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Short communication

Expenditures and postsecondary graduation: An investigation using individual-level data from the state of Ohio

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ABSTRACT

Using detailed individual-level data from public universities in the state of Ohio, I estimate the effect of various institutional expenditures on the probability of graduating from college. Using a competing risks regression framework, I find differential impacts of expenditure categories across student characteristics. I estimate that student service expenditures have a larger impact on students with low SAT/ACT scores, while instructional expenditures are more important for high test score students and those majoring in scientific/quantitative fields. The individual-level nature of these data allows me to address measurement error and endogeneity concerns the previous literature has been unable to deal with.

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1. Introduction

In the current economic environment, nearly all postsecondary institutions face severe financial pressures. Therefore, it is critical that these institutions make the most efficient use of every available dollar.

The literature relating graduation rates in K12 and higher education to expenditures dates back to the Coleman Report of 1966. Unfortunately, much of this research has focused on aggregate measure of expenditures, ignoring a significant amount of variation in spending across functional categories not delivering even basic policy prescriptions. Notable exceptions include Ryan (2004) and Pike, Smart, Kuh, and Hayek (2006).

In one of the most comprehensive study to date, Webber and Ehrenberg (2010) used institution-level data to study the association between different expenditure categories (student services, instructional, etc.) and graduation rates at nearly 4000 4-year institutions. The study concluded that while all expenditure categories "matter", student services had the largest marginal impact on graduation rates at schools with low median SAT scores and high student financial need (as measured by Pell Grant dollars). In contrast, instructional expenditures had the greatest effect at schools with high median SAT scores and low rates of student need.

Using restricted-access student-level data for each public 4-year institution in the state of Ohio, I am able to address several major limitations of the previous literature. First, because I can identify which semesters each student is enrolled, I can accurately classify which expenditures students were exposed to. Using institution-level data, the previous literature tended to use six-year graduation rates and six-year moving averages of expenditures. This implicitly assumes each student was exposed to six years of expenditures and then graduates or fails to graduate after six years of enrollment. Second, I examine subgroups of students within schools rather than examine subgroups of schools. For instance, at a high-ACT school (defined as having a median ACT in the upper half of the test score distribution) there are a number of students who will have low ACT scores. Next, I look at how the effect of expenditures differs by the student's major, which has never

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been studied. Finally, I am able to include institution fixed-effects to control for the many school-level unobservables which could be correlated with expenditures. Due to a small number of observations and a lack of significant variation in the expenditure variables over time, much of the previous literature was unable to include these controls.

Qualitatively, I find support for the results of Webber and Ehrenberg (2010), namely that student service expenditures are a strong determinant of the probability of graduating for students with lower test scores and instructional expenditures are more important for students with high test scores. However, the magnitudes estimated in this study are larger than suggested by Webber and Ehrenberg (2010), which I attribute to the stronger data quality in this study and my ability to better assign exposure to expenditures. Additionally, I find that instructional expenditures are significant predictors of graduation for students majoring in a STEM (Science, Technology, Engineering, and Math) field.

2. Model

I utilize the theoretical model of an educational production function (see Hanushek, 1979 for details of the theory and estimation of these models). Specifically, I assume that the probability of graduation of individual I attending school j in time t can be modeled as a function of institutional inputs X, institutional characteristics Y, and student characteristics Z.

$$G_{ijt} = F(X_{ijt}, Y_j, Z_i) \tag{1}$$

I model the probability of graduating in a competing-risks regression framework. Using the empirical methodology developed by Fine and Gray (1999), we have:

$$\lambda_k(t, X_{ijt}, Y_j, Z_i) = \lambda_{j0}(t)\exp(\beta X_{ijt} + \gamma Y_j + \delta Z_i) \tag{2}$$

where λ_k represents the kth cause-specific hazard function. This is distinct from the traditional Cox proportional hazard model because it allows for multiple failure types and separate subhazard functions for each type. In the context of this paper I specify two failure types: graduating or dropping out.[1] Observations on students who are still enrolled after 6 years are treated as right-censored. To the best of my knowledge, this modeling strategy has never been employed in the education production function literature.

