“Do algebra and geometry provide the same value in preparing high school students for economics?

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Abstract

Prior researchers (for example, Ballard & Johnson 2004; Hoag & Benedict 2010) have demonstrated a link between math ability and performance in economics courses. However, few researchers have deeply probed this issue. In this paper, I compare the merits of Algebra and Geometry test scores as predictors of Economics test scores. Data are provided by the Georgia Department of Education and include all Georgia public high school students who completed Economics in 2006, 2007, and 2008. Students completed standardized examinations in Algebra I, Geometry, and Economics following the completion of each course. These scores serve as proxies for abilities in each subject. Compared to Algebra I test scores, I find that performance on the Geometry test is a better predictor of success on the Economics exams. Results of this study could be used to determine course-sequencing in high school and recruitment efforts. For example, scores in a Geometry course could be used to sort students into Honors and AP Economics. Additionally, my results indicate that prior research using generic proxies for math abilities may suffer from misspecification biases.

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I. Introduction

Research indicates that a strong ability in mathematics correlates with an aptitude in economics (Ballard & Johnson 2004; Hoag & Benedict 2010). There are two potential explanations for this relationship. One possibility is that high performance in mathematics is correlated with unobserved latent variables; for example, students demonstrating high marks in mathematics may be hard workers or the children of highly motivational parents. This effect is indirect; math scores signal an innate ability that may transfer to any discipline, including economics, but mathematical prowess of this nature does not *cause* economics aptitude. High math ability may also have a direct effect on one's aptitude in economics; in other words, the relationship could be causal (Hoag & Benedict 2010). A student with a solid mathematical background may be able to problem-solve more easily and make quicker calculations. For example, a calculation of consumer surplus for a linear demand curve requires students to calculate the area of a triangle. Students with knowledge of geometry will have likely mastered such a calculation, allowing them to focus on the theory, rather than learning a new formula.

It seems possible that some math abilities are more likely to have a direct effect on a student's potential in economics than others.[1] For example, a student receiving high grades on a test concerning imaginary numbers will likely have high Economics test scores due to indirect effects (more educated parents, dedication to school, etc.). However, a student showing proficiency in graphical tasks will likely succeed in an Economics course due to indirect *and* direct effects (correlation captures causality and non-causality).

[1] Hoag and Benedict (2010) and Ballard and Johnson (2004) both report some evidence of this position.

In this essay, I empirically investigate the effects of algebra and geometry performance on economics performance. The data come from the state of Georgia and include all public high school students who completed Economics in 2006, 2007, and 2008. Performance in each subject (Algebra I, Geometry, and Economics) is proxied by scores on End-of-Course-Tests (EOCT), which are high-stakes exams taken at the end of each course. While many researchers have found a positive correlation between performance in math classes and Economics, very few have analyzed the potential differences among different math courses in predicting economics performance.

Compared to Algebra EOCT scores, I find that Geometry EOCT scores are statistically more strongly correlated with Economics EOCT performance. Economics educators can use this finding to strengthen student placement and improve recruitment efforts. In addition, this essay should contribute to the econometrics of economic education research. Because algebra and geometry skills correlate with economics aptitude to different degrees, the employment of generic math proxies is not advised when estimating models predicting economics performance.

II. Literature Review

In many studies estimating schooling outcomes in economics, a generic math variable is used in regressions to account for math aptitude. Typically, the math variable is positive and significant, but the magnitude and interpretation of the coefficient for math is often ignored. These studies do not provide adequate evidence for a positive correlation—the math variable may simply account for effort or overall intelligence. Research described in the remainder of this section is specifically aimed at finding the relevance and robustness of math abilities net of other relevant variables in determining students' economics performance.

Hoag and Benedict (2010) collected grades from fall Principles of Microeconomics courses between 2002 and 2006 at Bowling Green State University. After omitting individuals who had transferred to Bowling Green or were missing ACT scores, the authors found that performance on the math section of the ACT was significantly and positively related to performance in the introductory college economics course, net of other explanatory variables.

Myatt and Waddell (1990) reported a similar result. They tracked the matriculation of students from one high school to a small university on the Atlantic Coast over a nine-year period. Among all students sampled, achievement in 11th grade math and enrollment in 12th grade math were each positively correlated with final grades in an economics principles course.[2] A dummy variable for high school economics was also significant, providing additional evidence that students retain knowledge from high school economics. However, when a regression was run that only included students who had taken Economics in high school, the effects of math enrollment and performance were less robust—the coefficient for 11th grade math fell by 72% and enrollment in 12th grade made was no longer significant. The authors took this as evidence that high school math ability and the completion of high school economics were substitutes.

Arnold and Straten (2012) sought to control for motivation in models predicting success in economics courses. The authors ran factor analysis based on responses to a series of survey questions to reduce the results to four categories. For example, the "extrinsic motivation" category was based on responses to job prospects and personal development—both of which likely encouraged students to attain higher grades, while the "intrinsic motivation" was largely composed of questions gauging a student's interest in economics and math. Even after

[2] The authors are unable to gather data on 12th grade math performance. 12th grade math is not compulsory—a positive sign is an indication that high aptitude students are more likely to take 12th grade math.

controlling for motivation, high school track, high school GPA, and other relevant variables, the results corroborate with Hoag and Benedict (2010): Math ability and performance in Economics were positively related. Interestingly, the authors also discovered that intrinsic motivation was of utmost importance for students who lacked a strong analytical background.

Using a similar method to those described above, Cohn et al. (1998) did *not* find that math skills were important for success in an economics course. Principles of Economics students were asked to complete a 30-question math quiz prior to taking economics. After controlling for similar variables as the authors above (e.g. SAT, GPA, etc.), the authors found that the math quiz score was not significantly related to grade earned in Principles of Economics. Also, the completion of college calculus was found to be insignificant. The findings of Cohn et al. (1998) notwithstanding, math ability and performance in economics courses are generally found to be positively correlated.

It is possible that some math abilities are more highly correlated with economics performance than others. For example, Butler et al. (2001) found that the level of calculus attained and subsequent calculus grades were, for the most part, positively related to performance in the Intermediate Microeconomic Theory class. However, calculus class-taking and calculus grades were not found to correlate with performance in Intermediate Macroeconomic Theory.

Likewise, Anderson et al. (1994) found that the completion of Calculus correlated with students' performance in an economics course. The authors tracked students who enrolled in Introductory Economics at the University of Toronto after graduating from high schools in Ontario. This course spanned two semesters and included topics in both microeconomics and

macroeconomics. They found that, among high school course grades, calculus grade was the strongest predictor of a student's Introductory Economics grade—even stronger than economics grades in high school. Next, the authors included a dummy variable for taking high school calculus (along with other relevant variables) and found that it positively correlated with collegiate economics grade. Then, the authors ran a regression that included a dummy variable for Calculus enrollment and a variable for final grade in Calculus. In this regression, the coefficient for the dummy variable was no longer significant (and is actually negative). This suggests that it was *knowledge* of calculus that improved success in Economics, rather than exposure. Interestingly, the authors did not find a statistically significant coefficient for performance in high school Algebra or Functions and Relations.

Hoag and Benedict (2004) provided the most thorough investigation on the topic. To gain a grasp on specific math abilities, Hoag and Benedict (2004) used performance on the three components of the math ACT. Each of these components aimed to target the proficiency of students for specific tasks:[3]

1. Elementary Algebra: Basic operations, factoring, linear equations.
2. Algebra and Coordinate Geometry: Functions, exponents, arithmetic and geometric series, matrices, complex numbers.
3. Plane Geometry and Trigonometry: Circles, rectangles, area, triangles, trigonometry equations

Scores on these three components served as the only measure of aptitude in specific math sub-disciplines.

