State Merit Aid and the Supply Curve of Higher Education

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Abstract

Financial aid is ubiquitous in higher education. A fundamental goal of giving financial aid to students is to lessen financial barriers to attending higher education. An unintended consequence of increasing financial aid generosity is that higher education institutions may raise prices in response to higher demand for their services. Previous research largely focuses on estimating price responses to increases in financial aid generosity. We estimate the elasticity of supply of higher education to quantify institutions' response to changes in state-sponsored merit grant programs. Our approach has two main advantages: the elasticity of supply determines the price response, and it captures institutions' ability to respond to changes in financial aid policy by changing enrollments. We find that public four-year institutions have an estimated elasticity of supply of 2.1 and private non-profit four-year institutions have an estimated elasticity of 1.31. Based on these results, we conclude that the institutional response to these programs did not inhibit their intended effect of increasing postsecondary enrollments.

Keywords: Higher education, Financial aid, Bennett Hypothesis

JEL Codes: I2, H2, H3

1 Introduction

Increases in the cost of attendance at American colleges and universities have outpaced the rate of inflation for many years. Average published tuition and fees at public four-year institutions doubled between academic years 1999-2000 and 2018-19 (Ma et al. 2019). Over the same period, financial aid to students has risen substantially as policymakers have become more concerned with the accessibility of higher education; federal and state governments spent $164 billion on financial aid (comprised of both grants and loans) in 2018-19. With such a substantial investment of public resources, it is important to evaluate the costs and benefits of publicly-funded financial aid programs. A full accounting of these programs must include the institutional responses to understand the impacts on student welfare. Studies in the literature that evaluate institutional responses to financial aid primarily focus on subsequent price increases. We take a different approach by estimating the short-run elasticity of supply of higher education. We do so using state merit grant expenditures as a source of plausibly exogenous variation in the demand for higher education across states while holding the supply curve fixed.

Our analysis of the institutional responses to changes in financial aid explicitly focuses on supply and demand for higher education which subsequently determines the prices institutions charge. Previous work in the literature largely focuses on the price response to financial aid programs. Researchers motivate this approach with the (sometimes implicit) assumption that institutions face frictions in expanding enrollment capacity in the near term and therefore the primary margin of adjustment to changes in demand is increasing tuition, not enrollments. We estimate the short-run elasticity of supply of higher education rather than assume it is inelastic. Further, our approach reframes how we should expect institutions to respond on price to increases in financial aid generosity.

Expanding financial aid, by either making more students eligible or increasing the award amounts for existing programs, is a positive shock to demand for higher education since financial aid lowers the net price paid by aid recipients. If institutions have upward-sloping supply curves and students have downward-sloping demand, then basic supply and demand theory tells us that a price increase following financial aid expansion is a natural market outcome. Institutions may also expand to meet the increased demand for their services depending on the slope of the supply curve and the magnitude of the demand shock. A price increase following a demand shock is a market outcome; its determinants are the magnitude of the demand shock and the shape of the supply curve. Given this, the parameter of interest which more fully captures the supply-side response is the elasticity of supply.

Much of the previous work on the literature studying institutional responses to changes in financial aid focuses on price increases (Black, Turner, and Denning 2023; Kramer, Ortagus, and Lacy 2018; Lucca, Nadauld, and Shen 2019; Turner 2017; Welch 2014).[1] Often cited is the "Bennett Hypothesis" (Bennett 1987), a claim by former Secretary of Education William Bennett that institutions raise their prices by the full amount of increases in financial aid, leaving students no better off. But as we just argued, institutions should increase prices in response to an increase in financial aid that generates a sufficiently large increase in demand for higher education. Given this, the Bennett Hypothesis as a claim about price increases is not very interesting economically. This is not to say that quantifying price increases caused by financial aid policy is not important for understanding how these programs affect student welfare. Rather, we suggest reframing the Bennett Hypothesis as a statement that institutions have perfectly inelastic supply curves. If this is the case and policymakers allocate more money to financial aid programs, then institutions will not increase enrollments and they will raise prices such that students are left paying the same out-of-pocket price. Financial aid is less effective at achieving policy goals of reducing prices for students and increasing access to higher education the more inelastic institutions' supply curves are. Our formulation of the Bennett Hypothesis more closely aligns with supplier behavior and is more informative for policy.

We are the first paper to estimate the short-run elasticity of supply of higher education which we label ϵ. Our conceptual framework is to leverage the implementation of state merit grant programs in the 1990s and 2000s as plausibly exogenous cross-state variation in demand for in-state higher education, while holding the supply curve fixed, to identify ϵ. We are able to control for a number of factors that might shift the supply curve, like governmental appropriations, in our empirical analysis and we discuss whether other factors like technical changes may be shifting the supply curve in Section 3. We motivate our approach of estimating the elasticity of supply by using a simple supply and demand framework which we present in Section 3. The key contribution of

1. Black, Turner, and Denning (2023) and Lucca, Nadauld, and Shen (2019) also estimate changes in enrollments.

this paper is estimating ϵ instead of imposing assumptions on its value (i.e. $\epsilon < 1$) and focusing on estimating price changes in response to a change in financial aid policy. We also reframe the Bennett Hypothesis from a statement about pricing behavior to a claim that the elasticity of supply of education is perfectly inelastic. When higher prices are understood as the natural market outcome, the more pertinent approach to understanding the supply response to financial aid policy is to estimate the elasticity of supply. We also contribute to the literature on evaluating merit grant programs. Previous studies only consider a subset of state merit grants in their analyses and parameterize treatment using a single post-treatment dummy variable. We allow for the impact of a merit grant program to vary with its per-student generosity; accounting for differences in generosity is important as there is significant variation in spending levels across programs. We also study the supply response among public two-year institutions whereas previous studies focus on the public and private four-year sectors.

We find that public four-year and private not-for-profit four-year (hereafter referred to as private) institutions have elastic supply curves (around the pre-merit grant equilibria). Our baseline estimates reveal that public four-year institutions have an estimated elasticity of supply of 2.1 and private institutions have an estimated elasticity of supply of 1.31. Our baseline estimate is 1.36 for public two-year institutions, although point estimates for this sector vary significantly in robustness checks. We find suggestive evidence that some institutions within the private sector have inelastic supply curves although we lack power to precisely estimate heterogeneity in supply curves in most subsector analyses. Overall, our results find that four-year not-for-profit institutions do increase prices following increases in per-enrolled undergraduate merit grant expenditures, but first-time first-year resident enrollments increase by about 2.1% and 1.3% for each 1% increase in net prices at public and private institutions, respectively. Based on these findings, it appears inappropriate to assume that the supply response is inelastic, at least in the case of merit grant programs. This finding suggests that merit grant programs were successful in increasing access to higher education. It also suggests that the institutional response to merit grant programs enhanced aggregate student welfare. Further, our results constitute evidence against our reformulated version of the Bennett Hypothesis given that we consistently estimate elastic supply curves among public and private institutions. We reject the idea that institutions are "capturing" financial aid dollars, at least in response to the merit grant programs we study. Rather, prices rise after merit grant implementation because institutions are moving upwards along their supply curves to meet greater demand.

2 Background

State-sponsored merit grant programs reward state residents who attend in-state higher education institutions for demonstrated academic success. They provide financial aid to high achieving students who graduate from a high school in the state. These programs generally condition eligibility on having a high school grade point average (GPA) above a threshold, frequently 3.0, or scoring above a threshold on standardized tests. Financial need or (family) income is not considered for program eligibility. Many of these programs also require recipients to maintain a college GPA above a threshold to renew eligibility. Recipients can use their award to pay for tuition and fees, with some grants allowing recipients to use their award to pay for additional expenses like room and board and textbooks. Some grant programs offer more generous awards for attending public in-state institutions than for attending private in-state institutions.[2] Policymakers aim to achieve several goals with merit grants. Merit grants incentivize improved academic performance by financially rewarding students for achieving a certain test score or GPA. Merit grants are also a policy lever for a state to retain its "best and brightest." States typically limit eligible institutions to those in the state.[3]

Arkansas was the first state to implement a merit grant in 1991. Initially it was not a very generous grant although program eligibility and generosity were both later expanded. Georgia is typically credited with pioneering merit grants for its Helping Outstanding Pupils Educationally (GAHOPE) scholarship which it enacted in 1993. The GAHOPE scholarship fully covers tuition and mandatory fees at public Georgia institutions for Georgia residents who graduate high school with at least a 3.0 GPA. The GAHOPE program began as a request by then-governor Zell Miller to the state legislature to enact a state lottery whose proceeds would go towards education (Dynarski 2000). The GAHOPE scholarship was a pathbreaking financial aid program and several states followed suit. The nature of HOPE's creation suggests it was an experiment in higher education policy that propogated to other states. Most merit grant programs were implemented in the mid-

2. This could cause merit grant expenditures to be weakly correlated with demand for private institutions. We investigate this concern in the Results section.

