Changing the Calculus: An Investigation of Undergraduate Economics Program Quality

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Changing the Calculus: An Investigation of Undergraduate Economics Program Quality

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ABSTRACT. This paper identifies some factors that affect undergraduate Economics program quality as measured by the College Factual "Economics - Overall Best Nationwide" rankings. Specifically, this research suggests that Economics programs that use calculus in their coursework have significantly better rankings than those that do not and that Economics programs that are located in a college other than the Business College of their universities have moderately better ranks. The results of this paper provide Economics departments information about how to increase program quality, recruit more students, and receive more funding.

I. Introduction

The quality of university programs affects enrollment and donations. Students and donors often rely on external sources, such as third-party rankings, when making their decisions on where to apply and donate. Rankings use university statistics that aim to measure the teaching, learning resources, advising, and management that contribute to the overall quality of each university (Tambi, Ghazali, and Yahya 2008, 1000). Because a higher rank increases enrollment and donations, universities seek ways to increase their quality and rank. This is true both for universities as a whole and for the individual programs offered by the universities. Economics programs are not exempt from this desire to improve. Therefore, Economics departments need to be able to identify the factors that are associated with highly ranked programs.

My analysis identifies the factors that are typical for a high-quality Economics program. Specifically, I identified two elements that are important for an Economics program: whether the program applies calculus in its coursework (measured by whether calculus I is a prerequisite for intermediate microeconomics) and whether the program is located in a business school. My research provides Economics

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departments with the information required to increase their program's quality, enrollment, and funding.

II. Literature Review

University quality is difficult to measure partially because there is no clear definition of what constitutes quality. Green (1994, 22-27) suggested five definitions of university quality: tradition of quality, conformance to specification or standards, fitness for purpose, effectiveness in achieving institutional goals, and meeting customers' stated or implied needs.

The first definition, tradition of quality, referred to a university's internally high standards and expectations that produced a reputation of above-average quality (Green 1994, 23). These standards and expectations are costly, creating a barrier for other universities to achieve the same level of quality. Ivy-League universities are an example of this university quality definition. These universities are consistently regarded as the best while most non-Ivy-League universities do not have such a reputation. The resources required to achieve Ivy-League quality makes it nearly impossible for other universities to obtain this reputation.

Green's second definition of university quality, conformance to specification or standards, was related to quality control. Benchmarks are set that, if met, imply a high-quality university (Green 1994, 23). An example of a benchmark is a university's job placement rate. A higher rate implies the university did a better job preparing its students, and therefore, is a higher-quality university. This definition raises several questions that lower its usefulness: What are the benchmarks measuring? Are they sufficiently high? How long will they be effective? While there are many questions regarding this definition, it does provide a simple rule that applies to all universities.

Fitness for purpose, Green's third definition of quality, judges a university on whether it meets its stated purpose (Green 1994, 25). "Instruction in skills", "promotion of the general powers of the mind", "advancement of learning", and "meeting the needs of the economy" are examples of university purposes (Green 1994, 25). Unlike conformance to specification or standards, fitness for purpose does not allow for comparison across universities. Additionally, a devious university could have something simple like "have at least one student graduate each year" as its purpose and be considered high quality.

Effectiveness in achieving institutional goals was Green's fourth definition of university quality. "A high quality institution is one that clearly states its mission and is efficient and effective in meeting the goals it has set for itself" (Green 1994, 25). This definition allows universities to set their own mission and judges them based on how they achieve them. It analyzes the processes a university uses to meet its goals. Measuring effectiveness removes the issues of fitness for purpose while allowing the universities to customize their goals and purposes.

Green's fifth definition of quality assesses whether a university meets its customers' needs (Green 1994, 26). Before using this definition, one must identify the university's customer. I argue that the students are the customer because students attend universities to expand their knowledge base to meet the demands of potential employers. Students hope that by attending a university they will be more likely to secure a job and advance their financial position in the future.

Using Green's fifth definition of university quality, it is possible to begin measuring university quality by judging how well a university meets the needs of its students. Lagrosen, Seyyed-Hashemi, and Leitner (2004, 64-65) surveyed Austrian and Swedish university students to determine what aspects of the university the students believed made a quality university. The following aspects were significant: corporate collaboration, information and responsiveness, courses offered, internal evaluations, computer facilities, collaboration and comparisons, and library resources. Specific elements of these aspects are in Table 1.