The authors created five different ordered probit regressions. The dependent variable was the final grade in principles of microeconomics, ranked from zero (final grade of "F") to four (final grade of "A"). When other math controls were excluded, each of the three math ACT

[3] Source: ACT Compass http://www.act.org/compass/

subscores was positively related to economics grade. However, in regressions that included freshman math placement (based on ACT scores, high school math outcomes, and University-conducted placement tests) and the most difficult college math course completed, score on the "Algebra and Coordinate Geometry" section of the ACT lost its significance. In each case, the score on the "Plane Geometry and Trigonometry" subsection was the strongest predictor of grades in Principles of Microeconomics. The authors reasoned that the abstract nature of Trigonometry and Geometry makes courses in the subject great preparation for Economics (Hoag & Benedict 2010, p. 37). However, the authors do not test this claim statistically.

Ballard and Johnson (2004) gathered data on students enrolled in an introductory microeconomics course at a large Midwestern university. These students all took the same professor for Principles of Microeconomics and the same exams were provided in each class. Of the 2,313 students enrolled in the class in 1998 and 1999, 1,462 participated in a survey, which included a ten-question math quiz[4]—thus the sample size was 1,462. The authors included four measures of mathematical ability:

(1) The score on the math section of the ACT
(2) The score on the math quiz administered early in the semester
(3) Whether the student had taken Calculus
(4) Whether the student had been required to take remedial math (Ballard and Johnson 2004, 8)

The authors sought to find the correlation between each of the above math measures and performance in Principles of Microeconomics. The authors found that each of these measures of math was statistically significant even when all four measures were included in one regression. Net of other variables, required enrollment in remedial math was correlated with a 1.59 point decrease in a student's final Microeconomics grade on a scale of 1 to 100. The completion of

[4] The students were unaware of the quiz and thus did not have time to prepare.

Calculus was correlated with a 2.83 point increase. Math quiz scores and math ACT results were correlated with 0.72 and 0.58 increases in Principles of Microeconomics grade, respectively. From these findings, the authors (Ballard and Johnson 2004) concluded, "Quantitative skills are sufficiently multidimensional that no single variable is likely to represent them adequately (p. 21)." This claim shows that more research is needed to identify which dimensions of mathematics are most indicative of economics success.

Researchers have shown a connection between math and economics ability and some have found indications that certain math abilities are more relevant than others in determining a student's success in economics. However, no existing research compares the benefits of algebra and geometry skills for economics students and all current research focuses on performance in college economics rather than high school economics. Because this line of research could influence course-sequencing and econometrics methods, more investigation is needed. In the forthcoming sections, I develop an approach to compare the correlation of performance in Geometry and Economics with Algebra I and Economics.

III. Georgia High School Math and Economics

This study analyzes Georgia high schools under the Quality Core Curriculum (QCC), which has been gradually phased out over the last several years. In this system, Georgia students were placed into one of four program categories; College Preparatory (CP), College Preparatory with Distinction (CP+), Technology/Career-preparatory (TC), or Technology/Career-preparatory with Distinction (TC+). High-achieving students often entered high school having already completed Algebra I in middle school. Thus, these students typically took Geometry and Algebra II in 9^{th} or 10^{th} grade, before enrolling in upper-level classes like Statistics, Analysis,

and Calculus. CP and CP+ students were required to take at least 4 units of mathematics. Tech Prep students were required to complete three units of mathematics, which included Algebra I.[5] Students completed an end-of-course-test (EOCT) in Geometry and Algebra I at the end of course completion. They were not required to pass these exams, but each test counted as 15% of a student's final grade in the class. According to the Georgia Department of Education:

> The EOCT are designed to improve student achievement by assessing student performance on standards in the QCC specific to each course tested. The results of the EOCT will be used to help make instruction more effective and to ensure that all Georgia students have access to a rigorous curriculum that meets high performance standards. Student performance on the EOCT will be available for diagnostic and remedial use. The results will also be used for student accountability and for gauging the quality of education in the state. (Georgia End-of-Course Tests)

Algebra I and Geometry EOCT contained 90 multiple choice questions, which were divided into two sections of 45 questions. Students were given a five minute break between sections. Depending on the EOCT, each student received between 100 to 135 minutes per test (Geometry Study Guide 2004).

Algebra I, under the QCC, was usually taken during eighth or ninth grade. The five content domains were (1) Algebraic Fundamentals, (2) Operations on Real Numbers and Algebraic Expressions, (3) Solving Equations and Inequalities, (4) Functions and Their Graphs, and (5) Connections and Applications. Upon completion, students took the Algebra EOCT. The Geometry curriculum implemented under QCC was grouped into six domains: (1) Logic and Reasoning, (2) Points, Lines, Planes, and Angles, (3) Congruence and Similarity, (4) Polygons and Circles, (5) Perimeter, Area, and Volume, and (6) Coordinate, Transformational, and Three-

[5] Instead of completing Algebra I, students had the option to complete "a locally developed course equivalent to Algebra I that has been approved by the State Board of Education, or earn two units of credit by passing both Applied Problem Solving and Applied Algebra, or two units of credit by passing both Concepts of Problem Solving and Concepts of Algebra. (High school graduation requirements for students enrolling in the ninth grade for the first time in the 2002-2003 school year and subsequent years 2002.)"

Dimensional Geometry. Like Algebra I, students enrolling in Geometry completed one full unit in the course before taking the Geometry EOCT. Students were allowed a standardized formula sheet for the Geometry EOCT that includes formulas for perimeter, area, and volume of various two and three-dimensional shapes.

The QCC was initiated in 1985 in an effort to standardize education in Georgia by providing specific checkpoints for student learning. However, a 2004 statewide audit conducted by the U.S. educators organization, Phi Delta kappa, found that QCC did not meet the national standards set by No Child Let Behind (Thomas 2008). Twenty-two years after its inception, QCC was gradually phased out, beginning in 2007. It was replaced by Georgia Performance Standards (GPS), which further standardized the educational guidelines by providing specific guidelines for schools, students and test makers (Thomas 2008, p. 20). This new program provides math courses that are wide-reaching so that basic geometry and algebra concepts (along with other mathematical ideas) would be taught within the same introductory math class—Mathematics I. Mathematics II and Mathematics III expand on this broad-based knowledge.[6] In providing more comprehensive courses, policy makers hoped that students would develop a more sophisticated degree of understanding. Adoption of the GPS also altered the EOCT. Starting in 2008-2009, all high school freshmen were placed in GPS and QCC was gradually phased-out. Since I have no data on EOCT test scores after GPS was implemented, this paper will focus on QCC mathematics only. Although Georgia high schools no longer provide specifically characterized math courses, the results found in my paper are still useful to Georgia's educational policy makers. This is especially true considering there is no state-wide mandate on the grade in which economics is taken or the pre-requisites for enrollment.

[6] Accelerated classes will also be offered for high-achieving students.