3. Or, additionally, institutions in other states that share a reciprocity agreement. We do not account for reciprocity agreements here.

1990s or 2000s (Sjoquist and Winters 2015). Merit grants are often funded by state lotteries or tobacco settlement funds (Heller and Marin 2004) rather than by states' general revenues. Some programs can be quite generous. The GAHOPE scholarship, for example, covers up to 100% of tuition for recipients. State-specific average per-student merit grant expenditures are shown in Appendix Table A1.

Previous studies categorize merit grant programs as "strong" or "weak" based on program participation rates and levels of per-student expenditures (Kramer, Ortagus, and Lacy 2018; Sjoquist and Winters 2015; Welch 2014). Strong merit grants have high program participation rates and substantial per-student expenditures. For example, the New Mexico Lottery Success Scholarship, which Sjoquist and Winters (2015) classify as a strong program, had per full-time-equivalent (FTE) student expenditure of \$494.67 and 20.71% of FTE students received an award in 2010 (see Table 1 from Sjoquist and Winters 2015). Oklahoma's PROMISE scholarship is classified as weak for its 11.89% participation rate and \$58.33 average award per FTE student.

3 Conceptual Framework

The quote that constitutes the Bennett Hypothesis is, "increases in financial aid in recent years have enabled colleges and universities blithely to raise their tuitions, confident that Federal loan subsidies would help cushion the increase" (Bennett 1987). Previous studies in the literature frame their work as empirically testing the Bennett Hypothesis by examining whether aid-eligible institutions raise their prices in response to the implementation of financial aid programs. To be sure, understanding how institutional pricing responds to changes in financial aid policy is important for quantifying how financial aid affects student welfare and access to higher education. This paper departs from the literature by noting that price increases in response to program implementation by themselves are not sufficient evidence in favor of the Bennett Hypothesis — a full accounting of the institutional supply response must consider how enrollments change as well. An increase in net tuition may not be a desired outcome but it is an economically rational one in our framework. We now present the framework we use to understand and analyze the supply response to changes in demand for higher education.

Consider the following simple supply and demand framework for the higher education sector.

All else equal, the implementation of a merit grant should increase demand for in-state higher education by reducing the net price (cost of attendance less financial aid) for grant recipients. This increase in demand could arise from two sources: students substituting in-state for out-of-state higher education when they earn a merit grant and marginal students who enroll only when they receive a merit grant.[4] To the extent that institutions have upward sloping supply curves because they face increasing marginal costs of supplying education services, then one should expect that the price of these services should increase when demand rises. Given this, finding that prices increased following an expansion in financial aid generosity is necessary, but not sufficient, evidence in favor of the Bennett Hypothesis. One must also consider whether institutions expanded to meet the increase in demand. The elasticity of supply, along with the magnitude of the demand shock, governs the degree to which prices increase and the number of seats institutions are willing to provide following an increase in demand for their services. The elasticity of supply more fully captures the supply response to changes in financial aid policy and it is the parameter that ought to be estimated when studying the institutional response to changes financial aid policy or, more generally, changes in demand. Institutions would fully capture the increase in financial aid generosity, as the Bennett Hypothesis claims, without expanding enrollments if they have perfectly inelastic supply curves., i.e. $\epsilon = 0$.

We illustrate our framework in Figure 1. Panel A models a scenario where institutions have elastic supply curves and Panel B models the case where institutions have inelastic supply curves. Figure 1 highlights that prices *should* rise when demand shifts out.[5] The magnitude of the equilibrium price change is determined by the size of the demand shock which is usually measured as financial aid program expenditures and the elasticity of supply. When demand increases, prices increase by less and enrollment increase by more when supply is elastic relative to the inelastic case. We implement our conceptual framework and estimate the slope of the supply curve for undergraduate higher education by leveraging cross-state differences in merit grant generosity as variation in demand shocks for higher education, while holding the supply curve fixed, to estimate the elasticity of supply of higher education.

Crucial for our approach is that we hold the supply curve fixed while demand is shifting. Other

4. Zhang and Ness (2010) find that merit grants are successful in raising resident enrollments.
5. With the exception of the unlikely case where institutions have perfectly elastic (i.e., horizontal) supply curves.

factors that may shift the supply curve are technological changes, changes in input costs, government regulations, and changes in expectations. The shift to offering courses virtually represents both a technological change and a decrease in the costs of providing instruction. We do not believe online courses shift the supply curve given that our sample ends at the 2018-19 academic year, before the COVID pandemic induced many institutions to increase their virtual course offerings, and because we are studying institutions that primarily offer in-person instruction. Many institutions have shifted their faculty composition towards more contingent faculty (Hemelt et al. 2021) to reduce instructional costs. We control for total instructional expenditures in our analysis to account for changing faculty composition. We also control for the state unemployment rate to control for variation in non-instructional labor costs. We are focusing on government regulation in the form of subsidies to students but other policy changes may be occurring during our sample window. We control for per-student Pell Grant expenditures in our analysis as the Pell Grant is the largest grant program by dollars spent. We are not aware of events during our sample window that changed institutions' expectations.

Figure 1: Impact of a Financial Aid Expansion on Tuition and Enrollments

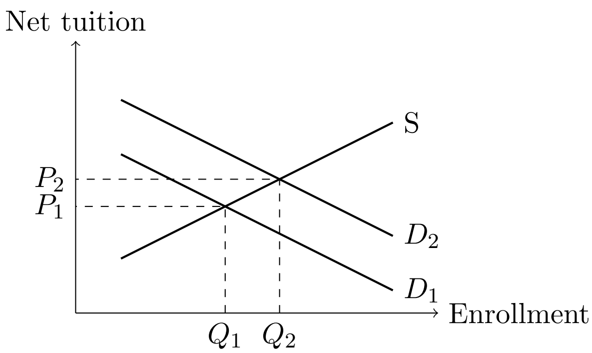

Figure 1a: Elastic supply

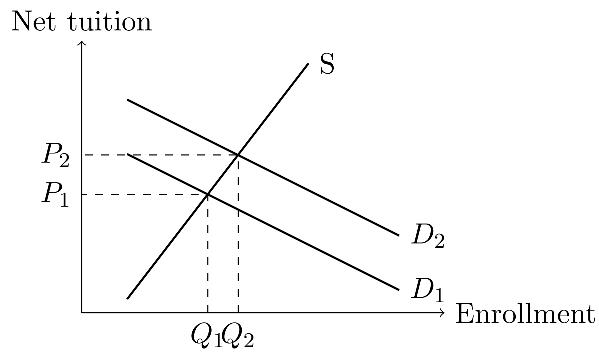

Figure 1b: Inelastic supply

This framework is useful in its market-based approach to studying higher educational responses to changes in demand, but it abstracts from two important aspects of the higher education market. First, the institutions we study here (public and private not-for-profit institutions) are likely not setting prices to maximize profits. Second, this is a matching market which clears through admissions policies, not through prices that equate seats demanded to seats supplied. We are agnostic on the nature of their objective function. What is important for the validity of our approach is that institutions do indeed face increasing marginal costs. While these institutions may not be setting the profit-maximizing price, we believe that it is costly to maximize whatever their objectives are and they are sensitive to changes in their revenues, of which tuition is a major component, and costs.[6] Our analysis relies on institutions facing a cost structure and optimizing subject to increasing marginal costs. With regards to admissions policies, one can think of the relevant demand as the demand from admitted students.

