Calculus Requirements and the Popularity of the Economics Major

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Abstract

Approximately sixty percent of undergraduate economics programs in the United States require calculus to be taken by their majors. Many of these departments have had a calculus requirement in place for decades and, given the general academic aptitude of their students, do not think twice about the possibility of calculus discouraging students from majoring in economics. Other departments would like to require a course in calculus, but do consider the potential drop in recruitment of new majors. In this study we examine over 600 U.S. universities that graduated annually at least one economics major from 2010 through 2019 to test whether or not requiring calculus reduces the percentage of a school's degrees that are awarded to economics majors. Our results suggest that requiring calculus influences the decision to major in economics, but only for schools with less-restrictive enrolment standards.

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I. Introduction

Amid the decline in the number of students earning undergraduate degrees in economics in the early 1990s, interest in both the nature of this decline and factors influencing it flourished. This decline had bottomed out by the mid 1990s, and the number of economics degrees earned had fully recovered by the mid 2000s (Siegfried 2006), continued on an upward trend (Siegfried 2009), and recently flattened out (Stock 2017). But when compared to all degrees awarded to undergraduates, economics has actually lost market share since 1991--- economics degrees have increased 19.5 percent while the total number of degrees awarded grew 41.1 percent (Siegfried 2009). The relative size, and clout, of individual economics departments might still be a concern at many schools.

Over the last few decades the emphasis on calculus in the undergraduate economics curriculum has risen substantially. One study suggested that about 22 percent of economics departments surveyed required calculus in 1979 (Siegfried and Wilkinson 1983), while our data suggests that the number rose to around 59 percent by 2021. This paper investigates whether or not requiring calculus influences the decision to major in economics. We hypothesize that if requiring calculus discourages students from majoring in economics, this effect would be seen only at schools with less-selective enrollment standards. Yunker and Pledge (1971) suggested that a calculus requirement may make economics appear to be a more quantitative degree and might actually lead some students to choose it as a major. We also test for this potential positive influence, but hypothesize that if it does exist, it would be at schools with more selective enrollment standards.

We investigate whether a calculus requirement influences the share of economics graduates using data for 654 institutions over the years 2010-2019 retrieved from National Center of Education Statistics' Integrated Postsecondary Education System (NCES IPEDS). We find evidence that a calculus requirement deters some students at institutions with lower levels of quantitative ability from majoring in economics. While we find that a number of institutional factors are significant in determining the share of economics graduates, we find no evidence that the presence of a calculus requirement deters students from majoring in economics at institutions with moderate to higher levels of quantitative ability.

Section II of this paper will discuss earlier studies that investigate the economics major trends and factors that influence them. Section III will discuss the data and the theoretical model used in this study and will present the empirical model employed to determine the significance of a calculus requirement on the share of economics majors. Section IV will present and discuss the findings of our OLS regressions and Section V will conclude and discuss the implications of our findings and offer suggestions for future research.

II. Literature Review

Yunker and Pledge (1972) conducted a small survey of economics departments regarding the experiences a few departments of economics have had with requiring calculus in their economics major. Their survey asked for the enrollment size of the economics major for the three years prior to the imposition of the higher math requirement, as well as the enrollment size for the three years after the calculus requirement was imposed. The useable responses of the survey consisted of only 19 colleges and institutions, but an empirical model was formulated nonetheless. The conclusion from this study was that the imposition of a mathematics

requirement of a semester of calculus does not have a long-term depressing effect on the size of enrollment in the economics major.

Siegfried and Wilkinson (1982) administered a questionnaire which analyzed the curriculum in the undergraduate bachelor's degree programs in economics. The study found that about 900 institutions in the United States offer a four-year degree in economics, 546 of which were accounted for in their sample. The availability of a business major is the dominant factor associated with the number of economics majors and institution graduates. A regression analysis suggested that the presence of a business major is associated with a 6.6 percent decrease in the proportion of students who major in economics. Willis and Pieper (1996) also found that institutions that offer an undergraduate degree in business have close to one-fourth the number of economics majors as those schools without an undergraduate degree in business. Furthermore, their study indicated that the existence of a degree in business economics was associated with an additional slight decrease in the number of economics degrees awarded[1].

Siegfried and Wilkinson (1982) reported that only 21.6 percent of the departments of economics required a course in calculus to complete a degree in economics, with schools that offer a doctoral degree in economics being more likely to require calculus. It appears that over the last few decades, the emphasis on calculus in the economics curriculum has risen substantially. The results from this study reveal that 59 percent of the colleges in the United States offering a degree in economics require at least one semester of calculus (Table 2).