Under the QCC, all students were also required to complete "one-third or one-half unit of Principles of Economics/Business/Free-enterprise" (High School Graduation Requirements for Students Enrolling in the Ninth Grade for the First time in the 2002-03 School Year and Subsequent Years 2002) and complete an Economics EOCT. Like Algebra I and Geometry, the Economics EOCT served as a high-stakes examination, accounting for 15% of a student's final grade in the course. Economics was composed of five domains: (1) Fundamentals of Economics, (2) Microeconomic Concepts, (3) Macroeconomic Concepts, (4) International Economics, and (5) Personal Finance Economics.[7] When the Economics EOCT was first introduced in 2004, many students were taking Economics during ninth grade. However, first-year results on the economics EOCT indicated that many students were failing to develop an adequate knowledge of economics. As a result, many districts began offering economics during student's senior years. The economics EOCT increased the degree of uniformity among economics courses throughout Georgia and incentivized students and teachers alike. The data consist of all Georgia public high school students who took the Economics EOCT between fall of 2005 and spring of 2008. Most students in this sample completed economics during twelfth grade.[8]

IV. Data

Data are available for 240,874 students in Georgia who took the Economics EOCT. Scores on the Algebra and Geometry EOCT are available for 60.1% and 60.2% of students, respectively. For 41.4% of students, scores for both math courses are available. Math EOCT

[7] Sample questions for each domain can be found at http://www.gadoe.org/DMGetDocument.aspx/eoct_guide_economics_a.pdf?p=4BE1EECF99CD364EA5554055463F1FBB77B0B70FECF5942E12E123FE4810FFF53501CAAE8CB82838D4AB2B58B058C41D&Type=D

[8] Much of the information concerning the Georgia high school Economics was provided in a telephone interview with Glen Blankensip, Associate Director and Chief Program Office for the Georgia Council on Economic Education.

scores are only available for students who took the classes prior to completion of Economics—I am provided with no information concerning a student after he or she completes Economics. Economics was usually completed during 11th or 12th grade. Thus, I can assume that most students in the data eventually graduated. However, the exact percentage of students who did indeed graduate is not provided in the data.

In addition to test scores for the three EOCT (which are standardized to improve interpretations), a host of control variables are included. I have grouped the variables into seven categories: Family, peer, community, teacher, school, student, and time. Based on the results of prior research in economic education, I expect that each of the variables discussed below will correlate with Economics EOCT scores. Tables 1 and 2 provide a brief description and summary statistics for these variables.

---Insert Table 1 Here---

---Insert Table 2 Here---

In my analysis, I attempt to create an education production function model. Variables are placed into five distinct categories; (1) Family Effects, (2) Peer Effects, (3) Community Effects, (4) Student Characteristics, and (5) Time Variables. The inclusion of these variables is based on prior research and economic theory. A discussion of these variables follows.

1) Family Effects

The only family characteristics variable provided in the data is *LowIncome*, which equals one if a student qualifies for free or reduced lunch based on Federal income eligibility

guidelines.[9] For the 2007-2008 school year, students from four-person families with a household income not exceeding $38,203 were eligible for free or reduced lunch. While some economists have found that family income is indirectly related to a child's schooling outcome, (through parental ability, attitudes, expectations, schooling, etc. [Plug & Vijverber 2005; Davis-Kean 2005; Shea 2000]), income is generally considered a causal determinant of schooling success.[10] Previous studies using a database similar to the one I employ found that family poverty is inversely related to performance on the Economics EOCT (Clark et al. 2011; Swinton 2009). Thus, I expect to find a negative relationship between *LowIncome* and achievement on the Economics EOCT. In my sample, 35.0% of students are characterized as *LowIncome*.

2) Peer Effects

Peer ability (*EconPeers*) is simply the average standardized Economics EOCT score of fellow students who all completed Economics at the same school, during the same year, with the same teacher. Due to limitations in the data, there is not enough information to identify Economics EOCT scores for students within the same class. However, *EconPeers* still manages to provide a solid indicator of the degree of effort and success of a student's peers in Economics. A working paper (Clark et al.) shows that peer effects on the Economics EOCT do exist in this data set—I use a similar description for *EconPeers* as these authors.[11]

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[9] Income guidelines for 2007-2008 can be found here:
http://www.fns.usda.gov/cnd/governance/notices/iegs/IEGs07-08.pdf

[10] Most of the literature seems to support both a direct and indirect effect of family income on a child's schooling.

[11] Some of the data are flawed. For example, one teacher is shown to have hundreds of students and teach at dozens of schools. Obviously, this is a mistake and is excluded from the data in the Clark et al. paper. However, there are several additional teachers that are shown to teach at more than three schools. While this may very well be the case, it is also possible to that this is an error in the data. I decided to exclude peer effects for all students who had a teacher shown to teach at more than three schools within a given year.

3) Community Effects

Because a student's community influences his or her achievement (Owens 2010), it is necessary to create community control variables. There are no community variables provided in the original data, but I am provided with the district in which a student attends school. Using data from the United States Census Bureau, I create five district-level controls. *Dpopulation* is the population density (per square mile) of the district in which a student attends school. *Dincome* is the average income within this district, while *Dwhite* is the percentage of residents who identify themselves as "white". While these three variables certainly do not completely capture the characteristics of a student's community, they should provide a snapshot of the socioeconomic landscape of the students' district.

A fourth distinct district level control is *Tsalary*, which is the average teacher salary within a student's school district. [12] In Georgia, teacher salaries are based on experience and training; two factors that could improve a teacher's overall ability level, in addition to the district in which a teacher in employed. By including this variable, I do not seek to analyze the ability of a student's economic teacher, but rather aim to gauge the overall educational prowess of a student's school district. The average district-level teacher salary in my sample is $48,341.

ClassSize, defined as the number of students divided by the number of teachers in a district, serves as the fifth and final district-level variable. Although debated, some researchers (Rivkin et al. 2005; Project STAR; Finn & Achilles 1989) have found that students from small classes learn more than students in larger classes. Furthermore, class size is inversely related to school funding—a higher ratio of teacher requires more spending per pupil. Thus, I suspect that

[12] Admittedly, students may transfer in and out of districts, diminishing the effectiveness of this variable. Furthermore, teacher quality may differ within districts. Nonetheless, *Tsalary* likely provides some indication of a student's educational experience.

ClassSize is a relevant variable, inversely related to a student's overall academic performance, including scores on the Economics EOCT.

4) Student Characteristics

The first student characteristic is race. Ethnicity is measured by four dummy variables: *Asian*, *Black*, *Hispanic*, and *Other*. The control variable is *White*. Asian and white students outperform all other races on the math section of the SAT, so it is expected that these two races are also likely to perform comparatively well in high school economics. Within the literature, there is a great deal of disparity—some find a significant correlation between race and performance in economics courses (Clark, et al. 2011; Swope & Schmitt, 2006) and others do not (Borg & Stranahan 2002; Lopus 1997; Mccoy & Brasfield, 1991). The NAEP indicate a significant difference in test scores between whites and blacks, whites and Hispanics, Asians and blacks, and Asians and Hispanics (Walstad & Buckles, 2008). It is possible that these differences in scores are not significant once controlling for family income and other relevant variables. I have chosen to include dummy variables for race to stay consistent with prior literature in economic education, but acknowledge the possibility that race is merely spuriously related to performance on a standardized economics exam. As indicated in Table 2, 38.4% of students in the sample are Black, while 5.3% and 3.5% of students are Hispanic and Asian, respectively.

The second variable in this category is *Disabled*, which indicates if a student is characterized to have a disability. The Georgia Department of Education categorizes disability based on the Individuals with Disabilities Education Act (IDEA), which states that a "child's educational performance must be adversely affected" to be considered disabled (Categories of

Disability Under IDEA 1).[13] On the NAEP, students without disabilities outscored disabled students 153 to 116. Because disabilities provide additional challenges for students, I expect *Disabled* to be negatively related to one's Economics EOCT score (Economics Report Card). Seven percent of students in the data are classified as "disabled."