4 Literature Review

Previous work has studied the institutional responses to changes in financial aid policy in a wide range of settings. We primarily focus our review on studies of grant programs since we study grant programs. Turner (2017) studies the incidence of the Pell Grant using regression discontinuity and kink designs with student-level data and finds that between 11 and 20% of Pell dollars are passed through to institutions via higher prices. Long (2004) estimates the incidence of the GAHOPE scholarship by comparing changes in outcomes at Georgia institutions to changes in outcomes at other southeastern institutions with a difference-in-differences design. She finds that, on average, prices at public institutions did not increase, although room and board rates did rise, while private Georgia institutions raised prices by 3.2% and decreased financial aid offers. Private institutions with many GAHOPE recipients raised net prices by 30 cents per GAHOPE dollar. Welch (2014) and Kramer, Ortagus, and Lacy (2018) both study the effects of strong merit grant programs on prices at the national level using difference-in-differences designs. Welch (2014) finds no evidence that in-state public or private institutions raised their prices in response to the implementation of a strong merit grant program.[7] Kramer, Ortagus, and Lacy (2018) find differential responses for in-state tuition across tuition-setting authority. Public institutions that are able to set their tuition rates and are in states that implement a strong merit grant program increase tuition by

6. Structural models of the higher education market have not modeled institutions as profit maximizers. Epple et al. (2017, 2019) model private institutions as quality maximizers where quality is a function of student body ability and educational expenditures and public institutions as maximizing the welfare of its in-state students. Fu (2014) models private institutions as maximizing a weighted average of student ability and net tuition revenues. Public institutions also maximize a weighted average of student ability and net tuition revenues, but with different weights placed on the net tuition and abilities of in-state and out-of-state students. Blair and Smetters (2021) define the objective function of elite institutions as a weighted average of net tuition revenues and their relative acceptance rate (relative to their peer institutions).

7. Kramer, Ortagus, and Lacy (2018) study the merit grant programs of Georgia, Florida, Kentucky, Louisiana, New Mexico, Nevada, South Carolina, Tennessee, and West Virginia. Welch (2014) studies the same set of programs as Kramer, Ortagus, and Lacy (2018) with the addition of Michigan's merit grant program.

5 to 6% following implementation compared to public institutions in merit-adopting states that do not set their tuition. This set of results suggests that prices rose only somewhat following the implementation of state merit grants. This weak price response could be because merit grant programs constitute a weak shock to student demand for higher education or because the eligible institutions have elastic supply curves; they expand to meet greater demand without substantially raising prices.

While most studies focus on institutional price responses, some estimate changes in enrollment as well. Looking at these two outcomes together provides more insight into the nature of the institutional response. Lucca, Nadauld, and Shen (2019) study the institutional response to increases in the maximum Pell Grant award and federal loan. They estimate a pass-through rate between 0.55 and 0.65 of Pell Grant dollars to list price and a 1.5% increase in enrollment in response to a $100 increase in the average Pell Grant per full-time-equivalent undergraduate. Together, these results suggest an elasticity of supply of higher education of 1.68.[8] They estimate statistically insignificant increases in enrollment of 0.6% and -0.02% associated with $100 increases in average federal subsidized and unsubsidized loans per full-time-equivalent undergraduate. While the authors view their results as evidence in favor of the Bennett Hypothesis because of the statistically and economically significant pass-through rates, we would reject the Bennett Hypothesis in the case of Pell Grants based on the implied elastic supply response to increases in Pell Grant awards. The authors note that institutions may face obstacles in expanding enrollment capacity in the short run; while prices did rise, their results suggest that full-time equivalent enrollments increased by 1.68% per 1% increase in net price.

Other studies have found null and even negative effects of financial aid on enrollments. Black, Turner, and Denning (2023) find that net prices increased by 64 cents per additional dollar of Grad PLUS borrowing with no corresponding change in enrollments. These findings suggest an inelastic supply response. While grants decrease the out-of-pocket cost to the recipient, loans do not change

8. The authors note that the data on institutional grants are noisy and estimated pass-through rates of Pell Grant dollars to net prices are not fully robust to the inclusion of controls. We take their point estimates at face value for the purpose of this back-of-the-envelope calculation. Then, their results suggest that $\frac{1}{Enrolls}\frac{dEnrolls}{d\Delta Pell} = 0.015/100$ and $\frac{dNetPrice}{d\Delta Pell} = 0.954$ $(0.577 + 0.377$, Table 10). Then, using $10,691 as the average net price from their sample (Table 3), $\epsilon = \frac{dEnrolls}{dNetPrice} \cdot \frac{NetPrice}{Enrolls} = \frac{0.015/100}{0.954} \cdot 10,691 = 1.68$. While estimating ϵ in this manner likely suffers from simultaneity bias that arises from tuition and enrollments co-moving, this calculation highlights how estimating ϵ versus estimating changes in tuition and enrollments separately matters for understanding the institutional response to changes in demand.

the cost to the student and must be repaid, which suggests that this particular policy change may not strongly boost demand for graduate education.[9] The characteristics of the market for graduate education may also differ from those of the undergraduate market in important ways. Baird et al. (2022) find that prices at for-profit institutions increased by one cent per dollar increase in the Post 9/11 GI Bill (PGIB) financial aid benefits for veterans. In addition, they estimate that enrollment at for-profits decreased by 2.8 students per $100 increase in PGIB benefits. The authors interpret this result as for-profits raising prices on non-veterans which lowered non-veteran enrollment. The other financial aid programs studied in the literature and in our paper, such as federal financial aid programs and state merit grant programs, have larger eligible student populations and thus likely generate a larger demand increase than the PGIB policy change that Baird et al. (2022) study.

We contribute to the literature by taking a new approach to evaluating the institutional response to financial aid programs. Studies in the literature focus on estimating price changes and, more recently, changes in enrollment. Motivating this approach is the belief that institutions face short-run frictions to expanding enrollment capacity which generates an inelastic supply response. We estimate the elasticity of supply of higher education without imposing any assumptions about the shape of the supply curve of higher education. This parameter encapsulates both the price and quantity margins of the institutional response to a financial aid policy change. We motivate our approach with a straightforward market-based framework of undergraduate higher education. Within our framework, the Bennett Hypothesis as traditionally understood is not an economically controversial claim. We reformulate the Bennett Hypothesis as a statement that institutions of higher education have perfectly inelastic short-run supply curves. We also contribute to the literature evaluating merit grant programs. We expand the set of merit grant programs that has been studied beyond the quite generous and widely available programs. We also allow for the effect of merit grant programs to vary by their per-student generosity whereas previous studies impose the assumption of homogeneous treatment effects of merit grant programs exposure.

9. The authors find the Grad PLUS expansion shifted graduate borrowing from private to federal sources. This may decrease the cost to the student if the federal loans offer lower interest rates.

5 Data

The primary data source for our analysis is the Integrated Postsecondary Education Data System (IPEDS) data set. IPEDS collects a wide range of data from Title IV postsecondary institutions (institutions where students are eligible to receive federal financial aid). We use the Urban Institute's EducationData application programming interface (API) to assemble the IPEDS data into a panel of institutions' attributes, cost of attendance, enrollments, and revenue sources. The panel spans the academic years beginning in the fall of 1986 through 2018. Table 1 presents summary statistics of IPEDS variables for the analytic sample. Federal per-student revenues at public and private institutions are nearly the same. Public institutions rely more on revenues from state and local governments whereas private institutions rely more on revenues from private sources. We measure the enrollment of first-time first-year resident students who graduated from high school in the past 12 months. Institutions mandatorily report these data in even-numbered years (resident enrollments were not surveyed in 1990). About a third of institutions voluntarily report resident enrollment data in odd-numbered years. We restrict our sample to the even-numbered years in which IPEDS mandates institutions report enrollments by state of residence to avoid potential issues of endogenous reporting. We end our sample window at the 2018-19 academic year because it is the last year before the 2020 COVID pandemic that institutions mandatorily report enrollments by state of residence. List price (tuition plus mandatory fees) is significantly higher at private institutions. There are 567 public four-year institutions, 1,006 private institutions

Institutions in IPEDS that have multiple campuses sometimes report financial data for the entire system. Other multi-campus institutions report financial data separately for each campus. How institutions report finance data to IPEDS data depends on how the institution is registered with the federal Department of Education. This data reporting pattern is called "parent-child reporting" (PCR). We allocate finance variables by each campus' percentage of total system enrollment to account for PCR and make reported finance data comparable across institutions. A full explanation of how we handle PCR can be found in the Appendix and the topic is covered extensively by Jaquette and Parra (2014).[10] After allocating finance variables to account for PCR, we limit the sample to institutions in the 50 American states that are active and open to the public. We further limit

10. While worth acknowledging, PCR is not overly prevalent in the sample. Only 2.8% of institution-year observations in the sample are flagged as parent institutions and 7% as children.

the analytic sample to school-year observations that are not missing data on cost of attendance, enrollments, parent-child linkages, or institutional sector. Lastly, we limit the sample to four-year public, private four-year not-for-profit, and two-year public institutions. The result of these selection criteria is a panel containing 574 public four-year institutions, 1,013 private not-for-profit institutions, and 929 public two-year institutions in the analytic sample.