Hill, Loman, and MacGregor (2003) conducted a survey that simply asked nursing, management, and teaching students in the United Kingdom, "What does quality education mean to you?" From the student responses, Hill, Loman, and MacGregor identified four themes of university quality: teaching quality, student engagement and input, social and emotional support systems, and campus resources. While these two surveys identify the students' needs, the surveys do not address how well a university meets the students' needs.

One method of measuring how well a university meets its students' needs is data envelopment analysis. This method calculates a ratio of university outputs to inputs that determines whether the university is efficient. The researcher sets a threshold for this ratio, and universities above the threshold are considered efficient. Output variables may include average salary, average employer recruiter scores, employment rates, and satisfaction of students or faculty (Palocsay and Wood 2014,

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278). Input variables may include student-faculty ratio, average SAT scores, number of electives, and tuition (Palocsay and Wood 2014, 278). Student-faculty ratio serves as a proxy for teacher quality, SAT scores control for student ability, and tuition reflects the quality of resources provided by the university (Kreutzer and Wood 2007, 358). Data envelopment analysis determines efficiency of meeting the students' needs, but it does not identify the significance of the model's variables or provide information on how to increase efficiency.

TABLE 1–Factors of Significant University Quality Aspects

Quality Aspect	Factors
Corporate Collaboration	Courses created in co-operation with business Contact between teachers and business Teachers having experience from business Ability to contribute to the corporate world
Information and Responsiveness	Responsiveness and accessibility to teachers Appropriate information at the beginning of the studies Career information and guidance Appropriate curriculum design and content Clear mission and vision
Courses Offered	Courses taught by guest lecturers Courses in foreign languages Short programs run by professionals Opportunities to study abroad
Internal Evaluations	Evaluation of Courses Evaluations presented
Computer Facilities	24 hour access to facilities Sufficient computer facilities
Collaboration and Comparisons	International standards for comparisons National co-operation
Library Resources	Library resources

Zhang (2009) conducted a two-step regression analysis to determine the university inputs that affect four year state university quality. Zhang studied the public universities by state, leaving 50 data points for his model. In the first step, Zhang estimated the quality of each state's

universities using post-graduate annual earnings. He estimated these earnings as a function of average SAT scores, family income, parents' education, state, and region of the United States (Zhang 2009, 471). Each of these variables is external to university procedures. Using the estimated quality for each state, Zhang fit a second model to identify factors associated with high quality that the university can control. The following internal variables were significant: fraction of faculty with doctoral degrees, fraction of undergraduates in research I universities according to the Carnegie Classification, and student expenditures on non-salary expenditures (Zhang 2009, 485).

While some literature exists for Business and Social Science Colleges on the whole, no easily accessible literature exists that specifically addresses the quality of undergraduate Economics programs. Therefore, I assume Economics programs behave similarly to universities as a whole and use variables that were significant in previous literature.

III. Model/Data

I regressed the following model:

Quality = f(Institution Type, Carnegie Classification, Student-Faculty Ratio, Fraction of Economics Faculty with Doctoral Degrees, Calculus as Prerequisite, College where Economics Department is Housed)

Quality refers to the College Factual rankings of undergraduate Economics programs. College Factual (collegefactual.com) is an online resource for high school and college students. The website's goal is to help students find a rewarding career path without acquiring unnecessary student debt from indecision (College Factual). College Factual provides the following rankings for United States universities: overall best, best for the money, best for the money with aid, best for the money with no aid, best for veterans, best for returning adults, best sports, best by religious affiliation, ethnic diversity, and male/female diversity. The website also provides overall best rankings at the college and major levels. In addition to the rankings, College Factual has a "matchmaker" software where future college students may enter their personal information (family economic status, location, gender, academic ability, campus characteristic preferences), take a quiz to identify their strengths and interests to choose

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a major, and then obtain a short list of universities. I used the "Economics - Overall Best Nationwide" rankings for my analysis. I chose to use College Factual's quality score as my dependent variable because the underlying factors are indications of how well a university is meeting the students' needs. The inclusion of early career salaries, mid-career salaries, and accreditations ensure that this quality score is measuring how well a university is preparing its students for their futures. Additionally, the student-focus of the College Factual personnel suggests that the purpose of these rankings is to inform students about how well the university will meet the students' needs.