Willis and Pieper (1996) found that economics majors come disproportionately from institutions that are academically selective and particularly those with students with greater

[1] The U.S. Department of Education classifies economics degrees separately from business economics degrees.

levels of mathematical aptitude. The results of their regression indicated that a significant positive correlation exists between the level of admissions selectivity at an institution and the number of economics majors they graduate. Schools with admissions rankings labeled as competitive, more competitive, and most competitive were separated using dummy variables and their results indicated that the number of economics graduates increased monotonically with greater admissions selectivity levels. This suggests that the undergraduate economics degree is tougher to get than the average degree. It is apparent that more-selective schools usually have students capable of more difficult degrees, including the economics degree. The aspiring economics majors at more-selective schools are certainly less likely to be deterred by higher math requirements than the prospective economics majors at a less-selective school would be. In fact, as Yunker and Pledge (1971) mentioned, requiring calculus may make economics appear to be a more quantitative degree and might actually be leading some students to choose it as a major.

Siegfried and Stock (2007) found that PhD granting institutions graduate about half of the economics majors in the United States in a given year. This is a similar finding from the Siegfried and Wilkinson (1982) survey mentioned previously, which also found that roughly half of the total economics degrees awarded came from schools offering doctoral degrees. It has been repeatedly found that the flagship state universities, usually with PhD programs in economics, tend to drive the trends of the total economics degrees each year (Siegfried 2007). The departments of economics that offer PhD programs are more likely to be noticed by undergraduate students at the university and therefore attract more majors at the undergraduate level. However, Siegfried and Stock (2007) found that a very small percentage of students pursue a PhD in economics at the university from which they received their undergraduate degree.

Willis and Pieper (1996) found that students at highly ranked liberal-arts colleges were just about four times more likely to receive a degree in economics. They also found that school size has a significant impact on the number of economics majors a school graduates. Their results indicated that schools with a smaller undergraduate student population were graduating economics majors at a rate twice as much as schools with large undergraduate populations. Skoorka and Condon (2002) found that economics degrees tend to follow the general trends of total bachelor's degrees awarded by a school. This would suggest that schools with bigger undergraduate populations don't see a deterrent effect to the proportion of economics majors. However, clearly the proportion of students receiving a degree in economics, or any one major, will be negatively correlated with size of undergraduate enrollment due to the larger number of different majors offered at larger institutions. Students have more options and will have a smaller probability of majoring in economics.

Siegfried (2007) found that the economics degree has grown in popularity. Siegfried stated that undergraduate degrees in economics in the United States grew eight consecutive years, from 1997-2005, but saw a slight decline in the 2005-2006 school year. Since then, Stock (2017) found that the percentage has flattened out. Siegfried further suggested the 2005-2006 decrease may be due to a sharp decrease in the share of women receiving economics degrees, which fell from 34.4 percent in 2001, to 31 percent in 2006. A few years earlier in 1997, only 29 percent of students majoring in economics were female. Siegfried (1998) stated that gender effects may have an important influence on trends in economics majors.

It is widely believed that mathematical ability can be useful to an undergraduate economics major (Siegfried et al., 1991). In general, mathematics can help explain relationships between economic variables, as well as enhance the understanding of economic theory. The use

of mathematics in economics encourages the accuracy of estimates and assists the mind to examine the side effects of a policy change, while illuminating relationships and improving student comprehension (Debreu 1991). It is because of these reasons that economics majors are often required to take calculus to prepare for intermediate theory courses. However, the fundamental principles taught in most intermediate macroeconomics and microeconomics course can often be learned, and taught, without calculus. The debate of how much, if any, calculus should be used in the intermediate economics courses has been, and will likely continue to be, an ongoing debate.

Gerard Debreu (1991) also discussed the mathematization of the economics major. In 1940, a basic undergraduate preparation in mathematics was almost always sufficient to follow the development of economic theory in every direction it was taking. By 1990, it required graduate training in mathematics. There is an apparent widening gap between the undergraduate curriculum and the first year of graduate work. A few decades ago, a significant portion of the first year of graduate work was a review of advanced undergraduate theory for many economic graduates at top liberal-arts colleges (Debreu 1991).

Though extensive mathematics can help some students understand economic theory, a working knowledge of advanced mathematics is not imperative for undergraduate economics majors. An understanding of mathematics will usually smooth the progress of a student's understanding of economic concepts, but instructors should stray from exclusively relying on it as their means of teaching economics. If an institution requires calculus in their economics degree program, instructors may be more tempted to stress algebraic manipulation instead of the intuitive explanations of economic behavior (Siegfried et al. 1991). Instructors may be tempted

to do this because it is comparably easier to present mathematical tools instead of providing students with the aptitude needed to apply the techniques.