The institutional inputs include student services, instructional expenditures, and academic support expenditures.[2] Student service expenditures include expenses for the admissions and registrar activities, for activities that contribute to students' emotional and physical well-being and to their intellectual, cultural and social development outside of the institution's formal instructional program. Examples here include student organizations, student health services (including psychological counseling) and supplemental instruction (such as tutoring programs). Instructional expenditures are analogous to faculty salaries. Academic support expenditures include technology expenses which support in-class academic instruction.[3]

Student-level characteristics controlled for include race, ethnicity, age, gender, intended major, entrance cohort, and entrance test score.[4,5] Time-invariant characteristics are absorbed through institutional fixed-effects.

Table 1
Summary statistics.

Variable	Mean	Std Dev
Six-year graduation rate	0.36	0.48
Semesters enrolled	8.03	3.13
Student service expenditures ($ per student*year)	1293	780
Instructional expenditures ($ per student*year)	7988	2315
Academic support ($ per student*year)	1884	516
ACT	22.3	4.3
Female	0.54	0.5
Black	0.10	0.30
Hispanic	0.02	0.13
Age at entry	18.7	1.96

The above summary statistics are computed from individual-level restricted access data provided by the Ohio Board of Regents. These statistics are computed from entering full-time first-year students in the 1998–2000 cohorts (94,880 individuals). The financial statistics denote the average expenditures faced by students during their tenure in the Ohio University System. Students are followed for six years from their entrance date, meaning that the data span 1998–2006.

3. Data

The data covering institutional expenditures is derived from the Integrated Postsecondary Education Dataset (IPEDS) and the Delta Cost Project, a nonprofit organization devoted to analyzing trends and consequences of expenditures in higher education. The expenditures which a student are exposed to are defined as the average of their institution's expenditures over all years they are enrolled. For example, if a student is enrolled at Ohio State from 1998 to 2000, and again in 2002, then for that student the student service expenditures which they are exposed to will be the average of Ohio State's student service expenditures for those years.

The detailed data on student characteristics and outcomes come from the Ohio Board of Regents, which maintains records on all students attending public

[1] A small number of students transfer from one four-year institution to another. These observations are dropped from the sample.

[2] Previous research has also included external research expenditures. However, among public schools in Ohio, external research funds are negligible at all but one institution.

[3] Detailed definitions of the content of each of these categories are found in the Integrated Postsecondary Education Data System online glossary (http://nces.ed.gov/ipeds/glossary).

[4] Since the ACT is the predominant test used by admission committees at these schools, those observations with only a reported SAT score were converted to an ACT equivalent using the standard crosswalk provided by the corporation which administers the ACT.

[5] For students with missing test scores or demographic information, an indicator variable denoting this is included in the model.

Table 2
Competing risks regression model estimates.

	Full sample	Low ACT	High ACT	STEM	Non-STEM
Student services coefficient	0.055	0.155**	−0.034	−0.049	0.137
Std error	(0.069)	(0.063)	(0.077)	(0.133)	(0.189)
Marginal effect	0.020	**0.041**	−0.015	−0.020	0.043
Instruction coefficient	0.11**	0.086	0.147**	0.188*	0.0341
Std error	(0.056)	(0.058)	(0.062)	(0.11)	(0.135)
Marginal effect	**0.039**	0.023	**0.065**	**0.077**	0.011
Academic support coefficient	0.105	0.137	0.104	0.126	0.100
Std error	(0.092)	(0.095)	(0.101)	(0.124)	(0.253)
Marginal effect	0.037	0.035	0.046	0.053	0.031
Pseudo R^2	0.33	0.25	0.36	0.35	0.29
Observations	94,880	44,392	50,488	43,471	51,409

Standard errors are clustered at the school-year level. The results in this table come from a competing risks regression (Fine & Gray, 1999) modeling the time until graduation (or leaving school) as a function of student characteristics (age, gender, ethnicity, race, entrance test scores, and major), institutional expenditures (student services, academic support, and instructional), institution fixed effects, and year fixed effects. The expenditure variables included in the model are scaled to be in $100 increments. The low ACT sample is defined as all students below the median ACT score of 21, while high ACT is defined as all students at or above the median. Marginal effects associated with a statistically significant variable are presented in bold. Marginal effects represent the impact on the probability of graduating from a $100 increase in the associated expenditure category.

* Significance at the 10% level.

** Significance at the 5% level.

universities in the state of Ohio.[6] The analysis dataset consists of three cohorts of first-time freshmen, spanning the years 1998–2000. Each of the 94,880 students in the sample is followed for six years from their initial date of enrollment. For a recent example of research using these data, see Price (2010).

