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Greer Howard March 31, 2018

An Analysis of the Effect of Advanced Placement Credit on Student Success in College

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Abstract

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Using Emory University registrar data this paper examines the impact of using Advanced Placement (AP) credit to gain exemption from introductory college courses on student performance in upper-level college courses. Additionally, attention is paid to the difference in performance between students with a score of 4 and 5 on the AP post-course examination. This study finds that the presence of AP credit does not have a significant impact on student performance. However, students with a score of 4 on the AP post-course examination perform worse than those with no AP credit, and students with a score of a 5 on the AP post-course examination perform better than those with no AP credit. The latter reflects selectivity. Furthermore, regardless of AP credit, students that are required to take at least one introductory course in a field perform better in the related upper-level courses than those who take no introductory courses.

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I. Introduction

Most high schools in the United States provide high achieving students with the opportunity to supplement their secondary education with collegiate-level coursework. Frequently, this means curriculum options that include classes at local colleges or The College Board's Advanced Placement (AP) courses. AP classes are usually taught on high school campuses by high school teachers, but The College Board assures its students and the nation's universities that all AP courses are taught and assessed at a 'college-level' (The College Board, Discover AP, 2018). The College Board attempts to maintain this standard across all high schools and teachers by allowing students to take a post-course examination to demonstrate mastery of the material or lack thereof (The College Board, About the Exams, 2018). These exams are scored on a scale from 1 to 5, and The College Board uses 'statistical processes' designed to ensure temporal grading consistency.[1]

In recent years, AP coursework and scores on the post-course examination have increasingly gained emphasis in the undergraduate admissions process. Many elite universities openly value AP credit on students' high school transcripts and the AP post-course examination scores in processing admission decisions, and it is common for these universities to state that a lack of AP or equivalent coursework can significantly hurt a student's chances of admission (Hotrum, 2015). Additionally, many of these universities allow students to use successful completion of an AP course and a passing or better score (3, 4, or 5) on the post-course examination as credit for a similar introductory undergraduate class at the university. This

[1] For example, they assert that 'a 3 this year reflects the same level of achievement as a 3 last year' (The College Board, About AP Scores, 2018).

combination of influence on admission decisions and the ability to get exemption from introductory courses make taking AP courses during secondary school extremely beneficial if not necessary for students considering post-secondary education.

The purpose of this analysis is to determine if AP courses are an adequate substitute for introductory college courses. More generally, I seek to provide insight into the relative ability of students with AP credit and those without AP credit to succeed in college. Since it is not possible to gather data on all students who have AP credit at every university, I analyze Emory University economics majors who graduated between 2007 to 2017. Economics majors at Emory University must take sequential courses at the introductory level and then the intermediate level for both microeconomics and macroeconomics. Alternatively, these students can use AP credit with a score of 4 or 5 on the post-course examination to get exemption from introductory microeconomics and from introductory macroeconomics, making this population of students ideal for a multifaceted analysis of AP credit's impact on student success in more advanced college courses.

In my analysis, I seek to determine if students who used AP credit to place out of introductory economics courses perform differently in intermediate economics courses than students who took the introductory courses at Emory University. Additionally, I look at the differences in intermediate course performance between students who scored a 4 on the AP post-course examination and students who scored a 5. The goal of this study is to provide a general understanding of how AP credit impacts student performances. Since the population of Emory University economics students in this study is representative of students in other

universities and departments, this analysis provides departments with information necessary to make the best decisions regarding their AP credit policy.

II. AP Credit as a Substitute for College Courses

The rise in popularity of the AP curriculum has come coupled with criticism directed towards universities for placing too much weight on a student's performance in the standardized post-course examination and The College Board for overstating the validity of AP courses as adequate substitutes for introductory college courses (Tierney, 2012). However, some of this criticism may be unwarranted because there is evidence both in theory and empirics that success in AP coursework is a good indicator of success in collegiate education (Murphy & Dodd, 2009). Moreover, there is some evidence that students who complete the post-course examination with a passing score outperform students who only take the AP course (Ewing, 2006). Although this literature suggests that criticizing universities for a preference towards students with AP credit is likely unfair, it reveals nothing about the effectiveness of AP coursework in preparing students for college-level classes in respective fields. For example, it is probable that the reason success in AP coursework is a good indicator of success in college is due to the type of student that is the most likely to succeed in AP coursework being the same type of student likely to succeed in college with or without AP coursework. To continue allowing students to be exempt from introductory classes using AP credit, the universities need to be able to show that students who use AP credit are at least as prepared as students who take the introductory classes for intermediate and upper-level coursework.

Unfortunately, the question of whether AP coursework adequately prepares students for college-level classes is complicated for several reasons. First, undergraduate courses cannot be generalized across institutions or even departments within the same institution, and it is likely

that this factor is the most influential in determining the effectiveness of AP courses in preparing students for intermediate classes. It is anecdotally evident that there are vast differences in rigor, curriculum, teaching and testing styles, and level of expectations even between universities of similar size and prestige. These differences increase even more when comparing specific departments across universities. Thus, any method for assessing AP coursework must be not only university specific but department specific.

Second, 'succeeding in college' is a vague idea. This success could be defined as a student's overall GPA, a student's GPA in the coursework of the same field as the AP coursework, a student's success in an equivalent class to the AP coursework, the ability of a student to find employment after graduation, and numerous other ways. Furthermore, it must be considered that when students are allowed to be exempt from introductory classes, they can take additional courses both in and outside the related field; courses that they would not have been able to take otherwise. This benefit for the students must be included by a department when evaluating the success of students with AP credit.