Table 1: Summary statistics for institutions by institutional sector

Institutional sector	Variable	Mean	SD
Public 4-year institutions	In-state Tuition + Mandatory Fees	3913.45	3357.68
	Average institutional grant	816.22	1252.61
	First-time first-year resident enrollees	1207.01	1154.46
	Per-student revenue from federal govt	2533.65	3708.91
	Per-student revenue from state and local govt	5622.92	7600.64
	Per-student revenue from private sources	527.57	1077.35
	Average Pell grant award	783.35	778.10
	Number unique instutions: 574		
Private institutions	Tuition + Mandatory Fees	14004.41	11149.03
	Average institutional grant	5453.77	8440.21
	First-time first-year resident enrollees	203.4	219.69
	Per-student revenue from federal govt	2624.73	15301.15
	Per-student revenue from state and local govt	511.91	1500.40
	Per-student revenue from private sources	4146.05	16722.87
	Average Pell grant award	811.08	1031.24
	Number unique instutions: 1013		
Public 2-year institutions	In-state Tuition + Mandatory Fees	1981.12	1710.59
	Average institutional grant	173.12	350.90
	First-time first-year resident enrollees	584.71	657.12
	Per-student revenue from federal govt	1465.27	1284.85
	Per-student revenue from state and local govt	3825.64	3497.92
	Per-student revenue from private sources	92.77	261.36
	Average Pell grant award	935.03	885.46
	Number unique instutions: 929		

Note: All dollar-valued variables are real 2016 dollars.

We obtain state-year counts of undergraduate enrollment and the number of 18 through 24 year olds from the October Current Population Survey (CPS) and and state-year unemployment rates from the Bureau of Labor Statistics. We obtain data on annual state merit grant expenditures from the National Association of State Student Grant & Aid's (NASSGAP) Annual Survey Reports beginning in 1998. We define merit grant expenditures as expenditures on a grant with eligibility only based on merit. We identify program implementation dates using Table 1 from Sjoquist and

Winters (2015). Data on annual state merit grant expenditures in years prior to 1998 were sourced from state government reports.[11] Data on the Georgia HOPE grant for 1994 — 1997 reflect state appropriations, not expenditures, and were provided to the authors by the Georgia Governor's Office of Planning and Budget. We linearly interpolate expenditures for Utah in 2002 and 2003, the first two years of Utah's merit grant program which are the only two data points that we could not find published expenditures for.[12] Annual state merit grant expenditures per enrolled undergraduate student, the independent variable of interest, are calculated by dividing expenditure data from NASSGAP by the estimated number of undergraduates in a state-year from the CPS. We use undergraduate counts from the CPS rather than IPEDS becaise this yields more reasonable per-student expenditure levels. Enrollment figures in IPEDS do not reflect the full student body since non-Title IV institutions are not required to report their data. Results are qualitatively unchanged when using data on undergraduate counts from IPEDS. Implementation dates and average per-student merit grant expenditures are presented in Appendix Table A1. All dollar-valued variables are deflated to real 2016 dollars using the Consumer Price Index.

Some states are reported in the NASSGAP data as spending money on a merit grant for only a one- or two-year spell. Some of these states fund a more substantial, lasting merit grant program in subsequent years. We define a state as having a merit grant in place in a given year if it is reported as spending any money on a merit grant in at least three out of five years on a rolling basis. This rule helps more accurately define which states are considered to have implemented a merit grant program and when a state implements a merit grant program. This eliminates 18 instances of a state having non-zero annual merit grant expenditures and shifts five states (California, Connecticut, Kansas, Maine, and Virginia) from being ever-treated to never-treated.[13] Our results are robust to estimating the model with or without using this rule for defining merit grant implementation. There are 37 states that ever spend money on a merit grant and 19 of those states continuously fund their merit grant after implementation.[14] Weak merit grant programs are typically not generous

11. These reports are linked in the publicly available code for this project.

12. In results not shown in the paper, we confirm that our results are unchanged when we zero out these pre-1998 merit grant expenditures. Our results are also qualitatively unchanged when we exclude years before 1990 from the sample.

13. The 13 never-adopting states are Arizona, California, Connecticut, Hawaii, Kansas, Maine, Minnesota, Nebraska, New Hampshire, Oregon, Rhode Island, Virginia, and Wyoming.

14. Some states do implement a merit grant program that is later defunded. Presumably, the defunding of a merit grant program generates a negative shock to demand for higher education which can be used to identify the elasticity of supply. One may be concerned that the decision to defund a merit grant program is endogenous. Michigan is one

in per-enrolled undergraduate terms, although Alaska and Arkansas have average expenditures more similar to the strong merit grant programs. They are weak programs because they both have participation rates below 5% (Sjoquist and Winters 2015). A merit grant program could have low per-student expenditures because the aid packages are small on average or because they offer generous awards to only a small subset of students. South Carolina has the highest average per-student expenditures at $828.78. The average per-student merit grant award conditional on one being in place is $221.74.

6 Empirical Strategy

The parameter of interest is ϵ, the short-run elasticity of supply of higher education. We measure price as tuition plus mandatory fees minus the average institutional aid award, henceforth the net price P. We measure quantity, Q, as the number of first-year, first-time resident enrollments at an institution. We believe this is the appropriate measure since state merit grant awards are only available to resident students attending in-state institutions. If net price and (resident) enrollments are determined independently, conditional on observable factors, then ϵ is identified and can be estimated with ordinary least squares (OLS) in the model

$$ln(Q_{ist}) = \epsilon ln(P_{ist}) + \delta X_{ist} + \gamma S_{st} + \mu_s + \tau_t + \varepsilon_{ist}. \tag{1}$$

Estimates of ϵ from equation 1 are biased if price and quantity are simultaneously determined which we believe to be the case. We operationalize our conceptual framework using a simultaneous equation model (SEM). Consider the following structural supply and demand equations:

$$ln(Q^d_{ist}) = \beta_1 ln(P_{ist}) + \delta_1 X_{ist} + \gamma_1 S_{st} + \mu_s + \tau_t + v_{ist} \tag{2}$$

$$ln(P_{ist}) = \beta_2 ln(Q^s_{ist}) + \delta_2 X_{ist} + \gamma_2 S_{st} + \mu_s + \tau_t + u_{ist} \tag{3}$$

where equation 2 specifies the natural logarithm of the quantity of seats demanded at institution i

such state that defunds their merit grant program. This occurred because policymakers funded the program with a tobacco settlement fund which was exhausted after four years of providing the grant. In this case, defunding is likely exogenous, but other states may decide to re-allocate lottery or tax revenues which may be endogenous to tuition or enrollments.

in state s and year t as a function of the natural log of average net price, a vector of institution-level characteristics X_{ist}, state-year level variables S_{st}, and state and year fixed effects, μ_s and τ_t respectively. Equation 3 is the corresponding supply equation which specifies the natural log of the price set by institutions as a function of the natural log of the quantity supplied and observable characteristics and X_{ist} and S_{st} and state and year fixed effects. Conditional on institutions' admissions policies, the market for undergraduate higher education is in equilibrium when they charge prices P_{ist} such that $Q^s_{ist} = Q^d_{ist}$ for all institutions i. The coefficient of interest is β_2 which is the inverse of ϵ. A full set of results from estimating equations 2 and 3 are shown in Appendix Table A3. The simultaneity bias that exists in equation 1 arises in equations 2 and 3 when P_{ist} and v_{ist} are correlated.