I also expect that the dummy variable, *Female*, will be inversely related to performance on the Economics EOCT. Between the years of 1970 and 2006, males outperformed females by an average of 38.6 points on the math section of the SAT, indicating a gender gap in mathematics. The cause of this gender gap is debated. It may be a result of socialization (Jussim, 1996; Fryer & Levitt, 2009; Wigfield et al., 2002) or based on preferences (Eccles 1994; Makri-Botsari 1999). Additionally, males are shown to have higher mathematical competency beliefs at an early age (Eccles et al., 1993; Eccles, 1994; Marsh, 1989; Wigfield et al. 1997), which may lead to a self-fulfilling prophecy as males extend more effort to the subject. Regardless of the cause, a gender gap in mathematics likely leads to a gender gap in economics.

The final two variables, *Algebra* and *Geometry*, are the standardized EOCT scores in Algebra I and Geometry. These two variables serve as the primary variables of interest in this paper. Because there is a strong link between math and economics skills (Ballard & Johnson 2004; Hoag & Benedict 2010), I expect that *Algebra* and *Geometry* both positively correlate with Economics EOCT scores.

[13] The specific conditions listed by IDEA: Autism, deaf-blindness, deafness, developmental delay, emotional disturbance, hearing impairment, intellectual disability, multiple disabilities, orthopedic impairment, specific learning disability, speech of language impairment, traumatic brain injury, and visual impairment, including blindness.

5) Time Variables

Additionally, it is necessary to include variables that account for time. For example, it is possible that students taking Economics in 2006 may systematically differ from those taking it in 2008. If I do not account for the year in which the Economics EOCT was taken, regression results would be biased. *Econ2006, Econ2007,* and *Econ2008* provide the year when Economics was completed. For example, *Econ2008* indicates that about 35.3% of my sample completed Economics in 2008.[14]

The duration between Economics and the math courses may also correlate with outcomes in Economics. *EconAlgGap* is the duration, in years, between Algebra I and Economics. Generally speaking, a larger gap indicates a more successful student. While most students take Economics in 11th or 12th grade, higher-achieving students are more likely to take Algebra I in 8th or 9th grade, whereas many (typically low and medium-achieving) students may not take Algebra I until their upperclassmen years. For this reason, *EconAlgGap* and *EconGeoGap* may serve as proxies for student ability. A mean of 2.26 for *EconAlgGap* indicates that the average student completes Economics 2.26 years after Algebra I. These values are based on the year and semester in which a student completes these courses. For example, a student completing the classes in the same semester and year would be given an *EconAlgGap* of zero, whereas a student completing Algebra I one semester prior to Economics would be give an *EconAlgGap* of 0.5. Unfortunately, only the year (as opposed to the year *and* semester) in which Economics was completed is available in the data. Thus, I suspect that *EconAlgGap* and *EconGeoGap* for many

[14] This high rate is due to data collection issues. Algebra and geometry scores are not available for any students prior to the second semester of 2004. Thus, many students who completed economics in 2006 took geometry and/or algebra prior to data collection. Since all three test scores are not available for these students, the data are omitted.

students are incorrect by one semester. Fortunately, many Georgia High School are on the full-year system, as opposed to taking different classes each semester—this mitigates the miscalculations associated with these variables. Since *EconAlgGap* and *EconGeoGap* equal 2.26 and 1.76, respectively, one can surmise that, on average, students complete Geometry one-half year (or one semester) after completing Algebra I.

V. Methodology

In my baseline regression, educational attainment (Economics EOCT score) is regressed on characteristics of family, peers, community, student, and time. I employ ordinary least squares for each regression. In addition to the variables below, teacher fixed effects are included in each regressions. Regressions are specified as:

$$Econ_i = \beta_0 + \beta_1 Asian_i + \beta_2 Black_i + \beta_3 Hispanic_i + \beta_4 Other_i + \beta_5 LowIncome_i + \beta_6 EconPeers_i + \beta_7 DPopulation_i + \beta_8 DIncome_i + \beta_9 DWhite_i + \beta_{10} TSalary_i + \beta_{11} ClassSize_i + \beta_{12} Disabled_i + \beta_{13} Female_i + \beta_{14} Algebra_i + \beta_{15} Geometry_i + \beta_{16} Econ2006_i + \beta_{17} Econ2007_i + \beta_{18} EconAlgGap_i + EconGeoGap_i + e_i .$$

I expect that each of the above variables will be significant. Of utmost importance is the sign and magnitude of *Algebra* and *Geometry*. While I fully expect B_{14} and B_{15} to be positive and significant, the magnitude of β_{14} and β_{15} may differ. Thus, I create a hypothesis test as follows:

H_o: $\beta_{14} - \beta_{15} = 0$ (alternatively, $\beta_{14} = \beta_{15}$)

H_A: $\beta_{14} - \beta_{15} \neq 0$ (alternatively $B_{14} \neq \beta_{15}$)

In order to estimate the model specified, many data must be excluded. This is largely a result of the fact that Algebra or Geometry EOCT scores are not available for many students. Table 3 provides the summary statistics for the primary model.

---Insert Table 3---

When considering what type of student is included in these data, it's easiest to consider who would be excluded. Firstly, anyone who does not take Geometry is obviously not included in the model. Students that do not take Geometry are typically low-achieving. Generally speaking, this explains why the average standardized Economics EOCT (*Econ*) and Algebra EOCT scores for this restricted set are greater than zero.[15] Secondly, any student who took Geometry or Algebra I prior to 2004 is not included in the data. This explains why such a small percentage of students in the primary model took Economics in 2006. Students not included for this reason were likely above-average, based on the fact that the math course(s) was taken more than two years prior to Economics.[16] Thus, the data for the primary sample excludes many low-achieving and high-achieving students. As a result, the data for the primary model includes a slightly higher proportion of "medium-achieving" students. This is indicated by the standard deviations, which are less than one, for *Econ*, *Algebra,* and *Geometry*. Because the primary regression utilized only a subset of data that obviously differs from the population, one cannot necessarily generalize the results from the primary regression to all students.

[15] I decided not to re-standardize these variables. By maintaining scores that are standardized for all data, interpretations can be made more easily.
[16] While almost all students took Economics as Juniors or Seniors, high-achieving students generally took Algebra I and Geometry in an earlier grade.

VI. Results

Table 4 provides the results from the primary regression, which includes all students for which complete data are available. As indicated by the table, most of the variables are significantly correlated with Economics EOCT score. Each of the race variables are inversely related to performance on the Economics EOCT, which indicates that white students outperform students from other races, net of other explanatory variables. The interpretations for these results are simple. For example, a -0.18 coefficient for *Black* means that being black is associated with a 0.18 standard deviation decrease on the Economics EOCT after controlling for other variables. As expected, *LowIncome* is also inversely related to Economics EOCT performance. Thus, each of the family characteristics variables exemplifies the predicted sign. Peer Economics EOCT scores (*EconPeers*) is shown to exert a positive effect on a student's Economics EOCT score. While this may simply be a result of peers helping peers or learning by example, it is also possible that this strong effect is a result of the degree by which a teacher prepares students for the economics EOCT. In other words, if an Economics teacher spend a semester deliberately preparing students for the EOCT, one would expect that the students would perform relatively well on the Economics EOCT. Conversely, a teacher who spends more time with tangential material can expect his or her students to perform poorly on the Economics EOCT. Thus, it could be the teachers that are driving this result. While the interpretation is unclear, this variable is relevant.