Third, as mentioned earlier, it is likely that students who choose to participate in AP coursework during high school are high achieving students. If these students are more likely to perform better in college regardless of whether they participate in an AP curriculum, this effect must be standardized in any evaluation of student performance. Luckily, this effect can at least be partially accounted for by including SAT and ACT score in the analysis. While SAT and ACT scores are certainly not measures of intelligence, they are decent indicators of ability to take standardized tests and work ethic. Both of these factors play huge roles in a student's success on

the AP post-course examination and should thus provide some form of standardization with those who did not take AP courses.

Fourth, The College Board considers three of the five possible scores on the AP post-course examination to be passing. Obviously, this lack of exclusivity poses a problem for the departments of elite universities that must decide what score satisfies a level of achievement equal to that of the university and the department in question. Unfortunately, The College Board's description of each of the scores is very vague; they state that a 5 means 'extremely well qualified,' a 4 means 'well qualified,' a 3 means 'qualified,' a 2 means 'possibly qualified,' and a 1 means 'no recommendation.' Therefore, there is no method for a department to assess this achievement level other than comparing the success of their students with various AP scores to that of students without AP course credit.

I have attempted to shed some light on the issues with an analysis of AP credit mentioned previously by narrowing my scope and being as specific as possible about my measure of success. I chose to only look at students from Emory University's Economics Department, specify success solely as a student's grade in intermediate microeconomics (ECON 201) and intermediate macroeconomics (ECON 212), standardize student achievement level using SAT and ACT score, and compare the success of students who did not take AP credit to those that earned a 4 on a specific AP test and those who made a 5.

III. Data and Econometric Model

Dataset

For this analysis, I use data collected by the Emory University office of the Registrar. The dataset provided by the registrar consist of the best SAT score, best ACT score, grade in introductory microeconomics, grade in introductory macroeconomics, grade in intermediate microeconomics, and grade in intermediate macroeconomics for 1097 economics majors who graduated from the Emory College of Arts and Sciences between 2007 and 2017. I use a conversion chart to convert ACT score to the equivalent SAT score in order to maintain a standard for standardized test score regardless of which test a student takes (Edwards, 2018). If they took both tests, I average the two scores and use that as the student's standardized test score. Additionally, the dataset includes whether or not the students used AP credit to place out of either introductory microeconomics or introductory macroeconomics and what their AP post-course examination scores were if they did.

Econometric Model

One goal of this analysis is to see if students who use AP credit to get exemption from introductory microeconomics and introductory macroeconomics courses perform differently in intermediate courses than those who do not. Another goal is to determine if it is actually the AP courses and credits that cause any difference. To perform this analysis, I use Ordinary Least Squares (OLS) regressions and variations of equations 1- 3,

$$ECON201 = \beta_0 + \beta_1 \mathcal{X} + \varepsilon \quad (1)$$

$$ECON212 = \beta_0 + \beta_1 \mathcal{X} + \varepsilon \quad (2)$$

$$ECON201 + ECON212 = \beta_0 + \beta_1 \mathcal{X} + \varepsilon \quad (3)$$

where ECON201 is a student's grade in intermediate microeconomics, ECON212 is a student's grade in intermediate macroeconomics, $\mathcal{X}$ is a vector of independent variables, and ε is an error term.

Table 1. List of Variables and Their Descriptions.

Variable Name	*Variable Description*
ECON101	Numerical Grade in Introductory Microeconomics
ECON112	Numerical Grade in Introductory Macroeconomics
ECON201	Numerical Grade in Intermediate Microeconomics
ECON212	Numerical Grade in Intermediate Macroeconomics
STANDTEST	Standardized Test Score
AP101CRED	Binary Variable for if the Student has AP Credit Equivalent to Introductory Microeconomics where 0 Represents no AP Credit and 1 Represents AP Credit
AP112CRED	Binary Variable for if the Student has AP Credit Equivalent to Introductory Macroeconomics where 0 Represents no AP Credit and 1 Represents AP Credit
AP101SCORE4	Binary Variable for if the Student used a 4 on the Post-Course Examination as Credit for Introductory Microeconomics where 0 Represents no 4 and 1 Represents a 4
AP101SCORE5	Binary Variable for if the Student used a 5 on the Post-Course Examination as Credit for Introductory Microeconomics where 0 Represents no 5 and 1 Represents a 5
AP112SCORE4	Binary Variable for if the Student used a 4 on the Post-Course Examination as Credit for Introductory Macroeconomics where 0 Represents no 4 and 1 Represents a 4
AP112SCORE5	Binary Variable for if the Student used a 5 on the Post-Course Examination as Credit for Introductory Macroeconomics where 0 Represents no 5 and 1 Represents a 5
APSCORE5	Binary Variable for if the Student used a 5 on the Post-Course Examination as Credit for Introductory Microeconomics or Introductory Macroeconomics where 0 Represents no 5 and 1 Represents a 5

Limitations

Unfortunately, the dataset used for the analysis presents several limitations. The first limitation is that there is no reliable way to standardize a score on an AP post-course examination to a numerical grade in the equivalent introductory course. This lack of standardization paired with the fact that students who have AP credit generally do not take the equivalent introductory

course means a regression that includes both numerical grades in introductory courses and AP scores is not feasible. Therefore, the only way to compare numerical grades in introductory courses to AP scores is to run multiple regressions on filtered datasets that only include specific grades and scores.