III. Data and Methodology

Using institution-level data, we test whether the presence of a calculus requirement has an effect on the share of bachelor's degrees awarded to economics majors, using the share of undergraduate degrees awarded to economics majors as the dependent variable. The means for all variables in the empirical model below were calculated over the years 2010-2019. Because we hypothesize that if the calculus requirement discourages students from majoring in economics, this effect will likely be stronger at less-selective schools, we estimate the following equation using ordinary least squares regression for all institutions in the sample and three subsets determined by the average 75th percentile SAT math scores of incoming freshmen:

$$\begin{aligned} PCTECON_i = {} & \beta_0 + \beta_1 CALC_i + \beta_2 SATMATH_i + \beta_3 BUSINESS_i + \beta_4 BUSECON_i \\ & + \beta_5 TOPLA_i + \beta_6 TOPECON_i + \beta_7 ECONPHD_i + \beta_8 PRIVATE_i \\ & + \beta_9 UGPOP_i + \varepsilon_i \end{aligned}$$

A summary of the variables and their hypothesized signs is provided in Table 1. In keeping with the notion that the economics major may be popular among quantitatively oriented students, 75th percentile SAT math scores of incoming freshmen (SATMATH) is expected to have a positive effect on the percentage of economics graduates. However, if the institution has a business school (BUSINESS) or business economics degree (BUSECON), students may substitute away from general economics degrees and thereby create a negative effect on the share of economics majors.

The effect of an institution's classification as a top liberal arts college (TOPLA) on the share of economics majors is unknown, but it is included in the model as it may capture characteristics of the students that differ from those attending a non-liberal arts college. If an institution is regarded as top 50 economics program (TOPECON), the program is likely to attract more students and therefore have a positive effect on the share of economics majors. Institutions with doctoral programs in economics produce a large share of economics majors (Siegfried and Wilkinson 1982,) so the presence of an economics doctoral program (ECONPHD) is expected to positively affect the share of economics majors. The expected effect of how institutional control (PRIVATE) influences the percent of economics majors is uncertain, but it is included in the model as it is an important institutional characteristic. Finally, the logged size of the undergraduate population (UGPOP) is expected to have a negative effect on the share of economics majors, as larger institutions have more programs and will result in the student body being distributed over a larger selection of majors.

Table 2 provides the descriptive statistics of the dataset. Of the programs offering degrees in economics, 59 percent of the programs require at least one course in calculus. About 14.9 percent of the economics departments in the sample offer a degree in business economics and 92.93 percent of the departments belong to institutions with business schools. In addition, a slight majority of economics departments, 52.75 percent, belong to private institutions.

Table 3 provides a summary of the average percentage of economics graduates and the share of programs requiring calculus by institutional control and math aptitude of incoming freshmen. Over all institutions, the average share of bachelor's degrees awarded to economics majors is 2.96 percent but varies across institutions of differing institutional control and levels of math aptitude when not controlling for the presence of business programs, institutional ranking,

size, or the presence of an economics doctoral program. Economics majors tend to be more prevalent at private institutions relative to public institutions. The average percentage of economics graduates at private institutions is 4 percent, compared with 1.78 percent at public institutions. Likewise, institutions with higher math aptitude as measured by average incoming SAT math scores have greater shares of economics graduates relative to the total sample. The percentage of economics graduates at institutions with higher math aptitude is about 6.01 percent, compared with 1.97 percent at institutions with average math aptitude and 1.25 percent at institutions with lower math aptitude.

A greater share of private institutions require calculus relative to public institutions. The underlying factor of this difference could be greater selectivity of private institutions and relatedly higher math aptitude on average. The differences in the shares of economics programs requiring calculus are most pronounced when institutions are separated by levels of math aptitude. Only a little more than a third (35.9 percent) of institutions with low incoming math SAT scores require calculus. This reflects the seeming concern of economics departments belonging to institutions with low levels of math aptitude that requiring calculus will discourage students from becoming economics majors. Conversely, a majority of institutions (82.3 percent) with high incoming SAT math scores require calculus and are clearly unconcerned with discouraging students from the major. Institutions with average incoming SAT scores require calculus at a similar rate as the rate associated with all institutions.