We estimate the system of equations 2 and 3 using two-stage least squares (TSLS). We assume that supply and demand are log-linear. We use per-student merit grant expenditures as an instrumental variable (IV) for price in the first-stage demand equation. The first-stage equation is

$$ln(Q^d_{ist}) = \alpha MeritExpPerStudent_{st} + \delta_1 X_{ist} + \gamma_1 S_{st} + \mu_s + \tau_t + v_{ist}$$

We report results from estimating the first-stage in Appendix Table A3. We then estimate the supply equation in the second stage using the fitted values of $ln(Q^d_{ist})$ from the first stage:

$$ln(P_{ist}) = \beta_2^{TSLS} \widehat{ln(Q^d_{ist})} + \delta_2 X_{ist} + \gamma_2 S_{st} + \mu_s + \tau_t + u_{ist}$$

When estimating the system for public institutions, X_{ist} contains per-student federal, state, and local government revenues sent to an institution and the average Pell grant paid to students at the institution i in state s and year t. When estimating the system for private institutions, we replace per-student state and local revenues with per-student private revenues in X_{ist} since private institutions rely more heavily on private revenues. S_{st} contains the estimated number of 18- through 24-year olds in state s and year t from the CPS and the unemployment rate in that state and year. We include these control variables to hold fixed other factors that may shift the supply or demand curves. We cluster standard errors at the state-year level because this is level at which treatment is assigned.[15] State policymakers set state budgets annually and thus state merit grant expenditures are determined annually. After estimating both equations in the system we present the estimates of the coefficient of interest, $\epsilon = \frac{1}{\beta_2^{TSLS}}$. Standard errors of ϵ are calculated using the delta method. Appendix Table A4 presents point estimates and standard errors for the full set of independent variables from equation 3. Following the literature, we estimate equations 2 and 3 separately for public two-year, public four-year, and private institutions.

Our conceptual framework is to use state merit grant programs as plausibly exogenous shocks to demand for in-state higher education across states with which we can estimate the slope of the supply curve of higher education. The internal validity of our approach rests on per-student merit grant program expenditures satisfying the assumptions for a valid instrument. Merit grant expenditures must be correlated with demand for higher education, Q^d_{ist}. Program implementation as well as the intensity of merit grant expenditures needs to be uncorrelated with the structural errors v and u. This assumption is critical as it is imposing that, conditional on covariates, we are holding the supply curve fixed. And finally, merit grant programs must influence net prices only through their impact on student demand for higher education. Under this assumption, institutions respond to the change in student demand and not the merit grant programs themselves.

The first identifying assumption can be tested by looking at the results of the first stage regression. We report Olea and Pflueger (2013) F-tests for weak instruments in all specifications. Their F-test is equivalent to the Kleibergen-Paap F-test in our setting with one endogenous variable and one instrument. We also report adjusted standard errors using the tF procedure prescribed by Lee et al. (2022) which adjusts standard errors in the structural equation for the strength of the instrument in the first stage. We estimate alternate specifications with different parameterizations of merit grant program exposure to test the robustness of the assumption that the level of merit grant expenditures is conditionally independent. While we cannot directly prove that the exclusion restriction holds, we argue that it is not an overly strong assumption in this case. The main feature of these merit grant programs is that they reduce the out-of-pocket cost of attending grant-eligible institutions for recipients. It is common for merit grant programs to require recipients to maintain

15. Abadie et al. (2023) demonstrate that clustering standard errors at the level of treatment assignment can be too conservative. Implementing their proposed estimators requires variation within cluster (here, the state-year) in treatment which does not exist in our setting.

a GPA above a threshold or to take a minimum number of credit hours per semester (Scott-Clayton 2011). However, we are not measuring the impact of these requirements since we are measuring enrollments as the number of first-time first-year resident enrollments. Beyond specifying which institutions that recipients can use their merit grant award at and which charges the grant can be used towards, these programs do not impose any restrictions on the institutions that might change their behavior. One possible violation of the exclusion restriction is that merit grant awards are typically disbursed through the institution that recipients attend. Institutions can therefore identify which students are merit grant recipients and potentially use this information to price discriminate.

7 Results

We begin by presenting results from estimating Equation 1 via OLS. In this specification, the elasticity of supply is identified under the strong assumption that net prices and enrollments vary independently of each other. Our preferred model is the SEM model which yields our baseline estimates; we begin here to facilitate comparisons between results from "naively" estimating ϵ via OLS versus estimating ϵ via TSLS. Results from estimating Equation 1 suggest that, on average, institutions across all sectors have inelastic supply curves. Point estimates and their standard errors are presented below in Table 2. Estimates and standard errors for the full set of independent variables are shown in Appendix Table A2. Public four-year and private institutions have similar estimated elasticities of supply of about 0.45 and 0.43. The estimate for public four-year institutions suggests that first-time first-year resident enrollment increases by 0.45% when net price increases by 1%. This set of results suggest that public four-year and private institutions face similarly shaped supply curves. Public two-year institutions have an estimated elasticity of -0.06 which is not statistically different from zero at the 95% confidence level. These results may be biased if enrollment and net tuition are simultaneously determined. Taken at face value, this set of OLS estimates of ϵ reject the claim that institutions have perfectly inelastic supply curves. We now turn to results from estimating the SEM which are unbiased if merit grant program expenditures satisfy the assumptions for a valid instrument.

Table 2: OLS Estimates of ϵ from Equation 1

	Public 4-years	Private 4-years	Public 2-years
Point estimate	0.451	0.425	-0.062
Standard error	0.040	0.042	0.043

Note: Standard errors are clustered at the state-year level.

The point estimates of ϵ from the SEM model, shown in Table 3 are larger for all sectors than those from equation 1. All are statistically different from zero as well as from the corresponding OLS estimates.[16] The estimated elasticity among public four-year institutions is 2.1. This result suggests that first-time first-year resident enrollments at public four-year institutions increase by 2.1% when net price increases by 1%. Private institutions have an estimated elasticity of supply of 1.31. As opposed to the OLS estimates which suggest inelastic supply responses, the results from estimating the SEM model suggest that both public four-year and private not-for-profit four-year institutions have elastic supply curves. It appears that public four-year institutions have a more elastic supply curve than private institutions, although the difference between the two estimates is not statistically significant. The estimated elasticity for public two-year institutions is 1.33 although after adjusting standard errors for the strength of the instrument in the first-stage (Lee et al. 2022) the estimate is not statistically significant. The first stage F-statistic for the public two-year results indicate that per-student merit grant expenditures may be a weak instrument for demand for public two-year institutions. It may be that merit grant awards induce recipients to attend a four-year institution over a two-year institution or that merit grant recipients are likely to attend a four-year institution with or without a merit grant award. These results suggest that four-year institutions have elastic supply curves, at least locally around the pre-merit grant program equilibria. Montiel Olea-Pflueger F-statistics from the first stages do not suggest that per-student merit grant expenditures is a weak instrument among the four-year sectors. Results from the first stage regressions are shown in Appendix Table A3 and full results from the second stage regression are in Appendix Table A4.

16. Point estimates are not statistically significant when standard errors are clustered by state or not clustered at all.

Table 3: SEM Estimates of ϵ from Equations 2 and 3

	Public 4-years	Private 4-years	Public 2-years
Point estimate	2.102	1.312	1.356
Standard error	0.570	0.339	0.587
0.05 tF std. error	0.665	0.488	1.137
First stage F-statistic	34.378	15.549	8.471

Note: Point estimates are the inverse of β_2 from equation 3. Unadjusted standard errors are estimated using the delta method. We follow Lee et al.'s suggestion of linearly interpolating between critical values to calculate the adjustment factor.

