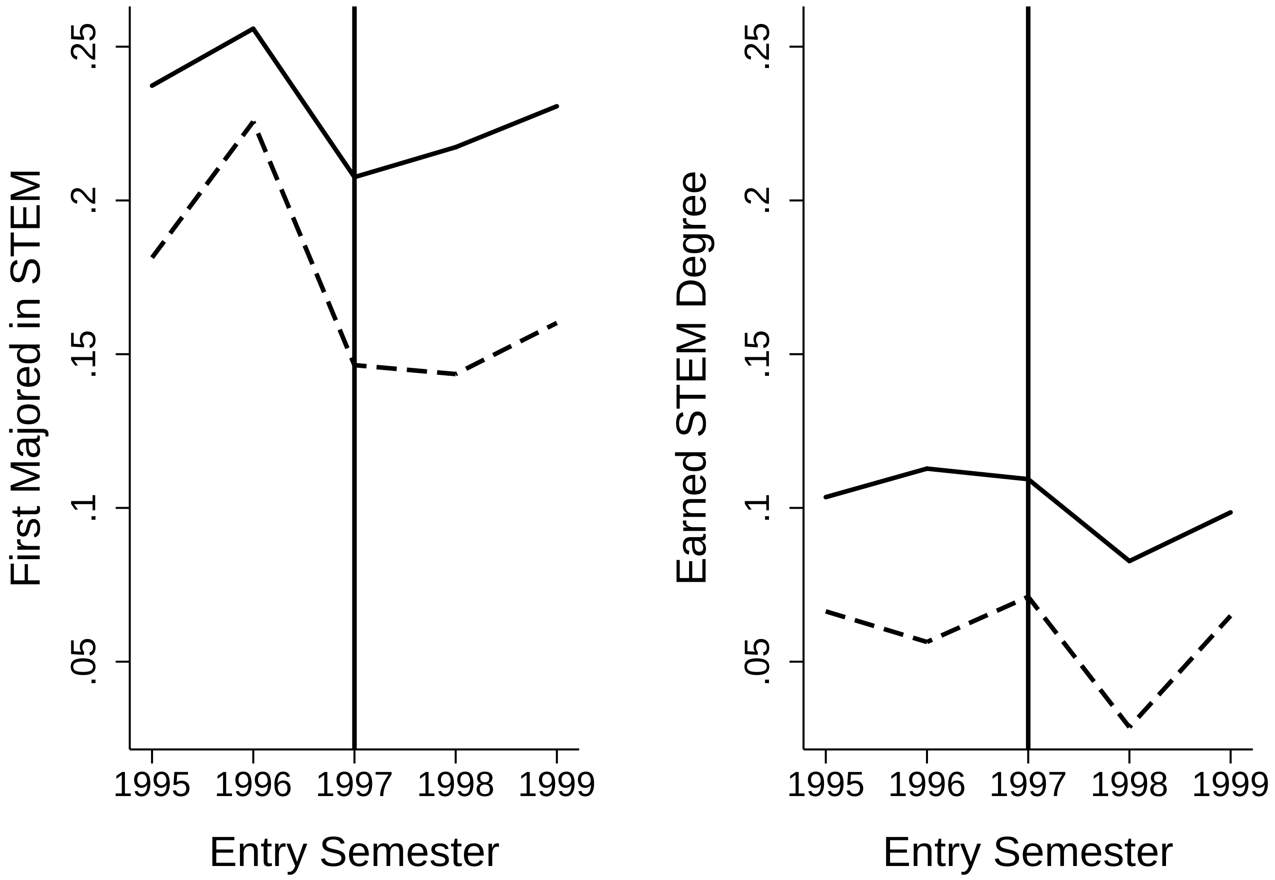

Note: Residents are represented as the solid lines; nonresidents as dashed lines.

Figure 1. Pre-post trends in first declaring a STEM major and earning a degree in STEM, 1995 – 1999

Data

- Majors categorized into STEM/non-STEM according to U.S. Census Bureau's American Community Survey (ACS)

- As a robustness check, also used "broad" and narrow" classification UNM's STEM Collaborative Center
  - ACS definitions are preferred because they're federally defined, sufficiently narrow, and are used in previous literature
  - UNM STEM Collaborative Center definitions are problematic…

Empirical Model

- Outcomes:
  1. Initial STEM major
  2. Earned STEM degree

- DD with kernel matching on the propensity score
  - Help balance residents and nonresidents on observables

- Awkward to predict propensity of being a state resident
  - All that matters is how well covariates are balanced (details here)

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Empirical Model

- Propensity scores estimated via logistic model including:
  - Cumulative high school GPA
  - Composite ACT score
  - Indicator of remedial college coursework
  - Indicators for family income less than $20,000 and $40,000
  - Gender
  - Race and ethnicity
  - Several interaction terms using selection criteria laid out in Imbens and Rubin (2015)
  - Results here