Second, due to privacy regulations on student data, I was only able to obtain a portion of the data needed to complete a comprehensive analysis. Knowing each student's overall GPA would help to ascertain a more accurate assessment of student ability, each student's overall economic GPA would show the impact of AP credit on all economic coursework, the professors a student took for each class would allow more accurate standardization, and a student's grades in other specific coursework, especially mathematics, would provide insight into other factors that influence a student's ability to succeed. Unfortunately, none of this data was available.

Finally, in the available data set, it is extremely rare for students to have AP credit for introductory microeconomics and not have AP credit for introductory macroeconomics. This rarity made any analysis on this set of students impossible. Fortunately, many students have AP credit introductory macroeconomics and do not have AP credit for introductory microeconomics. Thus, the analysis is possible in one direction but not the other.

IV. Empirical Results

Summary Statistics

For a variety of reasons, the data available for each of the students varies. This variation naturally divides the students into subcategories. Since the outcome values for analysis depend on a student's score in intermediate microeconomics and intermediate macroeconomics, I only included the students who took and earned a numerical grade for both classes at Emory but maintained the other subcategories of students.

Table 2. Summary Statistics of Each Variable in Dataset.

Variables	Mean	Standard Deviation	Median	Max	Min	Number of Observations
STANDTEST	1345.17	102.8	1350	1590	890	1025
ECON101	3.240	0.702	3.3	4	1	831
ECON112	3.142	0.717	3.3	4	0	927
APSCORE101	4.36	0.49	4	5	4	52
APSCORE112	4.33	0.47	4	5	4	130
ECON201	3.134	0.776	3.3	4	0	1097
ECON212	3.078	0.772	3.3	4	0	1097

Table 2 shows the summary statistics for the various subcategories of students. It clear that students more frequently use AP credit to get exemption from introductory macroeconomics than introductory microeconomics. However, it is more common in both courses for students to use a score of a 4 than a score of a 5 to get exemption. Additionally, we see that students perform better in microeconomics than in macroeconomics at both the introductory and intermediate level, and students perform better in both courses at the introductory level than at the intermediate level.

Figure 1. Histogram of the numerical grade in intermediate microeconomics for students who took the course at Emory University and graduated between 2007 and 2017.

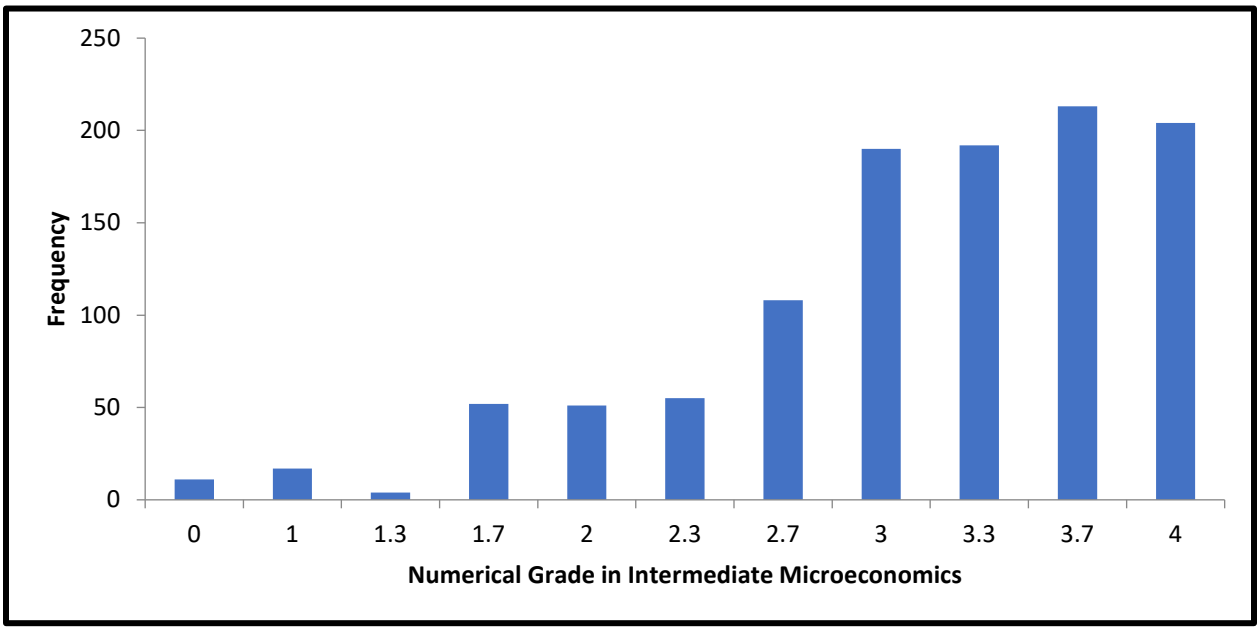
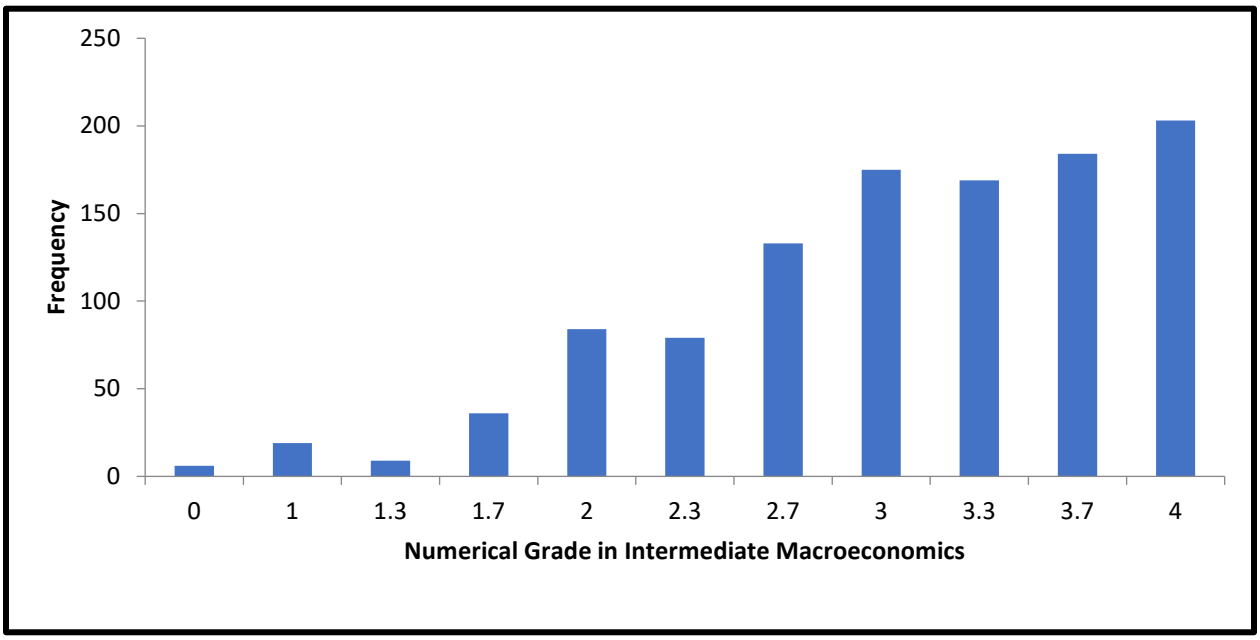


