Undergraduate Mathematics Courses Required and Recommended for Admission to Economics PhD Programs in the United States

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Abstract

This note presents a list of mathematics courses, normally taken at the undergraduate level, which are required or recommended as part of the admissions criteria for all economics PhD programs in the United States. The data in this note were gathered through a survey of PhD program directors, retrieval of data from PhD program websites, and personal conversations with PhD program directors in the United States. All of the data were collected during the spring and summer of 2016.

Introduction

Many students considering a PhD in economics often wonder whether or not they have enough mathematics courses in their credentials. A posted question from an aspiring economist on Greg Mankiw's (2006) Blog exemplifies this curiosity to which Mankiw offered insightful answers based on his own professional experience. He noted that a PhD economist needs to have a solid understanding in the language of mathematics not only to succeed in graduate school but also to succeed in research and in some jobs. The extensive use of mathematics in the education of economists, and in the profession itself, has been a subject of considerable debate for years (Colander, 2005; Colander & Brenner, 1992; Colander & Klamer, 1987; Quddus & Rashid, 1994). The primary concern of this debate is the potential disconnect between the use of advanced mathematical techniques in both theoretical and empirical works, and the need for a deeper understanding of economics in the real world. However, there appears to be a consensus that a working knowledge of mathematics and statistics is important for PhD economists. It is the degree and depth of mathematical literacy that is in question.

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A typical PhD program admission committee assesses different aspects of an applicant's portfolio to see whether or not the applicant is a fit for the program. One of these aspects is competency in mathematics. Most programs weigh an applicant's competency in mathematics by examining the mathematics courses he or she has already taken during his or her academic career. In this note, we identify the specific mathematics and statistics course requirements and recommendations for admission to PhD in economics programs in the United States. We hope this note can be a guide to potential applicants to PhD programs so that the applicants will have adequate mathematics and statistics courses when they enter graduate school. Please note that these data were compiled during the spring and summer of 2016. If you are reading this note a few years from now, the requirements and recommendations may have changed for a particular program.

The Data

We compiled a list of PhD programs in economics from Peterson's (2015) guide to graduate education. We then compared the list with the one available from the website of the American Economic Association (2015). We identified 134 economics PhD programs in the United States. Once we had a complete list, we contacted the program directors via e-mail requesting them to fill out an online survey that we developed in *SurveyMonkey* ("Survey of Math Requirements and Recommendations for PhD Students," 2015). The survey contained a list of mathematics, statistics, and econometrics courses that might be required or recommended for admission to their program. We included 11 courses on the list: Calculus 1, Calculus 2, multivariate calculus, matrix theory/algebra, differential equations, stochastic processes, real analysis, Statistics 1, Statistics 2, Econometrics 1, and Econometrics 2. We asked respondents to identify which of these courses are required or recommended for admission into their programs. Respondents were also given the option of adding other courses not listed. We solicited participation in the survey through three rounds of emails and received 67 completed surveys. Please note that some schools may require particular grades in these mathematic courses, but we have no evidence of this.

For the programs that did not complete a survey, we examined their admission websites to gather the information about mathematics requirements and recommendations. In some cases, the stated mathematics requirements are vague and required interpretation. In Table 1, those programs with interpreted requirements are shown in italics. We were able to collect 59 complete observations from the program admission websites. There were eight programs that did not address mathematics requirements or recommendations on their admissions website. For these programs, we conducted phone interviews with the graduate program directors. Table 1 reports the responses for all of the programs included in our comprehensive sample. A "1" in the table indicates that the course is required for admission, while a "2" indicates that the course is recommended. A "3" indicates that the course is neither required nor recommended.

A few programs responded that they recommend courses other than those listed on the survey. Those courses are Numerical Methods, Functional Analysis, Probability Theory, Complex Analysis, Topological Space, Convex Analysis, Sets and Logic, Optimization Theory, Game Theory, and Mathematical Economics.

Conclusion and Advice

Mankiw's (2006) advice to aspiring students "to take math course until it hurts" is confirmed by our data. Table 1 suggests that aspiring students for PhD programs in economics will need to have Calculus 1 (required by 80.5% of the programs), Calculus 2 (72.9%), Statistics 1 (57.1%), matrix theory/linear algebra (54.1%), to confidently expect that they have enough mathematics courses to be admitted to the majority of PhD programs in the United States.

Table 1. Mathematic Courses Requirement and Recommendation for Admission to PhD in Economics Programs.