To obtain the quality scores that underlie the published rankings from College Factual, I contacted their data scientist, Tony Fischetti. He agreed to share the scores if I did not share or attempt to reverse engineer the scores. The variables used to develop the undergraduate Economics program quality score are early career earnings, mid-career earnings, percent of the university's students enrolled in the Economics major, percent of the nation's Economics majors enrolled at the university, related major focus/breadth, accreditation, and overall university quality[1] (McWilliam 2014). The variables' weights and significance are unknown. College Factual ranked 433 undergraduate Economics programs in the United States.

Institution Type is a binary indicator that takes the value 0 if the university is public and 1 if the university is private. These two types of universities experience different budget constraints that cause them to allocate resources to their Economics programs differently. All universities are held accountable by their donors and students. Public universities are also accountable to the taxpayers. Including *Institution Type* controls for the pressures felt by these two types of universities. *Carnegie Classification* is a dummy variable that proxies for the amount of research conducted at the university according to the Basic Carnegie Classification of Institutions of Higher Education. Values and descriptions of *Carnegie Classification* found in the dataset are in Table 2. For the included values, a lower *Carnegie Classification* value implies more research. *Institution Type* and *Carnegie Classification* were taken from the U.S. Department of Education's College Scorecard. The College Scorecard is a repository of data about United States higher education institutions collected from all students that apply for federal aid (US Department of Education 2015, 1).

TABLE 2–Values and Descriptions of the Carnegie Classification

Value	Description	Shorthand
15	Research Universities (very high research activity) school	R1
16	Research Universities (high research activity) school	R2
17	Doctoral/Research Universities school	R3
18	Master's Colleges and Universities (larger programs) school	M1
19	Master's Colleges and Universities (medium programs) school	M2
20	Master's Colleges and Universities (smaller programs) school	M3
21	Baccalaureate Colleges-Arts & Sciences school	
22	Baccalaureate Colleges-Diverse Fields school	

Student-Faculty Ratio is the number of students enrolled in an economics major divided by the number of faculty working in the economics department. *Fraction of Economics Faculty with Doctoral Degrees* is the number of economics faculty with doctorates divided by the total number of Economics faculty. I acquired both variables through a survey sent to the department head of the Economics programs included in a random sample of 200 universities from the 433 ranked universities. *Student-Faculty Ratio* and *Fraction of Economics Faculty with Doctoral Degrees* proxy for the teaching quality at the university. This is not a perfect representation for three reasons. First, the definition of faculty is not clear; it may or may not include adjuncts and lecturers. If a survey response identified the levels of faculty (full-time, adjunct, lecturer), I only recorded full-time faculty in the research dataset. Second, some survey responses reported approximate enrollment and faculty numbers. Third, these two variables do not account for everything that makes a commendable professor. It is impossible to quantify the relations professors have with their students that improve the education of students.

The final two variables, *Calculus as a Prerequisite* and *College where the Economics Department is Housed*, are the variables of interest in my model. The variables preceding these two serve as control variables. *Calculus as a Prerequisite* is a binary indicator for whether students must take a calculus course before taking an intermediate

microeconomics course. 0 indicates that calculus is not a prerequisite. *College where the Economics Department is Housed* is a dummy variable taking the value 1 for Business College, 2 for Social Science College, and 3 for Other College. I found these two variables in the online course catalogs of the universities that replied to the survey. Figure 1 shows the relations between Economics program rank and the two variables of interest in my analysis. These graphs show that on average, a program that requires calculus has a better rank than one that does not and that belonging to a Social Science College may also be associated with a higher rank.