Figure 2. Histogram of the numerical grade in intermediate macroeconomics for students who took the course at Emory University and graduated between 2007 and 2017



Figures 1 and 2 show histograms for students' grades in intermediate microeconomics and intermediate macroeconomics. For both courses the majority of students earn a 3, B, or better, and very few students earn worse than a 1.7, C-. Also, we see the most common grade earned in intermediate microeconomics is a 3.7, B-, and the most common grade earned in intermediate macroeconomics is a 4, A. The grade distribution for both courses is skewed to the right.

Comparative Statistics

Table 3. Simple Comparative Statistics for Student Categories of Interest.

Comparison Groups	Mean ECON101	Mean ECON112	Mean ECON201	Mean ECON212	MEAN ECON201 + ECON212	Mean STANDTEST
No AP Credit	3.220 (0.706)	3.134 (0.719)	3.119 (0.775)	3.045 (0.783)	6.154 (1.33)	1336.5 (103.23)
AP Credit for ECON101	- -	3.64 (0.108)	3.243 (0.115)	3.293 (0.106)	6.537 (0.193)	1407.6 (89.0)
AP Score of 5 for ECON101	- -	3.667 (0.351)	3.576 (0.539)	3.482 (0.668)	7.059 (1.07)	1417.7 (97.7)
AP Score of 4 for ECON101	- -	3.629 (0.364)	3.048 (0.845)	3.183 (0.735)	6.231 (1.356)	1401.9 (84.9)
AP Credit for ECON112	3.455 (0.632)	- -	3.217 (0.77)	3.254 (0.68)	6.471 (1.273)	1394.5 (78.7)
AP Score of 5 for ECON112	3.723 (0.398)	- -	3.412 (0.67)	3.560 (0.432)	6.972 (0.964)	1398.4 (69.9)
AP Score of 4 for ECON112	3.321 (0.688)	- -	3.122 (0.801)	3.105 (0.73)	6.223 (1.338)	1392.6 (83.0)

Note: Standard deviations are shown in parentheses.

Table 3 shows comparative statistics for different subpopulations of students. We see that students with AP credit perform better, in general, in the courses they take at Emory than students without AP credit, and that students who use a 5 as AP credit perform better in the courses they take at Emory than students who use a 4. However, it is also evident that students with AP credit have higher standardized test scores than those without AP credit, and students who use a 5 as AP credit have higher standardized test scores than those who use a 4. To test

whether these apparent differences are significant two sample t-tests were performed. The results are reported in Table 4.

Table 4. Mean Difference T-Test for Student Categories of Interest.