The data covers 654 institutions in the United States over the years 2010-2019 that graduated at least one economics major annually. Data regarding the number of economics graduates and total graduates, institutional control, presence of a business school, a business economics degree, the size of the undergraduate population, the 75th percentile SAT math scores

of incoming freshmen and the acceptance rate of the institution were retrieved from the National Center for Education Statistics' Integrated Postsecondary Education Data System (NCES IPEDS.) Economics Department rankings were retrieved from the 2017 US News Best Colleges report and the liberal arts college rankings were retrieved the 2021 US News Best Colleges report. The presence of an economics doctoral program at the institutions was determined by referencing the Alphabetical List of US Graduate Programs in Economics from the American Economics Association website. Calculus requirements were obtained by referencing each institution's economics department website or course catalog. An institution is coded as requiring calculus if a required course for the program contains "calculus" in its title or course description. Institutions that offer a Bachelor of Science degree that requires calculus but a Bachelor of Arts degree that does not require calculus are coded as not requiring calculus, as students are still able to earn a degree in economics without having to take calculus.

IV. Empirical Results

The results of the estimated model developed in the previous section for all institutions, and the three subsets distinguished by the average incoming mathematical aptitude of students[2], are presented in Table 4. The model explains 60 percent of the variance in the share of bachelor's degrees awarded to economics majors for all institutions, but the value falls when regressions are run for the smaller subsets of institutions.

The first column of results ("All Institutions") provide the estimated coefficients on the explanatory variables for all institutions that had usable data for each variable. Although the estimated coefficient on CALC is negative, we fail to reject the null hypothesis that requiring

[2] The sample was divided into three equal groups by incoming average SAT-Math 75th percentile scores. Due to missing values for some variables for some schools, the sample sizes are not equal across groups.

calculus has no effect on the percent of economics majors at an institution, controlling for other factors. However, when the model is estimated using only the subsample of schools with the lowest average SAT math scores ("Least-Selective Schools"), the estimated coefficient on CALC is negative and statistically different from zero at the .05 level. Controlling for other factors, requiring calculus for the economics major reduces the number of economics majors by .312 percentage points. Since the average percent of economics majors is 3 percent, less-selective schools should expect about a 10 percent decrease in the number of economics majors should they decide to require calculus to be taken for graduation. The final two columns of results ("Average-Selective Schools" and "Most-Selective Schools") suggest that requiring calculus does not discourage students at schools with higher incoming average SAT math scores. These results support our hypothesis that if requiring calculus discourages students from majoring in economics, this will likely apply to only less-selective schools where many students might avoid higher-level math courses as they seek their degrees.

All other independent variables performed as expected. Wefocus our discussion on the All Institutions sample, and one can see that most of these signs and significance levels stay consistent across subsamples based on selectivity. There is strong evidence that mathematical aptitude, as measured by incoming SAT math scores, affects the share of economics graduates. The variable SATMATH has a positive effect on the share of economics degrees and is significant at the .01 level. For every one standard deviation increase in incoming freshmen's SAT math scores, the share of economics graduates increases by approximately 2 percentage points. There is also evidence that the presence of a business school has a negative effect on the share of economics majors. The variable is significant at the .01 level and indicates that the presence of a business school results in a 1.794 percentage point decline in economics graduates

relative to institutions that do not have a business school, holding other factors constant. The presence of a business economics degree also results in a decline in the share of economics majors. When students have the opportunity to major in business economics, the share of economics degrees decreases by .85 of a percentage point relative to institutions that do not offer degrees in business economics. This finding is significant at the .01 level, holding other factors constant.

An institution being regarded as a top liberal arts college has a positive impact on the share of economics majors, causing an increase of approximately 4.1 percentage points relative to all other institutions, holding other factors constant. Similarly, institutions regarded as having a top economics program increases the share of economics degrees awarded by about 1.5 percentage points relative to all other programs holding other factors constant. The presence of a doctoral program in economics also increases the share of economics degrees awarded by about 1.1 percentage points relative to institutions that do not have a doctoral program in economics. These findings regarding institutional rankings and the presence of a doctoral program are all significant at the .01 level. Whether an institution is private or otherwise, however, is insignificant and therefore has no impact on the share of economics graduates. Finally, the size of the undergraduate population has a negative and statistically significant effect on the share of economics majors at the .01 level. A .72 percentage point decrease occurs for every one percentage point increase in the student population.

V. Conclusions

This study set out to determine if requiring calculus to be taken to earn an undergraduate degree in economics deters students from majoring in economics. We extended upon prior

research that suggested requiring calculus has no effect on the decision to major in economics (Yunker and Pledge 1972) by investigating this relationship separately by the selectivity of the university, specifically the average mathematical aptitude of incoming freshman, and using a much larger sample size.