7.1 Robustness

We begin probing the robustness of our results by testing whether our results are robust to alternate measures of quantity. Our baseline results measure quantity as the number of first-time full-time resident enrollees who graduated high school in the past 12 months. Institutions can target a certain level of enrollment by choosing how many applicants to offer admission but finalized enrollments are co-determined by students' enrollment decisions. Dorm capacity may be a more direct measure of an institution's desired enrollment level. Results from estimating the SEM model with dorm capacity as the quantity measurement are presented below in Table 4. We only conduct this specification for the four-year sectors given that most public two-year institutions have large commuter populations or do not provide on-campus housing to their students. Estimates of ϵ are similar to the baseline estimates and the differences are not statistically different from each other. The estimated elasticity for public four-year institutions is 2.01 which is slightly lower than the baseline estimate of 2.1. The point estimate for private institutions of 1.6 is larger than the baseline estimate of 1.36 and this difference is not statistically significant. One reason we may expect the short-run supply response to a financial aid expansion to be inelastic is that institutions may face frictions in expanding enrollment capacity. While expanding capacity involves more than building dorms, it appears that institutional dorm capacity is relatively responsive to changes in students' ability to pay.

Table 4: SEM Estimates of ϵ with Dorm Capacity as Quantity

	Public 4-years	Private 4-years
Point estimate	2.013	1.600
Standard error	0.599	0.279
0.05 tF std. error	0.703	0.323
First stage F-statistic	21.979	35.285

Note: Point estimates are the inverse of β_2 from equation 3. Unadjusted standard errors are estimated using the delta method. We follow Lee et al.'s suggestion of linearly interpolating between critical values to calculate the adjustment factor.

We examine whether our results are robust to different parameterizations of merit grant exposure. We use three alternate measures of merit grant exposure. These results are presented in Table 5. The first is $StrongMerit_{st}$ which is a dummy variable equal to 1 if state s has a strong merit grant program in place in year t and 0 otherwise. Studies in the literature label a merit grant program as strong if it has a high participation rate (high typically being above 20%) and generous awards (in the hundreds of dollars per FTE student).[17] We follow Sjoquist and Winters (2015) and Kramer, Ortagus, and Lacy (2018) in categorizing Florida, Georgia, Kentucky, Louisiana, Nevada, New Mexico, South Carolina, Tennessee, and West Virginia as having strong merit grant programs. Welch (2014), who also focuses her analysis on strong merit grant programs, additionally classifies Michigan's Merit And Promise Scholarship as a strong program.[18] We parameterize treatment this way to test the robustness of our baseline results to relaxing the assumption that the level of merit grant expenditures is conditionally independent. The cost of relaxing this assumption is losing variation in the first stage equation by not allowing merit grant programs' effect on student demand to vary with their expenditures.

The second alternate way we measure the demand shocks generated by merit grant programs is using within-state average per-student merit grant expenditures $AvgMerit_{st}$. We calculate each state's average per-student merit grant expenditures by taking an average of per-student merit grant expenditures over the years in which the state funded a merit grant program. These averages

17. In results not shown that are available upon request, we conduct this analysis with a dummy variable for whether a state has average per-student expenditures over \$100. Point estimates differ slightly from using $StrongMerit_{st}$, but the results are qualitatively unchanged.

18. We focus only on strong merit grants in this analysis since weak merit grants may be only weakly correlated with demand for higher education.

are in Appendix Table A1. We then set $AvgMerit_{st}$ equal to state s' within-state average spending in the years t where state s had a merit grant program in place and 0 in the years in which a merit grant program was not funded. This specification averages out within-state variation across time in merit grant intensity (except for implementation) and leverages only the cross-state variation in merit grant expenditures to identify ϵ. Our baseline specification leverages variation across states and over time in merit grant generosity to identify ϵ. This approach may yield biased results if the evolution of program generosity over time is endogenous. This alternate specification of merit grant exposure with $AvgMerit_{st}$ addresses this concern by averaging out the time-series variation in merit grant expenditures. Results for both specifications are presented in Table 5.

We estimate the SEM model with a third alternate IV, $NumYears_{st}$, to exploit the variation over time in merit grant program exposure. $NumYears_{st}$ is equal to the cumulative number of years that state s has funded a merit grant program at year t. For example, observations of institutions in Florida in 2000 would have a value of 3 for $NumYears_{st}$ since Florida implemented its merit grant program in 1997. If a state eventually defunds its merit grant, then $NumYears_{st}$ is set equal to 0 in the following years. Institutions may be hesitant to respond to a perceived change in demand until policymakers have committed to a merit grant program by funding it over multiple years. If this is the case, we expect longer-lasting merit grant programs to induce a larger supply response.

The point estimates of ϵ for private institutions when using any of the alternate IVs are in line with the baseline estimate of 1.31 . All three estimates for the private sector are statistically insignificant when using the tF-adjusted standard errors from Lee et al. (2022). The point estimates for public four-year institutions increase substantially to 7.07 when price is instrumented for with $StrongMerit_{st}$, 3.59 when instrumenting for price with $AvgMerit_{st}$, and 4.43 when instrumenting with $NumYears_{st}$. However, there is a loss of precision when using these instruments and none of the point estimates are statistically different from zero. The first stage F-statistics suggest the three alternate IVs are weakly correlated with demand for higher education. Estimates for the public two-year institutions are negative with low first stage F-statistics. Missing tF-adjusted standard errors in Table 5 are omitted because the tF-adjustment factor tends to infinity as the F-statistic approaches 3.84 (1.96^2, Lee et al. 2022) from above and the corresponding F-statistics are below 3.84. Given the variation in point estimates for this sector, we are more hesitant to characterize the supply curves of public two-year institutions. While point estimates for four-year private and four-year public institutions vary across specifications of the SEM model they all indicate that these institutions have elastic supply curves.

Table 5: SEM Estimates of ϵ Using Alternate IVs

		Public 4-years	Private 4-years	Public 2-years
IV	$StrongMerit_{st}$			
Point estimate		7.074	1.289	-0.047
Standard error		11.51	0.393	0.698
0.05 tF std. error		19.630	0.731	—
First stage F-statistic		10.505	8.565	0.005
IV	$AvgMerit_{st}$			
Point estimate		3.586	1.175	-0.093
Standard error		2.916	0.418	0.546
0.05 tF std. error		4.711	0.94	—
First stage F-statistic		11.728	6.925	0.005
IV	$NumYears_{st}$			
Point estimate		4.433	1.407	-2.331
Standard error		4.738	1.237	2.962
0.05 tF std. error		10.975	—	—
First stage F-statistic		6.759	0.952	2.12

Note: Point estimates are the inverse of β_2 from equation 3. Standard errors are estimated using the delta method. Adjusted standard errors are calculated following Lee et al. (2022). Omitted values for tF-adjusted standard errors are due to first-stage F-statistics less than 4, for which Lee et al. do not provide critical values for.

We also test the robustness of our baseline results to varying the institutions included in the analysis. We do so in two ways: by excluding institutions from states that implement a weak merit grant from the analysis, and by setting weak merit grant expenditures to zero, moving these institutions into the never-treated group. This exercise has two purposes. First, it tests the robustness of our results to the composition of the sample that is exposed to a merit grant program. Second, since weak merit grant programs typically offer smaller awards to fewer students, they should generate a smaller increase in demand for higher education than the strong, more well-funded, merit grant programs. In this specification, we identify ϵ using the same variation across states and time in merit grant expenditures as in the baseline model, but when we exclude institutions from weak merit grant states we are comparing institutions with zero merit grant exposure to institutions with substantial merit grant exposure.