Null Hypothesis	ECON101	ECON112	ECON201	ECON212	ECON201 + ECON212	STANDTEST
No AP Credit – AP Credit for ECON101 = 0	- -	-2.222** (0.0265)	-1.059 (0.2897)	-2.106** (0.0355)	-1.859* (0.0633)	-4.486*** (<0.0001)
No AP Credit – AP Score of 5 for ECON101 = 0	- -	-1.283 (0.1998)	-2.42** (0.0157)	-2.286** (0.0225)	-2.758*** (0.0059)	-3.121*** (0.0019)
No AP Credit – AP Score of 4 for ECON101 = 0	- -	-1.819* (0.0692)	0.485 (0.628)	-1.376 (0.176)	-0.267 (0.7895)	-3.316*** (0.0009)
No AP Credit – AP Credit for ECON112 = 0	-2.316** (0.0208)	- -	-1.316 (0.1885)	-2.815*** (0.005)	-2.412** (0.016)	-5.924*** (<0.0001)
No AP Credit – AP Score of 5 for ECON112 = 0	-2.926*** (0.0035)	- -	-2.358** (0.0186)	-4.132*** (<0.0001)	-3.802*** (0.0002)	-3.706*** (0.0002)
No AP Credit – AP Score of 4 for ECON112 = 0	-0.809 (0.419)	- -	-0.034 (0.973)	-0.669 (0.5035)	-0.411 (0.6809)	-4.751*** (0.0001)
AP Score of 5 for ECON101 – AP Score of 4 for ECON101 = 0	- -	0.153 (0.8825)	2.31** (0.0257)	1.376 (0.176)	2.152** (0.037)	0.562 (0.5770)
AP Score of 5 for ECON112 – AP Score of 4 for ECON112 = 0	2.223** (0.0308)	- -	1.98 (0.5)	3.639*** (0.0004)	3.148*** (0.0021)	0.377 (0.7071)

Notes: Values shown are the t-statistics for each null hypothesis. P-values are in parentheses. *Significant at the 90% confidence level, two-tailed test. **Significant at the 95% confidence level, two-tailed test. ***Significant at the 99% confidence level, two-tailed tests.

Table 4 shows the t-test results used to determine if there exists a difference in the means of ECON101, ECON112, ECON201, ECON212, ECON201 + ECON212, and STANDTEST for certain groups of students. These results indicate that students who use AP credit to gain exemption from introductory coursework perform better in all four courses than those who take the introductory courses at Emory University.[2] Additionally, students who use an AP score of 5 to gain exemption from introductory courses perform better on all four courses than those who use an AP score of 4 to gain exemption from introductory courses. Most importantly these students perform better in the corresponding intermediate course with high significance. However, Table

[2] With the exception of students who used an AP score of 4 for introductory microeconomics who performed worse with no significance.

4 also shows that students with AP credit have higher standardized test scores than students who take the course at Emory and that students with an AP score of 5 have higher standardized test scores than those with an AP score of 4. The fact that students with AP credit perform better than those without AP credit in introductory courses and have higher standardized test scores suggests that the higher score in intermediate coursework might not be exclusively due to the AP credit. Instead, this grade difference could be due to higher superior test taking ability of the students with AP credit.

To overcome possible selection bias, we use a matched sample. Table 5 shows the t-test results used to determine if students that use AP credit to gain exemption from either introductory microeconomics or introductory macroeconomics but not both perform differently in intermediate microeconomics or intermediate macroeconomics, respectively. Here the performance of same students is compared with themselves, with AP credit for one introductory course and with Emory credit for the other introductory course.

Table 5. Matched Mean Difference T-Test for Students with One AP Credit.

Category of Students	Null: ECON201 - ECON212 = 0	Null: ECON212 - ECON201 = 0
AP Credit for ECON101 and Emory Credit for ECON112	-0.9947 (0.3360)	- -
AP Score of 5 for ECON101 and Emory Credit for ECON112	-0.1642 (0.8848)	- -
AP Score of 4 for ECON101 and Emory Credit for ECON112	-0.9731 (0.3498)	- -
AP Credit for ECON112 and Emory Credit for ECON101	- -	0.8648 (0.3894)
AP Score of 5 for ECON112 and Emory Credit for ECON101	- -	1.6169 (0.1164)
AP Score of 4 for ECON112 and Emory Credit for ECON101	- -	0.0668 (0.947)

Notes: Values shown are the t-statistics for the two null hypotheses. P-values are in parentheses. None of the values are significant at the 90% confidence level.

Table 5 suggests that students with AP credit for introductory microeconomics and Emory credit for introductory macroeconomics do worse in intermediate microeconomics than in intermediate macroeconomics and that students with AP credit for introductory macroeconomics and Emory credit for introductory microeconomics do better in intermediate macroeconomics than in intermediate microeconomics. Both these results are not significant. Therefore, we cannot argue that AP or Emory Credit at the introductory level leads to a better grade at the introductory level.

Regression Results

Using variations of equations 1, 2, and 3 with the dependent variables ECON201, ECON212 and ECON201 + ECON212 respectively, I perform OLS regressions on 11 different subpopulations of students who earned a letter grade in both intermediate microeconomics and intermediate macroeconomics. Table 6 describes each subpopulation of students. It should be noted that an additional variation is desired that includes the independent variables STANDTEST, ECON112, and AP101SCORE5. Unfortunately, the twelfth population needed for this variation that only includes students who earned a letter grade in introductory macroeconomics and took introductory macroeconomics at Emory has too few observations (students) to produce a meaningful result. Tables 7, 8, and 9 show the coefficient estimates for equations 1, 2, and 3.

Table 6. List of Populations and Their Descriptions.