We provide evidence that requiring calculus to earn a degree in economics at institutions that enroll students with relatively low average math aptitude deters some students from electing to major in economics. Our regression results suggest that if an economics department in a university with less-selective acceptance requirements, specifically relatively low average SAT math scores, implements a calculus requirement for its major, it should expect about a 10 percent decline in the number of majors. Although we find a number of influential factors that explain the share of economics majors, we find no evidence that requiring calculus deters students from majoring in economics at institutions with average or high mathematical aptitude among the student body. Our data suggests that the majority of institutions with students with low average math aptitude do not require calculus for the economics major, and our regression results are consistent with a reluctance for many of these economics departments to implement this requirement.

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Appendix

Table 1: Variable Definitions

Variable	Description	Hypothesized Sign
Dependent Variable		
$PCTECON_i$	Mean of the percentage of students receiving a bachelor's degree between 2010-2019 that were economics majors	
Independent Variables		
$CALC_i$	1 if calculus is required for the bachelor's degree in economics, 0 otherwise	?
$SATMATH_i$	Mean of the 75th percentile SAT math scores of incoming freshmen between 2010-2019	+
$BUSINESS_i$	1 if the institution has a business school, 0 otherwise	_
$BUSECON_i$	1 if the institution has a business economics degree, 0 otherwise	_
$TOPLA_i$	1 if the institution is a Top 100 Liberal Arts College, 0 otherwise	?
$TOPECON_i$	1 if the institution has a Top 50 Economics Department, 0 otherwise	+
PHD_i	1 if the institution has an economics PhD program, 0 otherwise	+
$PRIVATE_i$	1 if the institutional control is private, 0 otherwise	?
$UGPOP_i$	Mean of the natural log of the undergraduate population between 2010-2019	_

Table 2: Descriptive Statistics (n=608)

Variable	Mean or Proportion	S.D.	Min.	Max.
Dependent Variable				
$PCTECON_i$	3.00	3.6	0	19.99
Independent Variables				
$CALC_i$	59.0%			
$SATMATH_i$	624.31	65.31	465.50	798.00
$BUSINESS_i$	92.93%			
$BUSECON_i$	14.98%			
$TOPLA_i$	11.16%			
$TOPECON_i$	7.03%			
PHD_i	18.96%			
$PRIVATE_i$	52.75%			
$UGPOP_i$	8.60	1.05	6.16	10.89

Table 3: Institutional Characteristics (n= 654)

	Percentage of programs requiring calculus	Average percentage of economics graduates
All Institutions	59.0%	2.96%
Public	54.9%	1.78%
Private	62.8%	4.00%
Institutions with low incoming SAT math scores (Scores less than 589)	35.9%	1.25%
Institutions with average incoming SAT math scores (Scores between 589 and 641)	58.2%	1.97%
Institutions with high incoming SAT math scores (Scores exceeding 641)	82.3%	6.01%

Table 4: OLS Regression Results
Dependent Variable = PCTECON

Variable	*All Institutions*	*Least Selective Institutions*	*Average-Selective Institutions*	*Most Selective Institutions*
CALC	-0.312	-0.312**	0.034	-0.921
	(1.528)	(2.081)	(0.130)	(1.486)
SATMATH	0.022***	0.007**	0.012*	0.032***
	(9.570)	(2.383)	(1.655)	(4.817)
BUSINESS	-1.794***	-0.335	1.387	-1.594**
	(4.320)	(0.761)	(1.419)	(2.145)
BUSECON	-0.850***	-0.646***	-0.337	-1.320*
	(3.113)	(3.013)	(0.977)	(1.752)
TOPLA	4.118***	7.418***	0.137	4.060***
	(10.421)	(6.948)	(0.169)	(5.632)
TOPECON	1.486***	----	0.747	0.995
	(3.179)		(0.538)	(1.216)
PHD	1.059***	0.182	1.756***	1.673**
	(3.248)	(0.531)	(4.086)	(2.105)
PRIVATE	-0.309	-0.178	-0.770*	0.541
	(0.979)	(0.734)	(1.731)	(0.711)
UGPOP	-0.727***	-0.253*	-1.143***	-0.953**
	(4.314)	(1.964)	(5.193)	(2.020)
Constant	-2.894	-0.013	3.492	-8.569
Sample size	*608*	*199*	*225*	*191*
Adj. R^2	*.600*	*.304*	*0.170*	*0.528*
F statistic	*102.071****	*11.444****	*6.116****	*24.569****

Notes: Absolute values of t-statistics in parentheses.
*,**,*** denote significance at the .1, .05, .01 levels, respectively (2-tailed test).