Figure 1. Calculus as a Prerequisite and College where Housed Effects
         on Program Quality
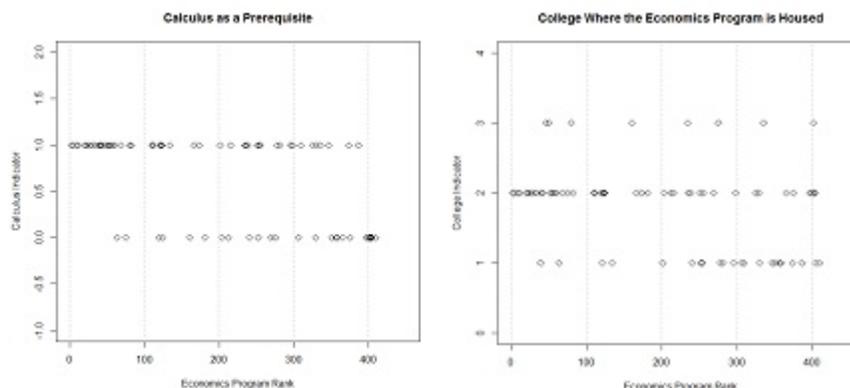
Figure 2 shows how many Business Colleges and Social Science Colleges require calculus as a prerequisite. 67.44 percent of programs in social science colleges require calculus as opposed to 60.87 percent located in business colleges. Fisher's exact test revealed that the proportions of universities that require calculus are not statistically significant between colleges. If this test had shown a shown a statistical difference between colleges, I would have added an interaction variable to the model.

Figure 2. Distribution of Calculus as a Prerequisite and College
where Program is Housed
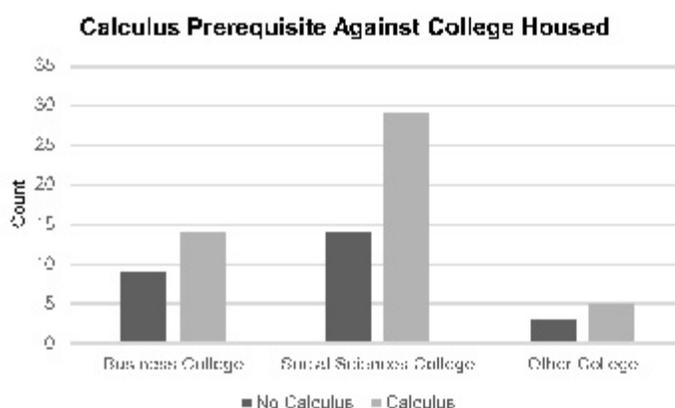
My initial theoretical model included the variables tuition and average SAT scores from the College Scorecard data repository. The goal of including these two variables was to proxy for the quality of campus resources and student quality (Kreutzer and Wood 2007, 358). Unfortunately, College Factual used these two variables to calculate their overall university quality which was a variable in the calculation of Economics program quality. Therefore, including these variables in my model caused over-fitting because tuition and average SAT scores were reflecting overall school quality rather than campus resource and student quality as intended. Figure 3 depicts overall university rank's relation to the Economics program rank. It also shows how tuition and average SAT scores reflect overall rank rather than campus resources and student quality. If this study is replicated, the future researcher could attempt to obtain these variables for the Economics program rather than the entire university. This would allow the future researcher to control for campus resource and student quality.

74 of 200 department heads replied to the survey that asked for the number of majors, faculty, and faculty with doctoral degrees, so my dataset had 74 observations. The descriptive statistics for the dataset are in Table 3. Exploratory analysis revealed no statistically significant difference between the average quality score of the 74 universities and the entire set of 433 universities indicating that the sample adequately reflects the population of ranked economics programs.

Figure 3. Overall Rank's Effect on Economics Rank and the Factors
Underlying Overall Rank
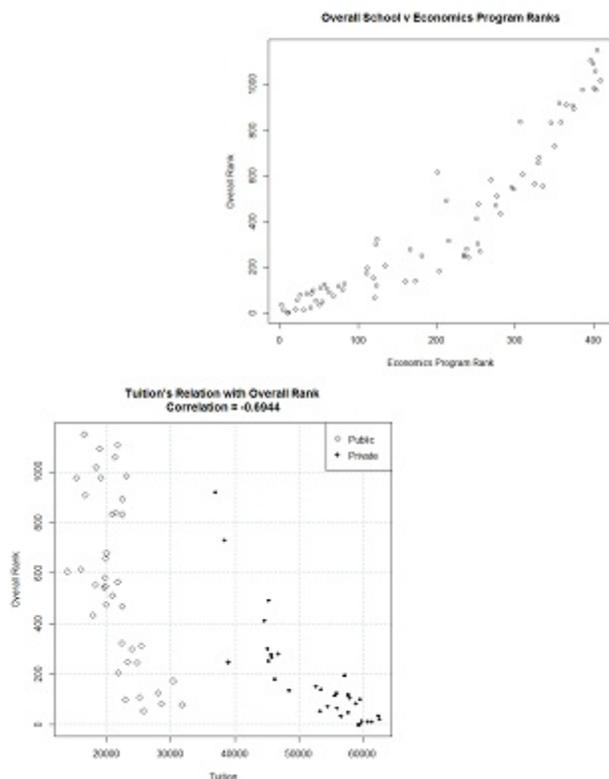
A list of the universities studied and their ranks are in Appendix A.
Appendix A also includes the *Calculus as a Prerequisite* and *College
where the Economics Department is Housed* variables.