Population	*Description*
1	Students that took both introductory microeconomics and introductory macroeconomics at Emory University. (No AP Credit)
2	Students that either took introductory microeconomics at Emory University or received AP credit for introductory microeconomics.
3	Students that either earned a letter grade of a B- or higher in introductory microeconomics at Emory University or received AP credit for introductory microeconomics.
4	Students that received AP credit for introductory microeconomics.
5	Students that either took introductory macroeconomics at Emory University or received AP credit for introductory macroeconomics.
6	Students that either earned a letter grade of a B- or higher in introductory macroeconomics at Emory University or received AP credit for introductory macroeconomics.
7	Students that received AP credit for introductory macroeconomics.
8	Students that either took introductory microeconomics at Emory University or received AP credit for introductory microeconomics and either took introductory macroeconomics at Emory University or received AP credit for introductory macroeconomics.
9	Students that either earned a letter grade of a B- or higher in introductory microeconomics at Emory University or received AP credit for introductory microeconomics and either earned a letter grade of a B- or higher in introductory macroeconomics at Emory University or received AP credit for introductory macroeconomics.
10	Students that received AP credit for introductory microeconomics and received AP credit for introductory macroeconomics.
11	Students that received AP credit for introductory macroeconomics but took introductory microeconomics at Emory University.

Table 7. Benchmark Comparison Regressions for Intermediate Microeconomic Grade.

ECON201	*Population 1*	*Population 2*	*Population 2*	*Population 3*	*Population 3*	*Population 4*	*Population 11*
STANDTEST	0.0000181 (0.000272) [0.07]	0.00113*** (0.000255) [4.45]	0.00112*** (0.000254) [4.41]	0.00117*** (0.000283) [4.12]	0.00115*** (0.000282) [4.07]	0.00295** (0.00112) [2.64]	-0.0009 (0.0014) [-0.64]
ECON101	0.1254*** (0.04263) [2.94]	- - -	- - -	- - -	- - -	- - -	0.6012*** (0.1751) [3.43]
ECON112	0.3163*** (0.04163) [7.6]	- - -	- - -	- - -	- - -	- - -	- - -
APCRED101	- - -	-0.02999 (0.1081) [-0.28]	- - -	-0.0699 (0.1071) [-0.65]	- - -	- - -	- - -
AP101SCORE4	- - -	- - -	-0.2457* (0.1323) [-1.86]	- - -	-0.2853** (0.1309) [-2.18]	- - -	- - -
AP101SCORE5	- - -	- - -	0.3565** (0.1749) [2.04]	- - -	0.3164* (0.1729) [1.83]	0.5660** (0.2132) [2.66]	- - -
AP112SCORE5	- - -	- - -	- - -	- - -	- - -	- - -	-0.1129 (0.2189) [-0.52]
Intercept	1.8008*** (0.3429) [5.25]	1.6867*** (0.3433) [4.91]	1.7090*** (0.3420) [5]	1.6807*** (0.3842) [4.38]	1.7091*** (0.3824) [4.47]	-1.1143 (1.5740) [-0.71]	2.3679 (1.9166) [1.24]
F-Statistic	40.27	10	9.34	8.49	8.41	7.83	4.07
Adjusted r^2	0.1423	0.0211	0.0291	0.0204	0.03	0.2179	0.146
Sample Size	711	835	835	719	719	50	55

Notes: Dependent variable is the numerical intermediate microeconomics grade in the range of 0 to 4. Sample size for each subpopulation is shown as N. Standard errors are in parentheses. T-statistics are in brackets. *Significant at the 90% confidence level, two-tailed test. **Significant at the 95% confidence level, two-tailed test. ***Significant at the 99% confidence level, two-tailed tests.

Table 8. Benchmark Comparison Regressions for Intermediate Macroeconomic Grade.

ECON212	*Population 1*	*Population 5*	*Population 5*	*Population 6*	*Population 6*	*Population 7*	*Population 11*
STANDTEST	-0.00032 (0.000265) [-1.22]	0.00102*** (0.00024) [4.25]	0.00102*** (0.000239) [4.24]	0.00104*** (0.00025) [4.16]	0.00103*** (0.000249) [4.16]	0.00136* (0.000706) [1.92]	-0.0010 (0.00115) [-0.84]
ECON101	0.2573*** (0.0416) [6.19]	- - -	- - -	- - -	- - -	- - -	0.6015*** (0.1406) [4.29]
ECON112	0.3572*** (0.4060) [8.8]	- - -	- - -	- - -	- - -	- - -	- - -
APCRED112	- - -	0.1238* (0.0731) [1.69]	- - -	0.005548 (0.067585) [0.08]	- - -	- - -	- - -
AP112SCORE4	- - -	- - -	-0.0183 (0.0863) [-0.21]	- - -	-0.13654* (0.0794) [-1.72]	- - -	- - -
AP112SCORE5	- - -	- - -	0.4158*** (0.1200) [3.47]	- - -	0.297564*** (0.1099) [2.71]	0.4327*** (0.1195) [3.62]	0.2771 (0.1757) [1.58]
Intercept	1.5916*** (0.3344) [4.76]	1.7118*** (0.3223) [5.31]	1.7190*** (0.3210) [5.36]	1.8001*** (0.3382) [5.32]	1.8094*** (0.3362) [5.38]	1.2192 (0.9891) [1.23]	2.3266 (1.5391) [1.51]
F-Statistic	72.66	12.38	11.45	9.05	9.87	8.59	9.27
Adjusted r^2	0.2324	0.0224	0.0306	0.0189	0.0309	0.1067	0.3148
Sample Size	711	993	993	835	835	128	55

Notes: Dependent variable is the numerical intermediate macroeconomics grade in the range of 0 to 4. Sample size for each subpopulation is shown as N. Standard errors are in parentheses. T-statistics are in brackets. *Significant at the 90% confidence level, two-tailed test. **Significant at the 95% confidence level, two-tailed test. ***Significant at the 99% confidence level, two-tailed tests.