Table 6: SEM Estimates of ϵ Using Strong Merit Grant Expenditures Only

		Public 4-years	Private 4-years	Public 2-years
Dropping weak merit states				
	Point estimate	1.64	0.711	0.202
	Standard error	0.448	0.4	0.443
	0.05 tF std. error	0.62	—	—
	First stage F-statistic	17.466	3.185	0.22
Setting weak merit grant expenditures = 0				
	Point estimate	1.761	1.402	0.619
	Standard error	0.587	0.395	0.488
	0.05 tF std. error	0.787	0.601	—
	First stage F-statistic	19.46	13.446	1.716

Note: Point estimates are the inverse of β_2 from equation 3. Standard errors are estimated using the delta method. Adjusted standard errors are calculated following Lee et al. (2022). Omitted values for tF-adjusted standard errors are due to first-stage F-statistics less than 3.84, for which tF-adjustment factors approach infinity

We present results from varying how weak merit grant programs are treated in Table 6. The first panel of Table 6 presents results from when we omit institutions from weak merit grant-adopting states from the analysis entirely. Estimates from this specification are all less than the corresponding baseline estimates. The estimated elasticity of supply for public four-year institutions is 1.64, reaffirming our finding that public four-year institutions have an elastic supply response. Estimates of ϵ for private and public two-year institutions are both statistically insignificant. When zeroing out weak merit grant expenditures and moving institutions in these states into the never-treated group, public four-year institutions have an estimated elasticity of supply of 1.76 and private institutions have an estimated elasticity of supply of 1.4. Both estimates are statistically significant with first-stage F statistics greater than 10. Public two-year institutions have an estimated elasticity of supply of 0.62. This estimate is statistically insignificant with a first-stage F-statistic of only 1.72.

7.2 Heterogeneity

We split the four-year sectors into subsectors to study whether there are heterogeneous responses within the public and private not-for-profit four-year sectors. We do this first by further categorizing institutions by highest degree granted and then by student body size. We conduct these subsector analyses for two reasons. First, public four-year and private four-year not-for-profit are broad categories. Different types of institutions within them may face differing supply curves and so there may be heterogeneity within these sectors. Second, one may question whether it's appropriate to be comparing, say, a public flagship research institution to a regional public institution that only offers undergraduate courses, both of which are in the public four-year sector. Following the literature, we separate the public and private four-year sectors into doctorate-, masters-, and baccalaureate-granting institutions using the 2015 Carnegie classifications to allay these concerns. Table 7 presents these results.

Table 7: SEM Estimates of ϵ by 2015 Carnegie Classification

	Estimate	Std. err	0.05 tF Std. err	1st-stage F-statistic	n
Public 4-years (Baseline)	1.605	0.493	0.665	21.462	6517
Public Doctoral	3.615	5.536	—	3.892	2414
Public Masters	1.150	0.568	1.288	6.504	3041
Public Baccalaureate	-0.234	0.243	—	0.950	1062
Private 4-years (Baseline)	1.319	0.341	0.488	15.187	9902
Private Doctoral	0.479	0.773	—	0.389	1235
Private Masters	2.500	0.867	1.254	15.386	4316
Private Baccalaureate	1.196	0.423	0.68	11.858	4388

Note: Point estimates are the inverse of β_2 from equation 3. Standard errors are estimated using the delta method. Adjusted standard errors are calculated following Lee et al. (2022). Omitted values for tF-adjusted standard errors are due to first-stage F-statistics less than 3.84, for which tF-adjustment factors approach infinity.

Estimated elasticities for the highest-degree-granted subsectors are estimated imprecisely. The point estimate for private masters-granting institutions is 2.5 and is statistically significant at the 90% confidence level. Point estimates for the other subsectors are all statistically insignificant. The results suggest that private doctoral institutions have inelastic supply curves. However, given the large standard errors in this analyses, we cannot distinguish differential supply responses to state merit grant programs by highest degree granted.

We also look for heterogeneity in supply curves by institutional size. We split the public and private four-year sectors by size using the Carnegie classification's size categories. We combine their smallest two categories of less than 1,000 students and at least 1,000 and less than 3,000 students into one category to improve precision. The other two categories are at least 3,000 and less than 10,000 students, and more than 10,000 students. We categorize institutions by taking within-institution averages of their total enrollments measured in the fall semester from IPEDS.

Private institutions with less than 3,000 students have slightly inelastic supply curves. As before, we lack power to conduct heterogeneity analysis as all other point estimates are not statistically significant.

Table 8: SEM Estimates of ϵ by institution size

Sector	Size	Estimate	Std. err	0.05 tF Std. err	1st-stage F-statistic	n
Public	<3000	0.222	0.253	—	0.816	1274
	3000-9999	1.922	1.922	9.173	4.458	2363
	>10000	1.395	0.497	0.887	9.681	2931
Private	<3000	0.948	0.251	0.382	13.526	8231
	3000-9999	1.019	0.884	—	1.568	192
	>10000	-2.436	2.091	—	3.575	1731

Note: Point estimates are the inverse of β_2 from equation 3. Standard errors are estimated using the delta method.Adjusted standard errors are calculated following Lee et al. (2022). Omitted values for tF-adjusted standard errors are due to first-stage F-statistics less than 3.84, for which tF-adjustment factors approach infinity.

Taken as a whole, our results point towards public and private four-year institutions having elastic supply curves. While we lose precision in robustness checks, point estimates suggest elastic supply responses. Estimates for public two-year institutions vary more and are frequently not statistically different from zero. We defer from making statements about the elasticity of supply for institutions in this sector given the wide range of ϵ that our results can support. Point estimates suggest that there is further heterogeneity in ϵ within the four-year sectors and across institutional size, although we run into power issues that preclude us from precisely estimating differences in elasticities of supply within the public and private four-year not-for-profit sectors.

8 Conclusion

Financial aid is meant to improve or maintain accessibility to higher education. One of the chief criticisms of financial aid is that institutions raise their prices to "capture" additional financial aid dollars. All else equal, increases in financial aid increase demand for higher education by reducing the out-of-pocket cost for aid recipients. While higher prices may be an unintended consequence of expanding financial aid, we argue that they should not be unexpected. Prices should rise in response to a positive demand shock if institutions face increasing marginal costs. It is natural for institutions to respond by expanding to meet this higher demand. However, institutions may face frictions that make it difficult for them to expand enrollment capacity in the short run, such as hiring additional instructors or building more student housing. In other words, the concern is that the institutions have an inelastic short-run supply curve. Previous work that studies institutional responses to financial aid expansions have mostly focused on changes in prices, perhaps taking institutions' inability to expand in the short-run as given. We study the institutional response by estimating the short-run elasticity of supply rather than make assumptions about institutions' ability to expand enrollment capacity.

In this paper, we leverage state merit grants as plausibly exogenous shifts in demand for higher education while holding the supply curve of higher education fixed to estimate the short-run elasticity of supply of higher education, which we label ϵ. The Bennett Hypothesis is more accurately stated as a claim that institutions have perfectly inelastic supply curves, i.e. $\epsilon = 0$. We largely reject this assertion in the context of state merit grant programs. Our baseline results find that both public four-year and private not-for-profit institutions have an estimated elasticity of supply of 2.1 and 1.31, respectively, suggesting that these institutions have elastic short-run supply curves. While prices ought to rise following a sizeable increase in financial aid, such as after the rollout of merit grant programs, we find that first-time first year resident enrollments increase more relative to net prices. When looking at heterogeneity in supply curves within the public and private sectors, estimates of ϵ are not significantly different from zero for public doctoral and baccalaureate and private doctoral institutions, although this result is more likely due to a lack of variation rather than these institutions having perfectly inelastic supply curves. We also study heterogeneous responses by institutional size but lack the variation for precise inference. Our results suggest that the merit grant programs we study here are successful in improving access to higher education for resident students. While there are distributional concerns about merit grant programs (Dynarski 2004; Fitzpatrick and Jones 2016), they do seem to reduce financial barriers to higher education for recipients and induce institutions to expand to educate more students.

The results of this paper should be viewed within the context of its limitations. We have made stronger assumptions than previous studies have about the exogeneity of changes in financial aid (by assuming the conditional independence of merit grant generosity in addition to the timing of implementation). A battery of robustness checks suggest that our baseline results are robust to relaxing the identifying assumptions about the exogeneity of merit grant aid as well as varying measurements of quantity. In return for making these stronger assumptions, we are able to identify the elasticity of supply, which previous studies have not estimated. These estimates will be biased if there is non-random selection into merit grant generosity or if institutions respond to these programs directly rather than to changes in student behavior. The main threat to identification is unobserved factors that affect merit grant generosity, tuition, and enrollments. The nature of the rollout of merit grant programs suggest that policymakers were experimenting with a new form of financial aid rather than responding to educational or economic factors (Dynarski 2004). Our parameterization of treatment, per-enrolled undergraduate merit grant expenditures in a state-year, imposes that all institutions within a sector in a state-year face the same demand shock, although this is likely not the case. This limitation may be overcome using student-level data on merit grant receipt. Another limitation is that the external validity of these estimates depends on the degree to which institutions respond similarly to other demand shocks. We have measured the demand shocks generated by merit grant programs as per-student expenditures, but individual merit grant programs have idiosyncratic programmatic details that we do not model here. Lastly, the estimates of ϵ presented here are local to the area of the supply curve around which state merit grants shifted the demand curve out. Our estimates are not necessarily generalizable to other financial aid programs.