Of the community characteristics variables, only *Dincome* is statistically significant. Teacher salaries at the district level are only marginally significant—in a two-tailed test, *TSalary* is significant at the 0.1 level of significance. Average district-level class size (*ClassSize*) is not found to correlate with Economics EOCT scores. The weak findings for the district-level data

are a bit surprising, but may be a result of the benefits/costs of district-level effects being absorbed by the math variables.[17] As expected, *Disabled* is negatively related to Economics EOCT performance and a negative coefficient for *Female* indicates that males tend to outperform females.

The last four variables accounting for time are all significant. *Econ2006* and *Econ2007* are both positive and significant. This indicates that, within this restricted data set, students from the earlier cohorts outperform students from 2008. Both *EconAlgGap* and *EconGeoGap* are positive and significant. This is almost certainly due to the fact that students taking Algebra I and Geometry at earlier grades are generally above average in Economics.

The two variables of interest—*Algebra* and *Geometry*—provide intriguing results. While both of these variables are positively correlated with Economics EOCT Score and exhibit relatively large coeffiicients, the magnitudes are quite different. Are the magnitudes statistically significant? As discussed in section V, I construct a two-tailed hypothesis test to test for different coefficients between *Algebra* and *Geometry*. Indeed, I find that the coefficient for *Geometry* is significantly larger. The F-test statistic is:

$$F(1, 89481) = 253.94, \quad p < 0.0001$$

This statistic indicates a high likelihood that *Geometry* has more predictive power than *Algebra* if the regression is properly specified. One potential foil to this model is multicollinearity driven by the high correlation between *Algebra* and *Geometry*, which have a simple correlation of 0.73. However, the variance inflation factor (VIF) indicates that multicollinearity is probably not a concern to the integrity of this model. No variable possesses a VIF exceeding three and the

[17] The benefits of high teacher salaries, for example, may enhance overall scholastic success. However, these benefits may already be capture by success in the math courses.

mean VIF is 1.72. There are clear ramifications to the discovery that, relative to Algebra EOCT scores, Geometry EOCT scores are a better predictor of Economics EOCT performance. These ramifications are discussed in detail in Section VII.

It seems likely that the order of math class-taking affects correlation between math EOCT and Economics EOCT. For example, consider a student who takes Algebra I as a freshman, Geometry as a junior, and Economics as a senior. The lessons learned from Algebra I may have been forgotten, weakening the apparent correlation between *Algebra* and *Economics*. Perhaps even more likely, a student's effort may be a function of time, i.e., a student's effort likely differs less over a one-year period than a three-year period. This would also skew the coefficient values for *Geometry* and *Algebra* perhaps inflating the coefficient for the more recent course completed. The primary model accounts for this effect, but the time variables provide little interpretive value. The following helps explore the effects of class order.

---Insert Table 5---

Table 5 includes only those students who took Algebra I and Geometry in the typical order; Algebra I prior to Geometry. Not surprisingly, the effect of Geometry is substantially greater than Algebra. The F-statistic testing for differing coefficients finds an F-test statistic of 247.30, which corresponds to a very, very low p-value. So, for students who take Algebra I prior to Geometry, the effect of Geometry is larger. This is not surprising in the least since this regression includes 96% of the data from the primary model.

---Insert Table 6---

Regression results presented in Table 6 include students who completed Geometry prior to Algebra I. Only 2.3% of students for whom data for all necessary variables is available took

Geometry before Algebra I. The reasons for taking the classes in this unusual order are unknown, but may be a result of changing schools or altering educational goals. As can be seen, the coefficients for *Geometry* and *Algebra* are quite different from prior models. Because Algebra I was taken more recently, the coefficients for *Algebra* and *Geometry* are similar. A two-tailed test for different coefficients finds an F- test statistic of 0.31 which corresponds to a p-value of 0.58. While the coefficient for *Algebra* is nominally larger than the coefficient for *Geometry*, there is no significant difference between these coefficients. From this regression, we can clearly observe that the order of Geometry and Algebra I affects the results from the regressions.

---Insert Table 7 Here---

Table 7 displays results for the regression that only includes students who took Algebra I and Geometry concurrently. Although the order of classes seems to influence the apparent correlation between the math EOCT and Economics EOCT, there will obviously be no such effect in this regression. This regression only includes 1.3% of students for whom all necessary variables are available. The only structural change to the model is the exclusion of *EconGeoGap*, which is equal to *EconAlgGap* for this subset of students. With an F-test statistic of 5.83, the coefficient for *Geometry* is larger than *Algebra* at the .025 level of significance. When the bias of time is totally eliminated, a student's Geometry EOCT score trumps his or her Algebra EOCT score as a predictor of performance on the Economics EOCT. This regression enhances the findings provided in primary regression. While the order of classes affects the magnitude, *Geometry* correlates more highly with *Econ*, as indicated by results in the tables, specifically Table 4 and Table 7.

VII. Conclusions

Economic education researchers have found a clear positive association between math and economics ability. However, only a few have tried to dissect this correlation by analyzing specific math abilities. In this study, I analyze data from the Georgia Department of Education, which includes all Georgia public high school students who complete a mandatory Economics standardized test at the end of a mandatory Economics course during 2006, 2007, and 2008. Various measures of demographics are included in the data along with performance on standardized Algebra I and Geometry tests. Relative to Algebra I, I find that Geometry standardized tests scores are more highly correlated with Economics standardized test scores. A discussion of this discovery follows.

Geometry could be more highly correlated with *Economics* than *Algebra* because of direct effects, indirect effects, or a combination of both. In other words, the correlation may or may not contain a degree of causality. Suppose the effect is causal. Clearly, completion of Geometry prior to Economics would improve student outcomes.[18] An extrapolation of this result might encourage college economic educators to encourage or mandate collegiate geometry prior to any economics courses. While the current research does not assert that geometry ability *causes* economics aptitude, this possibility cannot be dismissed.

The alternative possibility of non-causality is also interesting and worthwhile to investigate. For a prospective student considering majoring in economics, I often ask "Do you have a strong math ability?" The current research shows that a more informative inquiry would be "Are you good at geometry?" If high-achieving geometry students are more likely to succeed

[18] This may be a two-way street—perhaps the completion of Economics also improves a student's chances of succeeding in Geometry.

in economics classes, it seems obvious that economic educators can take advantage and improve the recruiting of students. If the results of this study are verified, geometry knowledge provides a powerful tool of predicting a student's Economics success. For example, the results from the Geometry EOCT could be used to assist in determining enrollment for an Economics AP Course. More investigation is needed to verify this finding and to see if similar correlation exists for college students. I believe that the potential benefit for recruitment and class placement is the strongest result from this paper. If the effect of geometry ability on economics aptitude is causal *or* non-causal, economic educators should be able to use measures of geometry performance to enhance predictions of a student's success in an economics course.

The findings may also impact the methods of modeling performance in economics classes. Prior research analyzing the effects of math ability on economics performance generally ignores the possibility that different math abilities correlate with math performance in different magnitudes. Consider the following studies. Butler et al. (2001) analyzed the effects of math ability on economics performance, using math SAT score as a proxy for math ability. Hoag and Benedict (2010) ran a similar model, but utilized math ACT score instead of math SAT score. This may seem to be a subtle difference, but the current research argues otherwise. In total, 45%[19] of the math ACT is comprised of geometry questions compared to 25%-30%[20] on the math SAT. The current research indicates that one cannot compare the results in these two studies. Because the math ACT includes more geometry questions, the correlation between scores on the math ACT and economics performance is probably larger than the correlation between scores on the math SAT and economics performance. While more investigation is needed, employing generic math ability control variables seems unwise.