4. Results

Table 1 reports summary statistics of the analysis sample. Table 2 presents model estimates for the student service, instructional, and academic support expenditure categories, along with marginal effects of a $100 per full-time-equivalent (FTE) student increase in the associated category.[7] All specifications include institution fixed-effects[8] and have standard errors clustered at the institution-cohort level. The first column contains estimates from the full sample of 94,880 students. As was the case in Webber and Ehrenberg (2010), both variables are positive predictors of the likelihood of graduating, with Instructional expenditures having approximately double the impact (3.9 versus 2 percentage point increase) in this particular sample.

Breaking down the sample into high and low test score students, the same pattern observed in Webber and Ehrenberg (2010) is observed, with student service expenditures being the dominant expenditure category for those students with low ACT scores (4.1 percentage point marginal effect) and instruction mattering most for those with high test scores (6.5 percentage point marginal effect). As discussed in Astin (1993) and Webber and Ehrenberg (2010), this may be indicative of relationship between student engagement and graduation. All else equal, students with low test scores may need more convincing (via outside the classroom activities such as a student newspaper or academically themed club) that their work inside the classroom has real-world value. Conversely, high-achieving students have always been academically engaged, and the quality of instruction is dominant factor in their academic success. In fact, the results imply that students with high entrance test scores may benefit from fewer student service-related expenditures and more instructional expenditures. Additionally, tutoring services are likely to provide a larger benefit to low achieving students.

Dividing the sample instead by whether a student's major resides in a STEM field, I find that Instructional expenditures are relatively more important than student service expenditures for STEM majors, whereas there is no relative difference among non-STEM majors.

5. Robustness

One potential concern with the results presented thus far is that students may endogenously select into schools with expenditure patterns most advantageous to their probability of graduating. I attempted to investigate his potential selection bias in several different ways. First, I estimate Eq. (3) as a logistic regression separately for each institution.

[6] The institutions included in this study are Akron University, Bowling Green State University, Central State University, Cleveland State University, Cincinnati University, Kent State University, Miami University, Ohio University, Northern Ohio University, Ohio State University, Toledo University, Shawnee State University and Youngstown State University.

[7] The model estimates for all other variables are similar in both sign and magnitude to Webber and Ehrenberg (2010). The coefficient estimates for academic support are all statistically insignificant. All results are available upon request. Additionally, a number of alternative specifications were tested, such as one in which shares rather than levels of expenditures are considered, with no qualitative change in the results.

[8] The within-institution variation (in standard deviations) is as follows: student services: 108; instructional: 210; academic support: 153.

$$\Pr(Attend\quad Inst.\quad j) = \frac{\exp(\beta X_{ijt} + \delta Z_i + HIGHSCHOOL_h)}{1 - \exp(\beta X_{ijt} + \delta Z_i + HIGHSCHOOL_h)} \tag{3}$$

Eq. (3) models the likelihood of a student attending institution j as a function of institutional expenditures, student level characteristics, and also indicators for which high school a student attended. The student service and instructional expenditure categories were each statistically significant in only one of the regressions, and in each case the magnitude was not large. Given that I am making 13 comparisons, I take this as suggestive evidence that institutional expenditures did not induce students to choose which college to attend in a systematic way. Second, I calculate propensity scores (using only individual and high school characteristics) for each student of attending the school that they are enrolled in. I then reweight my model by these propensity scores, and run each specification again. The logic behind this correction is that if student A has a low propensity for attending school X, relative to other students at school X, but attends this school anyway then they may have done so for unobserved reasons correlated with the expenditures of their institution. I thus reduce their contribution to the parameter estimates by down-weighting their observation. Alternatively I drop students with relatively low propensity scores from the model altogether. Neither of these methods produces results substantially different from my baseline results.

6. Conclusion

Using detailed individual-level data from the state of Ohio and a new empirical methodology, I estimate the determinants of graduating from a postsecondary institution. I am able to deal with endogeneity and measurement error issues Webber and Ehrenberg (2010) were unable to account for. I find that student services are the strongest predictor, among expenditure categories, for students who had below median ACT scores. For those with ACT scores at or above the median I estimate that instructional expenditures are the dominant category. Finally, I conclude that instruction tends to have a larger impact on students in STEM fields rather than non-STEM fields.

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