TABLE 3–Descriptive Statistics

	Mean	Standard Deviation	Median	Minimum	Maximum
Quality Score	5.933	1.359	5.887	3.607	8.533
Institution Type	0.459	0.502	0	0	1
Carnegie Classification	17.311	2.323	17	15	22
Student-Faculty Ratio	18.499	13.434	13.708	4	66.667
Fraction of Economics Faculty with Doctoral Degrees	0.951	0.097	1	0.400	1
Calculus as a Prerequisite	0.649	0.481	1	0	1
College where Economics Department is Housed	1.811	0.612	2	1	3

V. Results/Discussion

Table 4 contains the final model results. *Fraction of Economics Faculty with Doctoral Degrees* was removed from the model. This was not a surprise as two-thirds of the studied universities had only doctorate faculty and twenty percent had just one non-doctorate faculty member. Therefore, there was little variation of the *Fraction of Economics Faculty with Doctoral Degrees* variable and so not an indicator of Economics program quality. *Carnegie Classification* was transformed into seven binary variables with "Baccalaureate Colleges-Diverse Fields School" value initially being left out of the model. The regression revealed that a university with a Carnegie Classification of Research 1 or Research 2 has, on average, a higher Economics Program quality, but that the other six classifications did not provide any statistical difference in quality. *College where the Economics Program is Housed* was transformed into two binary variables with "Other College" being the baseline. The Social Science College indicator was found insignificant suggesting that social science-based Economics programs have a similar quality as the universities whose Economics Programs are in a college classified in as "Other".

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TABLE 4–Model Results

Variable	Coefficient	p-value	Statistical Significance
Intercept	3.99499	<0.0001	Very Strong
Private Institution	1.31062	<0.0001	Very Strong
Carnegie Classification Research 1	0.34326	0.1267	Slight
Carnegie Classification Research 2	0.40229	0.1607	Not
Student-Faculty Ratio	0.03703	<0.0001	Very Strong
Calculus is a Prerequisite	1.00812	<0.0001	Very Strong
Economics Program Housed in Business College	-0.65533	0.0047	Very Strong
Adjusted R^2: 0.6388 Model p-value: 6.381e-14 Note: Removal of Carnegie Classification Research 2 caused the model's AIC to increase from -22.72545 to -22.52873.			

The model suggests that Economics programs at a private university, have a Carnegie Classification of Research 1 or 2, have a higher student-faculty ratio, are not located in the Business College, and require calculus as a prerequisite are on average higher quality than those programs that do not have those qualities, ceteris paribus. The student-faculty ratio is an unexpected result, but it may be an indicator of program size and popularity, as the larger universities often had higher student-faculty ratios.

I removed the University of Delaware and St. Francis College from the model because these Universities were highly influential on the model. The University of Delaware had a Carnegie Classification of 22, but an Economics program rank of 63, which was much better than other universities with a similar Carnegie Classification. St. Francis College, on the other hand, had a Carnegie Classification of 15, but program rank of 365. Removing these two Universities increased the model's adjusted R^2, decreased the AIC, and after these points were removed from the model, no other influential points or outliers existed. The final model contained no multicollinearity issues and followed all underlying

regression assumptions. The regression diagnostic plots are Figure 4.