Empirical Model

- Kernel density matching is a one-to-many matching algorithm (more here)
- We choose it because we have significantly more treated units than control units (i.e., 8x as many)
  - With a simple nearest neighbor match, we would at most be able to include 22 percent of the sample in the matching algorithm
- Choice of bandwidth is critical
  - Higher includes more information (variance ↓), but also potentially more bad matches (bias ↑)

Table 5. NMLLS and major choice by academic preparation, American Community Survey definition, 1995-1999

Group	Obs.	First Declared STEM	Degree in STEM
Full Sample	9,804	.038	-.002
		(.032)	(.057)
$\bar{Y}$		.227	.099
HSGPA ≤ 3.28	4,780	-.034	.018
		(.038)	(.013)
$\bar{Y}$		.173	.040
HSGPA > 3.28	5,019	.123**	.005
		(.048)	(.033)
$\bar{Y}$		.278	.158
HSGPA > 3.78	1,886	-.016	-.018
		(.077)	(.061)
$\bar{Y}$		.334	.251

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1 percent-level, respectively. Estimates are from difference-in-differences kernel matching performed with a bandwidth of h = .2 using the Epanechnikov kernel function. We report estimates for students with below average or average high school GPAs (≤ 3.28), above average high school GPAs (> 3.28), and high school GPAs greater than one standard deviation above the mean (> 3.78). $\bar{Y}$ denotes the baseline rates of STEM major choice and STEM degree attainment by academic preparation.

Table 6. NMLLS and major choice by academic preparation, American Community Survey definition, 1995-1999, Family Income < $40,000

Group	Obs.	First Declared STEM	Degree in STEM
Full Sample	2,003	-.021 (.074)	-.006 (.035)
$\bar{Y}$		.221	.077
HSGPA ≤ 3.28	978	-.157** (.078)	.007 (.026)
$\bar{Y}$		.167	.028
HSGPA > 3.28	1,018	.244** (.118)	.028 (.070)
$\bar{Y}$		.274	.124
HSGPA > 3.78	361	-.058 (.269)	-.197 (.232)
$\bar{Y}$		.325	.224

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1 percent-level, respectively. Estimates are from difference-in-differences kernel matching performed with a bandwidth of h = .2 using the Epanechnikov kernel function. We report estimates for students with below average or average high school GPAs (≤ 3.28), above average high school GPAs (> 3.28), and high school GPAs greater than one standard deviation above the mean (> 3.78). $\bar{Y}$ denotes the baseline rates of STEM major choice and STEM degree attainment by academic preparation.

Table 7. NMLLS and major choice by academic preparation, American Community Survey definition, 1995-1999, Family Income ≥ \$40,000

Group	Obs.	First Declared STEM	Degree in STEM
Full Sample	7,792	.040	-.002
		(.036)	(.022)
$\bar{Y}$		.228	.106
HSGPA ≤ 3.28	3,791	-.023	.021
		(.050)	(.016)
$\bar{Y}$		.175	.043
HSGPA > 3.28	3,997	.090*	-.001
		(.052)	(.036)
$\bar{Y}$		.279	.168
HSGPA > 3.78	1,525	-.023	.008
		(.078)	(.066)
$\bar{Y}$		.336	.258

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1 percent-level, respectively. Estimates are from difference-in-differences kernel matching performed with a bandwidth of $h = .2$ using the Epanechnikov kernel function. We report estimates for students with below average or average high school GPAs (≤ 3.28), above average high school GPAs (> 3.28), and high school GPAs greater than one standard deviation above the mean (> 3.78). $\bar{Y}$ denotes the baseline rates of STEM major choice and STEM degree attainment by academic preparation.

Robustness Checks

- Using UNM STEM Collaborative Center definitions produced similar results attenuated in both magnitude and statistical significance.
- Alternative smoothing parameters in the matching algorithm produced very similar results
  - Results found here
- Using 1995 – 2000 cohort produced similar results
  - Results found here

Results

- Low-bar initial continuing/eligibility requirements may have induced a compositional change in the student body

- Possible chain of events for marginally-prepared students:

1. NMLLS removes price signals from higher education market
    2. College-going decisions distorted
        3. Students overmatch to max. “value” of NMLLS
            4. Academic preparation changes

Conclusions

- No evidence of any overall effect on either
  1) choosing STEM as first major
  2) completing a degree in STEM
- Academically well-prepared students seem to first declare a major in STEM more often as a result of the NMLLS
  - Opposite response for the less academically-prepared from low-income families
- Such programs may alter the composition of who majors in STEM

Conclusions

- STEM degree production may not be affected at UNM due to the low-bar nature of the NMLLS
  - Academic performance constraints may not be binding
- Changes in student composition may also be affecting results
  - Results appear to be driven by students from low-income families
- Program features matter!
  - Policymakers: broad merit scholarship programs not certain to curtail STEM degree production, esp. if renewal requirements are low

Thank You

- Thank you for your time
- Questions?
- Contact the author at:
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