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
American University	1	1	1	1	2	2	2	2	2	2	2
Arizona State University	2	2	2	2	2	3	2	2	2	3	3
Auburn University	*1*	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
Binghamton University	1	1	1	1	1	1	2	1	1	1	2
Boston College	*2*	*2*	*2*	*2*	*3*	*3*	*2*	*2*	*2*	*3*	*3*
Boston University	2	2	2	2	3	3	2	2	3	2	3
Brandeis University	1	1	1	1	2	2	2	1	2	1	2
Brown University	1	1	1	2	2	2	2	2	2	2	2
Carnegie Mellon University	3	3	3	3	3	3	3	3	3	3	3
Claremont Graduate University	1	1	1	1	3	3	2	1	2	3	3
Clark University	1	1	1	1	1	3	3	3	3	3	3
Clemson University	1	1	1	1	3	3	2	1	3	1	3
Colorado State University	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*1*	*3*
Columbia University	1	1	1	1	2	2	2	1	1	1	1
Cornell University	1	1	1	1	2	3	1	1	2	1	2
Drexel University	1	1	1	1	2	2	2	1	1	1	2
Duke University	1	1	1	1	1	2	2	1	2	2	2
Emory University	3	3	2	2	2	3	2	2	2	2	3
Florida International University	1	1	2	1	3	3	3	1	2	2	3
Florida State University	1	1	3	1	3	3	3	1	1	2	3
Fordham University	1	1	1	1	2	2	2	1	1	2	3
George Mason University	2	2	3	2	3	3	3	2	2	2	3
George Washington University	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
Georgetown University	2	2	1	2	2	3	3	1	1	3	3
Georgia Institute of Technology	1	1	1	1	3	3	3	3	3	3	3
Georgia State University	1	1	1	2	2	2	2	2	2	2	2
Harvard University	1	1	3	1	3	3	2	3	3	3	3
Howard University	3	3	3	3	3	3	3	1	1	1	3

(continued)

Table 1. (continued)

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
Indiana University Bloomington	1	1	2	2	2	3	3	2	2	3	3
Indiana University–Purdue University Indianapolis	3	3	1	1	3	3	3	1	1	3	3
Iowa State University	1	1	1	1	3	3	2	1	1	3	3
John Hopkins University	1	1	2	1	2	3	2	2	2	3	3
Kansas State University	1	3	3	3	3	3	3	1	3	3	3
Lehigh University	1	1	1	1	2	2	2	1	1	1	2
Louisiana State University	1	1	1	1	2	2	2	1	2	3	3
Massachusetts Institute of Technology	*1*	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
Michigan State University	1	1	1	1	1	3	1	1	2	3	3
Middle Tennessee State University	1	2	2	2	3	3	3	2	3	3	3
Mississippi State University	1	1	3	3	3	3	3	1	3	3	3
New York University	1	1	1	1	2	2	1	2	2	1	1
North Carolina State University	1	1	1	1	1	3	2	1	3	2	2
Northeastern University	1	1	2	2	3	3	2	1	2	3	3
Northern Illinois University	1	1	2	2	3	3	2	1	1	3	3
Northwestern University	*1*	*1*	*1*	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*
Oklahoma State University	1	1	2	1	2	3	3	1	1	3	3
Oregon State University	3	1	3	1	3	3	3	1	1	1	3
Pennsylvania State University	3	3	1	3	3	3	3	3	3	3	3
Princeton University	*3*	*3*	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
Purdue University	1	1	3	1	3	3	3	1	3	3	3
Rice University	3	3	1	1	3	3	2	3	3	3	3
Rutgers University	1	1	2	1	2	3	2	1	2	2	2
Southern Illinois University Carbondale	1	2	2	2	3	3	3	2	3	2	3
Southern Methodist University	1	1	1	1	3	3	2	1	3	3	3

Table 1. (continued)

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
Stanford University	3	3	1	1	3	3	3	1	1	3	3
Stony Brook University	1	1	2	2	2	2	2	1	1	1	2
Syracuse University	1	1	1	2	2	3	2	2	2	2	2
Temple University	1	1	1	1	2	3	2	2	3	2	3
Texas A&M University	1	1	2	1	2	2	2	1	2	1	2
Texas Tech University	1	1	1	2	2	3	3	1	1	3	3
The Graduate Center, City University of New York	3	3	3	1	1	3	3	1	3	3	3
The New School for Social Research	3	3	3	3	3	3	3	3	3	3	3
The Ohio State University	1	1	1	1	1	2	2	1	1	2	2
Tulane University	*1*	*1*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*
University at Albany	1	1	1	1	2	2	2	1	2	2	2
University at Buffalo, The State University of New York	1	1	2	2	2	3	2	2	2	3	3
University of Alabama	1	1	1	1	1	2	2	2	2	2	2
University of Arizona	1	1	3	1	1	3	1	2	3	2	3
University of Arkansas	1	1	2	1	2	3	2	3	3	3	3
University of California Irvine	1	1	1	1	3	3	3	3	3	1	1
University of California, Berkeley	1	1	1	1	2	1	1	1	1	3	3
University of California, Davis	1	1	1	1	2	2	2	2	2	2	3
University of California, Los Angeles	1	1	3	1	3	3	3	1	3	3	3
University of California, Riverside	3	3	1	1	3	3	3	1	1	2	3
University of California, San Diego	1	1	1	1	3	2	2	3	3	3	3
University of California, Santa Barbara	2	2	2	2	3	3	2	2	2	1	3
University of California, Santa Cruz	1	1	3	1	3	3	3	1	1	3	3
University of Chicago	*1*	*1*	*1*	*1*	*3*	*3*	*3*	*1*	*1*	*1*	*1*

Table 1. (continued)