Figure 4. Regression Diagnostic Plots
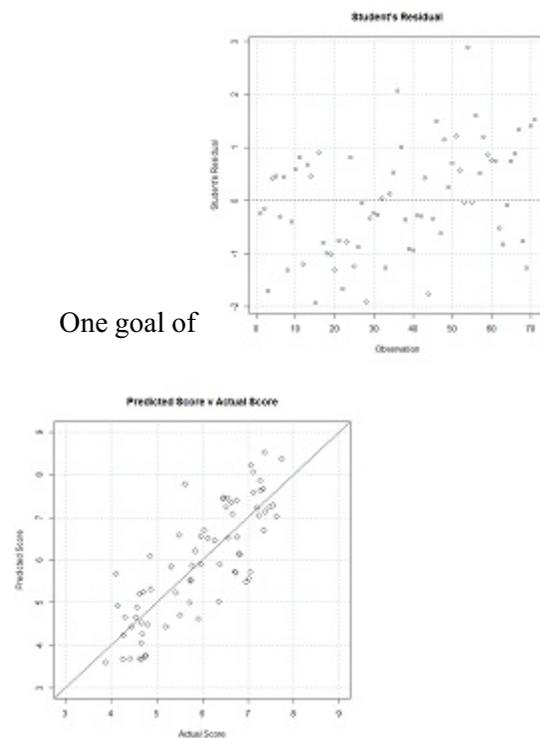
One goal of

identify whether requiring calculus or being housed in a particular college had an effect on undergraduate Economics program quality. The regression results suggest that an Economics program that requires calculus has on average a quality score 1.00812 higher than one that does not and an Economics program housed in the Business College has on average a quality score 0.65533 lower than one that is housed elsewhere. Because I agreed to not share the quality score, Table 5 shows the predicted change in rank if a university introduced calculus as a prerequisite, moved the program from the Business College, or implemented both changes. The calculus effect for the top 75 universities is slightly unrealistic as all of these universities in my model already

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require calculus. I must note that all Economics programs will likely not experience the entirety of these benefits, but the program quality should increase nonetheless.

VI. Conclusion

While my research successfully identified significant factors of Economics program quality it is not infallible. The *Student-Faculty Ratio and Fraction of Faculty with Doctoral Degrees* variables are not entirely accurate for two reasons. First, some universities only provided approximate enrollment numbers because of requirements before universities allow students to declare a major. Second, I did not provide a specific definition of faculty when I sent the survey to the department heads. As a result, the definition may not be consistent for each university as there are full-time, part-time, adjunct, and lecturer classifications for faculty that alter the definition for each university.

TABLE 5–Effects of an Economics Program Requiring Calculus
or Moving from Business College

Current Rank	Rank if Calculus was Added	Rank if Moved from Business College	Rank if Both Changes were Made
25	1	6	1
50	6	14	1
75	11	25	1
100	22	40	4
125	35	65	10
150	51	91	14
175	70	103	22
200	93	121	35
225	99	135	39
250	120	157	57
275	156	202	93
300	197	242	116
325	238	265	145
350	255	284	167
375	275	349	201
400	321	361	264

If the survey response broke up the faculty, I only included only full-time faculty. Furthermore, these proxies for teacher quality and *Carnegie Classification* as a proxy for the amount of research conducted at the universities likely do not adequately reflect the dimensions of the Economics program they are attempting to proxy. Another limitation of this research is that using College Factual's Economics program rank may not adequately reflect true program quality. Using a different rank or quality score would likely produce very different results.

Future research could replicate this study using a different quality score to see if results are consistent. A future researcher could also add variables to account for campus resources, like tuition, and student quality, like average SAT scores, that are specific to the Economics program. A future researcher should also provide a concrete definition of faculty when obtaining the number of faculty and number of faculty with doctoral degrees. A final suggestion for future researchers is to use a more comprehensive indicator of whether the Economics program actually uses calculus. This could be done by conducting interviews with department faculty to gauge how often calculus is actually used in the coursework. Two possible ways to gauge the frequency are to ask how many intermediate microeconomics lectures use calculus and the number of Economics courses that ever use calculus.

My analysis suggests that using calculus in undergraduate Economics programs and having the program housed somewhere other than the Business school on average provides a significant boost in the Economics program quality. My analysis also suggests that better-quality Economics programs are at private universities, have a higher student-faculty ratio, and have a Research 1 or Research 2 Carnegie Classification. Overall, my research provides Economics programs with information required to potentially increase their quality, attract more students, and increase funding for their programs.