[19] Source: Content Covered by the ACT Mathematics Test (2012)
[20] Source: SAT Facts and FAQs

References

Altonji, Joseph G. and Thomas A Dunn. The effets of family characteristics on the return to education. *The Review of Economics and Statistics* 78, no. 4; 692-704.

Anderson, Gordon, Dwayne Benjamin, and Melvyn A. Fuss. 1994. The determinants of success in university introductory economics courses. *Journal of Economic Education* 25, no. 2: 99-119.

Ballard, Charles L. and Marianne F. Johnson. 2004. Basic math skills and performance in an introductory economics class. *Journal of Economic Education* 35, no. 1: 3-23.

Biddle, Bruce J. and David C. Berliner. 2002. Small Class Size and its effects. *Educational Leadership* 59, no. 5: 12-23.

Boardman, J.D., B.K. Finch, C.G. Ellison, D. R. Williams, and J.S. Jackson. 2001. Neighborhood disadvantage, stress, and drug use among adults. *Journal of Health and Social Behavior* 42, no. 2: 151-165.

Borg, Mary O'Malley and Harriet Stranahan. The effect of gender and race on student performance in principles of economics: the importance of personality type. *Applied Economics* 34: no. 5: 589-598.

Categories of Disability Under IDEA. 2012. National Dissemination Center for Children with Disabilities. Accessed Mar 8, 2012. http://nichcy.org/disability/categories.

City-Data.com. Cities Used: Chickamauga. Pelham, Social Circle, and Trion. Accessed April 27, 2012. http://www.city-data.com/

Clark, Christopher, Benjamin Scafidi, and John R. Swinton. 2011. Do peers influence achievement in high school economics? Evidence from Georgia's economics end of course test. *Journal of Economic Education* 42, no. 1: 3-18.

Coleman, James S., Ernest Q. Campbell, Carl F. Hobson, James McPartland, Alexander M. Mood, et al. 1966. Equality of Educational Opportunity. Washington: U.S. Office of Education.

Content Covered by the ACT Mathematics Test. 2012. The ACT. www.actstudent.org/testpret/descriptions/mathcontent.html

Content Descriptions; Economics/Business/Free Enterprise. www.doe.k12.ga.us. Accessed Mar 8, 2012. http://www.doe.k12.ga.us/DMGetDocument.aspx/EOCT%20Economics%20Content%2Descriptions%20GPS.pdf?p=6CC6799F8C1371F6DFC2B5E0D0499E6B3E2BA120E0D18C8901597075164494C2&Type=D

Davis-Kean, Pamela E. 2005. The influence of parent education and family income of child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology* 19, no. 2; 294-304.

Eccles, Jacquelynne S. 1994. Understanding women's educational and occupation choices. *Psychology of Women Quarterly* 18, no. 4: 585-609.

Eccles, Jacquelynne, Allan Wigfield, Rena D. Harold, and Phyllis Blumenfeld. 1993. Age and gender differences in children's self- and tax perceptions during elementary school. *Child Development* 64, no. 3: 830-847.

Economics Report Card. The Nation's Report Card. Accessed Mar 8, 2012. http://nationsreportcard.gov/economics_2006/e0107.asp

Fryer Jr., Roland G. and Steven D. Levitt. 2009. An empirical analysis of the gender gap in mathematics. Harvard.edu. Accessed Mar 19, 2012. http://www.economics.harvard.edu/faculty/fryer/files/fryer-levitt%2Bgender.pdf.

Garron, David C. Sex-linked, recessive inheritance of spatial and numerical abilities, and Turner's Syndrome. *Psychological Review* 77, no. 2: 147-152.

"Georgia End-of-Course Tests (EOCT): Content Description Guide." The Georgia Department of Education. Accessed Mar 19, 2012. http://www.doe.k12.ga.us/DMGetDocument.aspx/geo.pdf?p=4BE1EECF99CD36EA5554055463F1FBB77B0B70FECF5942E12E123FE4810FFF53501CAAE8CB828388E19AE876F2FCE4E&Type=D

Georgia's GPS-Based Mathematics: Questions and Answers for Parents of Georgia Students. The Georgia Department of Education. Accessed Mar 19, 2012. http://kendrick.mcsdga.net/documents/Math% 20Toolkit %20Brochure.pdf

Hanushek, Eric A. Working Paper. Publicly provided education. Accessed April 2, 2012. http://www.nber.org/papers/w8799

Hanushek, Eric A. 2003. The failure of input-based schooling policies. Economic Journal 114 (485), F64-F98.

Hanushek, Eric A. 2002. Publicly provided education. Handbook of Public Economics, edition 1, volume 3. Edited by A. J. Auerbach and M. Feldstein. Chapter 30. 2045-2141.

Hanushek, Eric A. 1997. Assessing the effects of school resources on student perfomranc: An update. *Educational Evaluation and Policy Analysis* 21, no. 3: 143-163.

Hanushek, Eric A. 1986. The economics of schooling: Production and efficiency in public schools. *Journal of Economic Literature* 24, no. 3: 1141-1177.

Hanushek, Eric A. and Steve G. Rivkin. 2006. Teacher quality. Handbook of the Economics of Education, Volume 2. Chapter 18. Edited by Erc A. Hanushek and Finis Welch. 2006.

Hanushek, Eric A., Steve G. Rivkin, and Lori L. Taylor. 1996. Aggregation and the estimated effects of school resources. *Review of Economics and Statistics* 78, no. 4: 611-627.

High School Graduation Requirements for Students Enrolling in the Ninth Grade for the First time in the 2002-03 School Year and Subsequent Years 2002. Adopted Feb 14, 2002.

Accessed Mar 8, 2012. http://www.doe.k12.ga.us/External-Affairs-and-Policy/State-Board-of-Education/Lists/SBORules/Attachments/308/160-4-2-.47.pdf

Highsmith, F. 1974. A study to measure the impact of in-servie institutes on the students of teachers who have participated. *Journal of Economics Education* 5, no. 2: 77-81.

Hill, Martha S. and Greg J. Duncan. 1987. Parental Family Income and the Socioeconomic Attainment of Children. *Social Science Research* 16: 39-73.

Hoag, John, and Mary Ellen Benedict. 2010. What influence does mathematics preparation and performance have on performance in first economics classes? *Journal of Economics and Economic Education Research* 11, no. 1: 19-42.

Houtenville, Andrew J and Karen Smith Conway. Parental effort, school resources, and student achievement. *Journal of Human Resources* 43, no. 2: 437-453.

Jargowsky, Paul A. and Mohamed El Komi. 2011. Before or after the bell: School context and neighborhood effects on student achievement." In Harriet Newburger, Eugénie L. Birch and Susan M. Wachter, eds., *Neighborhood and Life Chances: How Place Matters in Modern America*. Philadelphia: Philadelphia Federal Reserve Board and Penn Institute for Urban Research, forthcoming.

Jussim, Lee, Jacquelynne Eccles, and Stephanie Madon. 1996. *Advances in Experimental Social Psychology* 28, 281-388.

Koedel, Cory and Julian R. Betts. 2007. Re-examining the role of teacher quality in the educational production function. http://econ.missouri.edu/working-papers/2007/wp0708_koedel.pdf

Kreguer, Alan B. 1999. Experimental estimates of education production functions. *The Quarterly Jorunal of Economics* 114, no. 2: 497-532.