Table 9. Benchmark Comparison Regressions for Sum of Intermediate Microeconomics Grade and Intermediate Macroeconomics Grade.

ECON201 + ECON212	*Population 1*	*Population 8*	*Population 8*	*Population 9*	*Population 9*	*Population 10*	*Population 11*
STANDTEST	0.00030 (0.000428) [-0.72]	0.002074*** (0.00045) [4.62]	0.00206*** (0.000446) [4.61]	0.006500*** (0.005202) [3.35]	0.001726** (0.001212) [3.35]	0.006402*** (0.002148) [2.98]	-0.00189 (0.0225) [-0.84]
ECON101	0.3828*** (0.067) [5.71]	- - -	- - -	- - -	- - -	- - -	1.2037*** (2.7526) [4.37]
ECON112	0.6736*** (0.0654) [10.29]	- - -	- - -	- - -	- - -	- - -	- - -
APCRED101	- - -	0.098248 (0.2182) [0.45]	- - -	-0.0648 (0.2068) [-0.31]	- - -	- - -	- - -
APCRED112	- - -	-0.15136 (0.16182) [-0.94]	- - -	-0.2420 (0.1594) [-1.51]	- - -	- - -	- - -
AP101SCORE4	- - -	- - -	-0.2404 (0.2592) [-0.93]	- - -	-0.3972 (0.2436) [-1.63]	- - -	- - -
AP101SCORE5	- - -	- - -	0.7004** (0.3222) [2.17]	- - -	0.5598* (0.3016) [1.86]	1.2198*** (0.39) [3.13]	- - -
AP112SCORE4	- - -	- - -	-0.4382** (0.18632) [-2.35]	- - -	-0.551*** (0.18386) [-3]	- - -	- - -
AP112SCORE5	- - -	- - -	0.3248 (0.2478) [1.31]	- - -	0.2272 (0.2352) [0.96]	0.4718** (0.4140) [2.11]	0.1642 (0.3440) [0.48]
Intercept	3.3924*** (0.539) [6.29]	3.5576*** (0.6052) [5.88]	3.5896*** (0.5998) [5.99]	4.2468*** (0.711) [5.97]	4.2820*** (0.7008) [6.11]	-3.536 (3.0566) [-1.16]	4.6945 (3.0136) [1.56]
F-Statistic	86.35	7.35	7.87	4.38	6.67	10.79	7.65
Adjusted r^2	0.2651	0.0232	0.0411	0.0164	0.0444	0.4708	0.2698
Sample Size	711	803	803	611	611	34	55

Notes: Dependent variable is the sum of numerical intermediate microeconomics grade and numerical intermediate macroeconomics grade in the range of 0 to 4. Sample size for each subpopulation is shown as N. Standard errors are in parentheses. T-statistics are in brackets. *Significant at the 90% confidence level, two-tailed test. **Significant at the 95% confidence level, two-tailed test. ***Significant at the 99% confidence level, two-tailed tests.

With the primary interest of this analysis being to determine if AP credit has an impact on student performance, it is clear that the regressions that only use standardized test scores and whether or not a student used AP credit to gain exemption from either introductory microeconomics or introductory macroeconomics are inconclusive. However, when the regression is limited to include only the students who made a B- or better in introductory microeconomics or introductory macroeconomic at Emory University, these coefficients become more negative. This result is anecdotally evident from looking at the regressions on population 1 which show that the grades a student earns in introductory microeconomics and introductory macroeconomics positively correlate to the grades a student earns in intermediate microeconomics and intermediate macroeconomics.

However, these results are not very significant and call for a more in-depth analysis. By looking at the regressions that include whether or not a student has a 4 or a 5 for their AP credit, the difference becomes more explicit. In all of the regressions the students that have a 4 as AP credit for either introductory microeconomics or introductory macroeconomics perform worse with reasonable significance than those who took the course at Emory University, and this difference becomes even more significant when only the students who earned a B- or better in the course at Emory University are considered. Additionally, in all of the regressions, the students that have a 5 for AP credit for either introductory microeconomics or introductory macroeconomics perform better than those who took the introductory course at Emory University. However, this result is not very significant and becomes even less significant when only the students who earned a B- or better in the course at Emory University are considered. It is worth noting that both the negative correlation of those who had a 4 and the positive

correlation of those who had a 5 is more significant for the regressions on equation 3 with the dependent variable of the sum of the numerical grade in intermediate microeconomics and the numerical grade in intermediate macroeconomics.

The previous regressions have a corollary result. Students who earned a 5 on either AP test perform better in both intermediate microeconomics and intermediate macroeconomics than those who earned a 4. This result is further shown by looking at the regressions that only include students with AP credit, populations 4, 7, and 10. It is clear that students with a 5 for AP credit perform better than those with a 4 with reasonable significance in both intermediate microeconomics and intermediate macroeconomics. Again, it is worth noting that this result is more significant for the regressions on equation 3.