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Endnotes

1. Factors of overall university quality are average test scores, average faculty compensations, expenditures per student, student-faculty ratio, percent full-time teachers, freshmen retention rate, 6 year graduation rate, expected v actual graduation rate, student loan default rate, starting salary boost, and mid-career salary boost. More information may be found at
    http://inside.collegefactual.com/methodologies/best-colleges-rankings-overview

Appendix A: List of Universities

University	Rank	Calculus Prerequisite	College Where Economics Program is Housed
Barnard College	80	1	NA - Unified School
Bowling Green State University-Main Campus	346	1	Business
Calvin College	234	1	NA - Unified School
CUNY Brooklyn College	309	1	Business
Dartmouth College	30	1	Social Sciences
Denison University	68	1	Social Sciences
East Carolina University	329	0	Arts & Sciences
Eastern Michigan University	399	0	Arts & Sciences
Florida Southern College	350	0	Business
George Washington University	34	1	Arts & Sciences
Grinnell College	46	1	NA - Unified School
Humboldt State University	401	0	Professional Studies
Illinois State University	215	1	Arts & Sciences
Illinois Wesleyan University	160	0	Liberal Arts
Iona College	251	1	Arts & Sciences
Lafayette College	54	1	Social Sciences
Linfield College-McMinnville Campus	166	1	Social Science
McKendree University	356	0	Business
Millersville University of Pennsylvania	325	1	Arts & Sciences

*Not included in final model

Appendix A: List of Universities

University	Rank	Calculus Prerequisite	College Where Economics Program is Housed
Missouri State University-Springfield	403	0	Social Sciences
North Carolina A&T State University	386	1	Business
North Dakota State University-Main Campus	335	1	Agribusiness and Applied Economics
Northeastern University	82	1	Social Sciences
Northwestern University	4	1	Arts & Sciences
Pacific Lutheran University	235	1	Social Sciences
Quinnipiac University	173	1	Arts & Sciences
Radford University	330	1	Business
Reed College	123	1	History and Social Sciences
Regis University	256	1	Business
Rochester Institute of Technology	255	1	Liberal Arts
Rutgers University-New Brunswick	57	1	Arts & Sciences
Salisbury University	277	1	Business
Seattle Pacific University	252	0	Business, Government, Economics
Southern Methodist University	60	1	Humanities and Sciences
Southwestern University	238	1	Social Science
St Francis College*	365	0	Social Science
Suffolk University	212	0	Arts & Sciences
Syracuse University	75	0	Arts & Sciences

*Not included in final model

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University	Rank	Calculus Prerequisite	College Where Economics Program is Housed
The University of Tennessee-Knoxville	240	0	Business
The University of Texas at Arlington	306	0	Business
Truman State University	298	1	Social & Cultural Studies
University of Akron Main Campus	402	0	Arts & Sciences
University of Arizona	122	1	Arts & Sciences
University of Arkansas	253	1	Business
University of California-Davis	26	1	Social Science
University of Central Florida	295	1	Business
University of Central Missouri	409	0	Business
University of Chicago	2	1	Social Sciences
University of Dayton	203	0	Arts & Sciences
University of Delaware	63	0	Business
University of Illinois at Urbana Champaign	40	1	Arts & Sciences
University of Iowa	134	1	Business
University of Maine	275	0	Natural Sciences, Forestry, and Agriculture
University of Maryland-College Park	42	1	Behavioral and Social Sciences
University of Massachusetts-Boston	269	0	Liberal Arts
University of Memphis	358	0	Business
University of Michigan-Ann Arbor	22	1	Literature, Science, and the Arts

*Not included in final model

Appendix A: List of Universities

University	Rank	Calculus Prerequisite	College Where Economics Program is Housed
University of Missouri-St. Louis	375	0	Arts & Sciences
University of Oklahoma-Norman Campus	181	0	Arts & Sciences
University of Oregon	124	0	Arts & Sciences
University of Pennsylvania	11	1	Arts & Sciences
University of Pittsburgh-Pittsburgh Campus	110	1	Arts & Sciences
University of Richmond	121	1	Business
University of Wisconsin-La Crosse	281	1	Business
University of Wisconsin-River Falls	373	1	Business
Ursinus College	111	1	Social Sciences
Utah State University	201	1	Business
Vanderbilt University	20	1	Arts & Sciences
Washington and Lee University	50	1	Commerce, Economics, and Politics
Washington University in St. Louis	39	1	Business
Western Kentucky University	404	0	Business
Western Oregon University	396	0	Arts & Sciences
Willamette University	119	0	Liberal Arts
Yale University	9	1	Social Sciences

*Not included in final model