Latkin, C.A. and A.D. Curry. 2003. Stressful neighborhoods and depression: A prsopsective study of the impact of neighborhood disorder. *Journal of Health and Social Behavior* 39, no. 2: 91-107.

Lewin, Tamar. 2011. Burden of College Loans on Graduates Grows. April 11, 2011. The New York Times**.** Accessed Mar 8, 2012. http://www.nytimes.com/2011/04/12/education/12college.html

Lewis, Darrell R., Donald R. Wentworth, and Charles C. Orvis. 1973. Economics in the Junior Coleges: Termainal or Transfer?" *Journal of Economic Education*, no. 4: 100-110.

Lopus, Jane S. 1997. Effects of the high school economics curriculum on learning in the college principles class. *Journal of Economic Education* 28, no. 2: 143-153.

Lumsden, Keith G. and Alex Scott. 1987. The economics student reexamined: male-female differences in comprehension. *Journal of Economic Education* 18, no. 4: 365-375.

Lusadri, Annamaria and Olivia S. Mitchell. 2009. How ordinary consumers make complex economic decisions: Financial literacy and retirement readiness. Working paper. National Bureau of Economic Research. http://nber.org/papers/w15350.

Lusadri, Annamaria and Olivia S. Mitchell. 2006. Financial literacy and planning: Implications for Retirement Wellbeing. Working Paper. Accessed Mar 19, 2012. http://www.dartmouth.edu/~alusardi/Papers/ FinancialLiteracy.pdf

Makri-Botsari, E. 1999. Academic intrinsic motivation: Developmental differences and relations to perceived scholastic competence, locus of control and achievement. *Evaluation and research in education* 13, no. 3: 157-171.

Mandell, Lewis and Linda Schmid Klein. 2009. The impact of financial literacy education on subsequent financial behavior. Journal of Financial Counseling and Planning 20, no. 1: 15-24.

Marsh, Herbert W. 1989. Age and sex effects in multiple dimensions of self-concept: Preadolescence to early adulthood. *Journal of Educational Psychology* 81, no. 3: 417-430.

McLanahan, S. and G. Sandefur. 1994. Growing up with a single parent: What hurts, what helps. Cambridge MA: Harvard University Press.

McCoy, J.P., and D.W. Brasfield. 1991. The impact of macro/micro course sequencing. *Journal of Education for Business* 66, no. 4.

Myatt, Anthony and Charles Waddell. 1990. An approach to testing the effectiveness of the teaching and learning of economics in high school. *Journal of Economic Education* 21, no. 3: 355-363.

Moyer, M. Eugene, and Donald W. Paden. 1968. On the efficiency of the high school economics course. *American Economics Review* 58, no. 4: 870-876.

National Center for Education Statistics. 2011. The Nation's Report Card: Civics 2010 (NCES 2011–466). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Center for Education Statistics. 2011. The Nation's Report Card: Geography 2010 (NCES 2011–467). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Center for Education Statistics. 2011. The nation's Report Card. U.S. History 2010 (NCES 2011-468). Institute of Educaiton Sciences. U.S. Department of Educaiton. Washington D.C. Accessed Mar 19, 2012. http://nces.ed.gov/nationsreportcard/pdf/main2010/2011468.pdf

Palmer, John, Geoffrey Carliner, and Thomas Romer. 1979. Does high school economics help? *Journal of Economic Education*, no. 10: 58-61.

Phase in Plan for GPS. Georgiastandards.org. Accessed Mar 19, 2012. https://www.georgiastandards.org/standards/GPS%20Sup port%20Docs/GPS%20Phase-in%20Plan.pdf

Plug, Erik and Wim Vijverberg. 2005. Does family income matter for schooling outcomes? Using adoptees as a natural experiment. The Economic Journal 115 (October); 879-906.

Sampson, R.J. and J.H. Laub. 2004. Urban poverty and the family context of delinquency: a new look at structure and process in a classic study. *Child Development* 65, 2: 523-540.

SAT Facts and FAQs. EriktheRed.com. www.erikthered.com/tutor/sat-facts-and-faqs.html

Shea, John, 2000. Does parents' money matter? Journal of Public Economics 77: 155–184.

Shipley, Calvin and Shekar Shetty. 2008. Factors affecting economic literacy of college students: some additional evidence. Journal of Economics and Economic Education Research 9, no. 1: 13-18.

Steele, Paul D. 2010. Rotten outcomes: How impoverished neighborhoods influence life trajectories of children in the United States. Forum on Public Policy. Accessed Oct 17, 2012. http://forumonpublicpolicy.com/Vol2010.no4/archive.vol2010.no4/steele.pdf

Stockly, Sue K. 2009. Is race a determinant of student performance in economics? *The Review of Black Political Economy* 36: 181-195.

Sucoff, C.A. and D. Upchurch. 1998. Neighborhood context and the risk of childbearing among metropolitan-area Black adolescents. *American Sociology Review* 63, no. 4: 571-585.

Swinton, John R. 2009. The impact of *Teaching High School Economics* workshop for teachers on student achievement. Working Paper. Accessed Mar 19, 2012. http://www.faculty.de.gcsu.edu/~jswinton/Research/Interests_files/teaching%20HS%20Economics.pdf.

Swope, Kurtis J. and Pamela M. Schmitt. 2006. The performance of economics graduates over the entire curriculum: The determinants of success. *Journal of Economic Education* 37, no. 4: 387-394.

Tennessee State Department of Education 1985-1990. The state of Tennessee's Student/Teacher Achievement Ration (STAR) Project: Final Summary Report. Prepared by: Elizabeth Word, John Johnson, Helen Pate Bain, B. DeWayne Fulton, Jayne Boyd Zaharial, Charles M. Achilles, Martha Nannette Lintz, John Folger, and Carolyn Breda. Accessed April 23, 2012. http://www.misd.k12.wa.us/departments/superintendent/class_size/documents/STARReport.pdf

Thurman, Paula. 2011. Personal phone interview. Math coach, Troup County High Schools, LaGrange, Georgia. Feb 18, 2011.

Undergraduate Students and Credit Cards in 2004. 2005. Nellie Mae. Accessed Mar 19, 2012. http://www.nelliemae.com/pdf/ccstudy_2005.pdf

U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits, Consolidated Federal Funds Report. Accessed April 27, 2012. http://quickfacts.census.gov/qfd/states/13000.html

Walstad, William and Stephen Buckles. 2008. The national assessment of educational progress in economics: findings for general economics. *American Economic Review* 98, no. 2: 541-546.

Walstad, William B. and Ken Rebeck. 2002. Assessing the economic knowledge and economic opinions of adults. *The Quarterly Review of Economics and Fiance* 42, no. 5: 921-935.

Wigfield, Allan, Ann Battle, Lisa B. Keller, and Jacquelynne S. Eccles. 2002. Chapter to appear in A. V. McGillicuddy-De Lisi & R. De Lisi (Eds.), Biology, sociology, and behavior: The development of sex differences in cognition. Greenwich, CT: Ablex. Accessed Mar 19, 2012. http://books.google.com/books?hl=en&lr=&id=za8YHOZZ9CIC&oi=fnd&pg=PA93&dq=sex+differences+in+motivation,+selfconcept,+career+aspiration&ots=Pglm5EzB2u&sig=vk8htvlu9atb8REGJEixCp3fURA#v=onepage&q=sex%20differences%20in%20motivation%2C%20selfconcept%2C%20career%20aspiration&f=false.