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
University of Cincinnati	1	1	1	1	3	2	2	1	1	1	2
University of Colorado	1	1	2	1	2	3	2	1	2	2	2
University of Connecticut	1	1	1	1	3	3	3	1	1	3	3
University of Delaware	1	1	2	2	2	3	2	1	2	1	2
University of Florida	1	1	1	1	1	3	2	1	3	3	3
University of Georgia	1	2	2	2	3	3	3	3	3	3	3
University of Hawai'i at Mānoa	1	1	2	2	2	3	2	3	3	3	3
University of Houston	1	1	1	2	2	2	2	2	2	2	2
University of Illinois at Chicago	2	2	2	2	2	3	3	2	3	2	3
University of Illinois Urbana–Champaign	3	3	3	3	3	3	2	1	1	3	3
University of Iowa	1	1	1	2	2	2	2	1	2	2	2
University of Kansas	1	1	1	1	3	3	3	3	3	3	3
University of Kentucky	2	2	2	2	3	3	3	2	2	3	3
University of Maryland, College Park	1	1	1	1	2	3	1	2	2	2	2
University of Massachusetts Amherst	1	1	3	1	3	3	3	1	3	3	3
University of Memphis	1	2	2	2	3	3	3	1	3	3	3
University of Miami	1	1	1	1	2	3	2	1	2	2	3
University of Michigan	1	1	3	1	3	3	3	2	2	3	3
University of Minnesota Twin Cities Campus	*1*	*1*	*3*	*3*	*2*	*3*	*2*	*2*	*2*	*3*	*3*
University of Mississippi	*2*	*3*	*3*	*2*	*2*	*3*	*3*	*2*	*2*	*3*	*3*
University of Missouri	1	1	2	3	3	3	3	2	3	3	3
University of Missouri–Kansas City	*2*	*3*	*3*	*2*	*2*	*3*	*3*	*1*	*3*	*3*	*3*
University of Nebraska–Lincoln	1	1	3	1	2	3	2	1	3	3	3
University of Nevada, Reno	1	1	3	2	2	3	3	3	3	2	3
University of New Hampshire	1	2	2	2	2	3	3	1	3	1	3
University of New Mexico	1	1	3	1	3	2	3	1	2	1	2

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Table 1. (continued)

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
University of North Carolina	1	1	1	1	3	3	2	3	3	3	3
University of North Carolina, Greensboro	1	2	2	2	2	3	3	1	1	1	1
University of Notre Dame	3	3	2	2	3	3	3	2	2	3	3
University of Oklahoma	1	1	3	2	3	3	3	1	3	3	3
University of Oregon	1	1	1	1	2	3	2	1	1	3	3
University of Pennsylvania	1	1	1	1	2	2	1	1	2	1	2
University of Pennsylvania, The Wharton School	1	1	1	1	2	2	2	1	2	1	2
University of Pittsburgh	1	1	3	1	2	3	2	2	2	3	3
University of Rhode Island	1	1	2	3	3	3	3	1	2	1	2
University of Rochester	2	2	2	2	3	3	3	2	2	3	3
University of South Carolina	1	3	3	3	3	3	3	1	1	3	3
University of South Florida	1	1	3	3	3	3	3	1	3	3	3
University of Southern California	1	3	3	3	3	3	3	1	1	1	3
University of Tennessee	1	1	2	1	2	2	2	1	2	1	2
University of Texas	1	1	1	1	2	3	2	1	1	2	2
University of Texas at Dallas	1	1	1	1	2	2	2	1	2	2	2
University of Utah	1	2	2	2	2	3	3	1	3	2	3
University of Virginia	1	1	1	1	2	3	2	3	3	3	3
University of Washington	1	1	2	1	2	3	3	1	1	2	3
University of Wisconsin–Madison	1	1	1	1	3	3	3	1	3	3	3
University of Wisconsin–Milwaukee	1	1	3	3	3	3	3	1	3	3	3
University of Wyoming	1	1	2	2	2	2	3	2	2	1	2
Utah State University	1	1	1	2	3	3	3	1	1	1	1
Vanderbilt University	1	1	3	2	2	3	2	1	3	2	3
Virginia Polytechnic Institute and State University	1	1	1	1	2	2	2	1	1	2	2

Table 1. (continued)

Name of university	Calculus 1	Calculus 2	Multi-variate calculus	Matrix theory/linear algebra	Differential equations	Stochastic processes	Real analysis	Statistics 1	Statistics 2	Econo-metrics 1	Econo-metrics 2
Washington State University	1	1	1	1	2	2	2	1	3	1	1
Washington University in St. Louis	1	1	2	2	2	2	2	2	2	2	2
Wayne State University	1	1	3	2	2	3	3	1	3	3	3
West Virginia University	1	2	2	2	2	3	3	1	3	3	3
Western Michigan University	1	1	3	3	3	3	3	3	3	3	3
Yale University	3	3	2	2	3	3	3	2	2	3	3
Percent of Programs Requiring Each Course	80.5%	72.9%	45.1%	54.1%	8.3%	1.5%	5.3%	57.1%	24.1%	21.8%	5.3%

Note. Values printed in italics are interpreted from the program's admission website. 1 = required; 2 = recommended; 3 = neither required nor recommended.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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