There are a number of avenues for future research. The framework we put forward in this paper can be applied to analyzing other financial aid programs. Other substantial financial aid programs such as federally subsidized loans and the Pell Grant have undoubtedly increased the demand for higher education. While overcoming the endogeneity that is inherent in which students receive these types of aid is a challenge, previous work has leveraged plausibly exogenous variation in these programs to study institutional responses (Turner 2017; Lucca, Nadauld, and Shen 2019) to these programs. In this paper, we estimate short-run institutional responses. Additional research studying the longer-run institutional responses will further the understanding of institutional strategic behavior. Another avenue for further research is to more accurately define whom institutions are competing with. We compare changes across states as a majority of students attend an in-state institution but many students attend out-of-state institutions. Further, while research has studied a number of determinants of the cost of attendance of higher education, there is little work studying how institutions compete with each other on price.

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Appendix

Parent-Child Reporting in IPEDS

A result of the IPEDS survey scheme is that the unit of observation can be a standalone entity or a group of separate campuses. Some institutions are part of a multicampus Title IV institution and data for these institutions may be aggregated to the system level. For example, the Pennsylvania State University system has 24 campuses which are all part of one multi-campus institution (Jaquette and Parra 2014). Some variables, such as endowment size and assets and liabilities, are reported cumulatively for all campuses under the flagship University Park campus. In contrast, institutions in other state systems, such as the University of Wisconsin (UW) system, each report data separately. As a result it would be a mistake to compare, for example, the reported assets of Pennsylvania State - University Park and UW- Madison. This reporting pattern is called "parent-child" reporting (PCR) since child campuses report data under the "parent" campus. Finance variables are affected by PCR. Child campuses may be missing data and data reported under parent campuses at the system level are inflated. While worth acknowledging, PCR is not overly prevalent in the sample. Only 2.8% of institution-year observations in the sample are flagged as parent institutions and 7% as children.

IPEDS includes identifiers for PCR status and if the institution is a child-reporter, the parent's identifier. These linkages are sometimes missing. We utilize Office of Postsecondary Education IDs (OPEID) to fill in missing linkages. Most of the missing parent-child linkages occur before 1997. We fill in pre-1997 missing parent-child linkages for institutions that have non-missing and unchanging parent-child identifiers in 1997 through 1999. The parent institution of an institutional system can change year to year, but in filling in pre-1997 missing linkages we assume they do not. We allocate finance variables by first calculating total annual system enrollments by summing the number of degree- and certificate-seeking undergraduates at each institution within a system Then we multiply each financial variable by each institution's percent of total system enrollment. Values of finance variables for institutions that are not part of an encompassing system are unchanged since their fraction of total "system" enrollment is one. This enrollment percentage (and any) allocation rule likely induces measurement error, although given the low rate of PCR in the data this potential for measurement error is likely inconsequential.

Tables and Figures

Table A1: Merit Grant Summary Statistics by State

Strong/Weak Program	State	Cohort	Average Merit Grant Award
Strong merit grants	FL	1997	308.00
	GA	1994	757.40
	KY	1999	424.13
	LA	1998	716.46
	NM	1997	389.34
	NV	2000	234.11
	SC	1998	828.78
	TN	1998	609.09
	WV	2002	601.72
Weak merit grants	AK	2011	267.45
	AL	1999	6.99
	AR	1992	357.70
	CO	2001	21.75
	DE	1998	89.25
	IA	1998	2.39
	ID	1998	42.38
	IL	1998	5.64
	IN	1998	1.21
	MA	1998	7.22
	MD	1999	13.06
	MI	2003	59.45
	MO	1998	136.74
	MS	1999	143.71
	MT	1998	20.64
	NC	2005	1.09
	ND	1998	8.18
	NJ	1998	36.28
	NY	1998	10.84
	OH	1998	10.99
	OK	1998	60.67
	PA	2008	3.36
	SD	2005	96.00
	TX	2005	17.37
	UT	1998	18.79
	VT	1998	3.02
	WA	1998	6.88
	WI	1998	10.69

Note: Expenditures are in real 2016 dollars. Per-student expenditures are calculated as total merit grant expenditures divided by the estimated number of enrolled undergraduates in the state-year from the October CPS. We follow Sjoquist and Winters (2015) and Kramer, Ortagus, and Lacy (2018) in defining merit grant programs as strong or weak.

Table A2: Full Results from Estimating Equation 1

	Public 4-years	Private 4-years	Public 2-years
ln(NetPrice)	0.451	0.425	-0.062
	(0.040)	(0.042)	(0.043)
Per-student federal revenues	62.441	25.828	-200.950
	(7.422)	(1.998)	(15.532)
Per-student state + local revenues	1.331		-111.122
	(5.974)		(9.097)
Num. 18-24 year olds	4.010	2.973	-2.155
	(0.883)	(0.994)	(1.355)
State-year unemployment rate	-0.005	-0.006	0.040
	(0.011)	(0.010)	(0.017)
Per-student private revenues		-26.315	
		(2.712)	
Num.Obs.	5560	8019	6864

Note: Standard errors are clustered at the state-year level. All dollar-value variables are re-scaled to thousands of real 2016 dollars. The number of 18-24 year olds in a state-year is measured in tens of thousands.

Table A3: First stage results from estimating SEM equation 2

	Public 4-years	Private 4-years	Public 2-years
Per-student merit expenditures	0.277	0.181	0.171
	(0.047)	(0.046)	(0.059)
Per-student federal revenues	0.019	0.018	-0.212
	(0.008)	(0.004)	(0.020)
Per-student state + local revenues	-0.024		-0.104
	(0.005)		(0.011)
Average Pell Grant award	-0.681	-0.413	0.064
	(0.041)	(0.051)	(0.041)
Per-student instructional expenditures	0.061	0.002	-0.003
	(0.007)	(0.003)	(0.015)
Num. 18-24 year olds	0.006	0.004	-0.001
	(0.001)	(0.001)	(0.001)
State-year unemployment rate	0.000	0.006	0.039
	(0.010)	(0.009)	(0.016)
Per-student private revenues		-0.031	
		(0.006)	
Num.Obs.	6517	9902	8081

Note: Standard errors are clustered at the state-year level. All dollar-value variables are re-scaled to thousands of real 2016 dollars. The number of 18-24 year olds in a state-year is measured in tens of thousands.

Table A4: Second stage results from estimating SEM equation 3

	Public 4-years	Private 4-years	Public 2-years
$\widehat{ln(Q^d_{ist})}$	0.476	0.762	0.737
	(0.129)	(0.197)	(0.319)
Per-student federal revenues	-0.009	-0.020	0.089
	(0.006)	(0.005)	(0.071)
Per-student state + local revenues	0.001		0.043
	(0.006)		(0.036)
Average Pell Grant award	0.209	0.094	0.046
	(0.085)	(0.080)	(0.044)
Per-student instructional expenditures	-0.029	0.002	0.027
	(0.009)	(0.002)	(0.014)
Num. 18-24 year olds	-0.001	-0.001	0.004
	(0.001)	(0.001)	(0.001)
State-year unemployment rate	0.039	0.004	-0.022
	(0.008)	(0.008)	(0.021)
Per-student private revenues		0.012	
		(0.010)	
Num.Obs.	6517	9902	8081

Note: Standard errors are clustered at the state-year level. All dollar-value variables are re-scaled to thousands of real 2016 dollars. The number of 18-24 year olds in a state-year is measured in tens of thousands.