Finally, the results of the regressions performed on population 11 show that for students who use AP credit to gain exemption from introductory macroeconomics but earn a letter grade in introductory microeconomics there is a strong correlation between their grade in introductory microeconomics and their grade in intermediate coursework regardless of the AP score they used to gain exemption from introductory macroeconomics. It is already clear from the regression performed on population 1 that this is true for intermediate microeconomics, but since introductory microeconomics and intermediate macroeconomics cover differing topics this result is surprising. While many explanations for this result are possible, the most likely explanation is that students who exert effort in an introductory course are more prepared for intermediate coursework.

Moreover, this reasoning explains why there is a negative correlation between using AP credit to gain exemption from introductory microeconomics and numerical grade in intermediate microeconomics but a positive correlation between using AP credit to gain exemption from introductory macroeconomics and numerical grade in intermediate macroeconomics. As mentioned previously, it is rare in the data set used for students to use AP credit to gain exemption from introductory microeconomics and not use AP credit to gain exemption from introductory macroeconomics. Thus, students who use AP credit to gain exemption from introductory microeconomics are unlikely to take an introductory economics course. In comparison, students who use AP credit to gain exemption from introductory macroeconomics frequently earn a letter grade in introductory microeconomics at Emory University. By, showing the effects when students use AP credit to gain exemption from both introductory microeconomics and introductory macroeconomics, the results from the regression on population 8 substantiate this explanation.

To again account for selection bias I performed a matched regression. The results are shown in Table 10.

Table 10. *Matched Regressions for Difference between Intermediate Economics Grades.*

ECON201-ECON212 or ECON212-ECON201		
STANDTEST	0.00000817 (0.0011373) [-1.22]	0.0000648 (0.001125) [0.06]
ECON101 or ECON112	0.1134 (0.1436) [0.779]	0.05292 (0.1476) [0.36]
APSCORE5	- - -	0.2720 (0.1796) [1.51]
Intercept	-0.3919 (1.5312) [-0.26]	-0.3490 (1.51) [-0.23]
F-Statistic	0.34	0.99
Adjusted r^2	-0.0226	-0.0003
Sample Size	61	61

Notes: Dependent variable is the difference between intermediate course grades for each student. Sample size for each subpopulation is shown as N. Standard errors are in parentheses. T-statistics are in brackets. *Significant at the 90% confidence level, two-tailed test. **Significant at the 95% confidence level, two-tailed test. ***Significant at the 99% confidence level, two-tailed tests.

The matched regression only includes students who used AP credit to get exemption from either introductory microeconomics or introductory macroeconomics and Emory credit for the other one. The dependent variable for the matched regression is the difference of a student's grades in the relevant intermediate course and the other intermediate course. For example, if a student used AP credit to get exemption from introductory microeconomics the dependent variable for this student would be their grade in intermediate microeconomics minus their grade in intermediate macroeconomics. The independent variable ECON101 or ECON112 is the students grade in the introductory course they took at Emory, and the independent variable APSCORE5 is a dummy variable that indicates if the student used a 5 for AP credit in the course they used AP credit to get exemption.

Surprisingly, table 10 shows that the better a student performs in the introductory level course they took at Emory the lower their grade in the intermediate course of the same field is

relative to their grade in the intermediate course of the field they used AP credit to gain exemption at the introductory level. Unsurprisingly, it shows that students with a 5 on the AP post-course examination perform better in the intermediate course of the field they used AP credit to gain exemption at the introductory level relative to the intermediate course of the field they took the introductory course at Emory than the students with a 4 on the AP post-course examination. Unfortunately, these results are not significant. Additionally, since it is uncommon for students to have AP credit for microeconomics and not macroeconomics and students perform better in intermediate microeconomics than microeconomics generally, the results are likely skewed.

V. Conclusion

While the results of this analysis are inconclusive about the impact of a student using AP credit to place out of introductory economics classes, it is clear that students who use a 5 for AP credit for introductory courses perform better in intermediate courses than those who use a 4. Furthermore, it appears that students who use a 5 for AP credit for introductory courses perform better than those who took the introductory courses at Emory University, and it is likely that students who use a 4 for AP credit for introductory courses perform worse than those who took the introductory courses at Emory University. However, it is unclear from this analysis alone if these differences in performance are due solely to the AP courses. In order to answer this question, further analysis is required with a dataset that includes more student data including overall GPA and overall field-specific GPA.

Despite the lack of certainty on the reasons behind these results, they provide significant policy implications for universities. Without knowing why students who earn a 5 perform better than those who take introductory courses, universities should not use these results alone to change their policy on students with 5s. However, merely knowing that students who earn a 4 perform worse than those who take introductory courses is sufficient for policy decisions to be made. Departments should consider that the students who use a 4 for AP credit may be at a disadvantage in upper-level coursework, but this fact does not necessarily mean that 4s should not be accepted as credit for introductory coursework. Students that can place out of introductory courses will have the opportunity to take additional courses in both the related field and unrelated fields which may enhance their college learning experience. Departments should

assess the importance of lesser success in upper-level coursework against the benefit of a student being able to take additional courses to make their decision. However, if a department determines to continue to accept 4s as credit for introductory courses the results of this study should be provided to the relevant students. This openness will allow students to make an informed decision about whether or not to place out of introductory courses that is best for them and their goals.

Additionally, it appears that students are benefited from being required to take an introductory level course in a field prior to taking an intermediate or upper-level course in the same field. Departments that have multiple introductory courses should consider allowing students to place out of some introductory coursework but not all. This policy would give students the opportunity to take additionally courses in the related field and unrelated fields while simultaneously providing students with valuable collegiate experience prior to taking upper-level classes.

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