Wigfield, Allan, Rena D. Harold, Carol Freedman-Coan, Jacquelynne S. Eccles, Kwang Suk Yoon, Amy J. A. Arbreton, and Phyllis C. Blumenfeld. 1997. Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. *Journal of Educational Psychology* 89, no. 3: 451-469.

Williams, Mary L., Charles Waldauer, and Vijaya G. Duggal. 1992. Gender differences in economic knowledge: an extension of the analysis. *Journal of Economic Education* 23, no. 2: 219-231.

Table 1: Variable Definitions

Variable	Definition
Female	One if female, zero otherwise
LowIncome	One if student receives free or reduced lunch, zero otherwise
Asian	One if student receives identifies himself/herself as Asian, zero otherwise
Black	One if student identified himself/herself as black, zero otherwise
Hispanic	One if student identified himself/herself as Hispanic, zero otherwise
Other	One if student identified himself/herself as "other" race (not asian, black, or white), zero otherwise
Disabled	One if student is listed as a student with disabilities, zero otherwise
Econ	Z-score on economics EOCT
EconPeer	Z-score of peers on economics EOCT
Algebra	Z-score on Algebra EOCT
Geometry	Z-score on Geometry EOCT
ClassSize	Average class size in school district
Dincome	Average income of all citizens within school district
Dpopulation	District population per square mile
Dwhite	Percent of district population who are white
Tsalary	Average salary for a teacher in school district

Table 2: Summary Statistics for all Data

n=240,874

Variable	Observations	Mean	Standard Deviation
Econ	240874	0.000	1.000
Asian	240874	0.035	0.183
Black	240874	0.384	0.486
Hispanic	240874	0.053	0.224
Other	240874	0.018	0.132
LowIncome	240874	0.350	0.477
EconPeers	220167	0.018	0.587
Dpopulation	240496	1047.122	933.751
Dwhite	240496	62.497	17.107
Dincome	240496	51420.830	13165.600
Tsalary	240319	48341.380	1969.855
ClassSize	240319	14.594	0.839
Disabled	240874	0.070	0.256
Female	240874	0.519	0.500
Algebra	144852	0.000	1.000
Geometry	144996	0.000	1.000
Econ2006	240874	0.317	0.465
Econ2007	240874	0.330	0.470
EconAlgGap	144852	2.263	1.051
EconGeoGap	144996	1.762	0.847

Table 3: Summary Statistics for Primary Model

90,845

Variable	Mean	Standard Deviation
Econ	0.007	0.909
Asian	0.029	0.169
Black	0.368	0.482
Hispanic	0.054	0.226
Other	0.018	0.133
LowIncome	0.345	0.475
EconPeers	0.010	0.552
Dpopulation	981.802	873.620
Dwhite	63.325	16.893
Dincome	52050.460	13390.710
Tasalary	48253.640	1936.791
ClassSize	14.617	0.825
Disabled	0.053	0.225
Female	0.530	0.499
Algebra	0.164	0.998
Geometry	-0.028	0.967
Econ2006	0.110	0.313
Econ2007	0.333	0.471
EconAlgGap	2.582	0.868
EconGeoGap	1.572	0.811

Table 4. Results for Primary Model			
Dependent Variable: *Econ*			
Variable	Coefficient	|t|	P>|t|
Intercept	-0.2641	0.45	0.649
Asian	-0.2023	14.86	0.000
Black	-0.1807	31.45	0.000
Hispanic	-0.1447	14.61	0.000
Other	-0.0608	3.88	0.000
LowIncome	-0.0545	10.82	0.000
EconPeers	0.2594	16.24	0.000
Dpopulation	-0.0000	0.71	0.476
Dwhite	-0.0009	0.75	0.453
Dincome	-0.0000	2.57	0.010
Tsalary	0.0000	1.42	0.156
ClassSize	-0.0187	0.83	0.408
Disabled	-0.0824	7.58	0.000
Female	-0.1669	41.17	0.000
Algebra	0.2004	47.68	0.000
Geometry	0.3442	64.82	0.000
Econ2006	0.1260	13.48	0.000
Econ2007	0.0543	10.09	0.000
EconAlgGap	0.0811	17.45	0.000
EconGeoGap	0.0860	17.73	0.000
n = 92669 R^2 = 0.581			

Table 5. Algebra prior to Geometry			
Dependent Variable: *Econ*			
Variable	Coefficient	|t|	P>|t|
Intercept	-0.1110	0.18	0.860
Asian	-0.2031	14.74	0.000
Black	-0.1797	30.76	0.000
Hispanic	-0.1431	14.21	0.000
Other	-0.0592	3.72	0.000
LowIncome	-0.0548	10.64	0.000
EconPeers	0.2546	15.46	0.000
Dpopulation	-0.0000	0.65	0.513
Dincome	-0.0000	2.24	0.025
Dwhite	-0.0014	1.00	0.315
Tsalary	0.0000	0.92	0.358
ClassSize	-0.0171	0.72	0.471
Disabled	-0.0795	7.19	0.000
Female	-0.1664	40.27	0.000
Algebra	0.1999	46.32	0.000
Geometry	0.3451	63.71	0.000
Econ2006	0.1335	13.78	0.000
Econ2007	0.0595	10.82	0.000
EconAlgGap	0.1083	16.29	0.000
EconGeoGap	0.0662	10.45	0.000
n = 89272 R^2 = 0.581			

Table 6. Geometry prior to Algebra			
Dependent Variable: *Econ*			
Variable	Coefficient	|t|	P>|t|
Intercept	0.2071	0.04	0.966
Asian	-0.1682	1.37	0.171
Black	-0.1700	2.97	0.003
Hispanic	-0.0289	0.32	0.750
Other	-0.2134	1.53	0.127
LowIncome	-0.0164	0.41	0.681
EconPeers	0.4060	2.99	0.003
Dpopulation	-0.0001	0.41	0.682
Dincome	-0.0000	0.20	0.841
Dwhite	-0.0005	0.08	0.940
Tsalary	0.0000	0.42	0.672
ClassSize	-0.1383	0.81	0.415
Disabled	-0.1778	1.91	0.057
Female	-0.1734	4.75	0.000
Algebra	0.2428	8.96	0.000
Geometry	0.2162	5.38	0.000
Econ2006	0.1221	1.86	0.064
Econ2007	0.0147	0.30	0.764
EconAlgGap	0.0036	0.10	0.923
EconGeoGap	0.0917	2.14	0.032
n = 2184 R^2 = 0.650			

Table 7. Algebra and Geometry Concurrent			
Dependent Variable: *Econ*			
Variable	Coefficient	|t|	P>|t|
Intercept	-0.7975	0.16	0.872
Asian	-0.0631	0.35	0.730
Black	-0.1434	1.92	0.056
Hispanic	-0.1713	1.65	0.099
Other	-0.0244	0.11	0.916
LowIncome	-0.0856	1.52	0.129
EconPeers	0.2420	1.15	0.249
Dpopulation	0.0005	1.54	0.125
Dincome	-0.0000	1.67	0.096
Dwhite	0.0252	1.17	0.241
Tsalary	0.0000	0.54	0.590
ClassSize	-0.0709	0.25	0.802
Disabled	0.1601	1.11	0.266
Female	-0.1415	2.75	0.006
Algebra	0.1882	4.48	0.000
Geometry	0.3872	7.34	0.000
Econ2006	0.1020	1.20	0.231
Econ2007	-0.0332	0.46	0.646
EconAlgGap	0.1034	2.67	0.008
n = 1213 R^2 = 0.737			