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A- or B+: The Signaling Effect of the Letter Grade

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Abstract

There are three main factors that influence student major choice: ability, labor market returns, and preferences. In their time at college, students update themselves on all three in order to determine their final major choice. Ability is updating using transcript letter grades. However, when testing the effect of grade point average and SAT scores, both of which are measure ability, it is difficult to parse out the students' actual ability versus the signal the measure gives the students about their ability. This paper will attempt to mitigate that issue by using a regression discontinuity design to determine the effect of student letter grades on major choice. To do this, the paper will focus on the effect of the letter grade in Economics 101, the introductory economics course at Wellesley College, on a student's probability of majoring in economics. The paper will examine students who are close to letter grade cutoffs, as determined by their final numerical weighted average of assignments in the course, but ultimately fall on one side or the other. Then, students on either side have the same ability level but ultimately receive different letter grades. What I found is that students above the cutoff are 50% more likely to major in economics relative to those below the cutoff. When I looked specifically at cutoffs that change the letter, such as the A-/B+ cutoff, I found that students above the cutoff are 80% more likely to major in economics. However, being on either side of the cutoff has no influence on whether students study other kinds of subjects, either if they do not choose economics or they double major with economics. The letter grade in Econ 101 is a strong signal to students about their absolute ability in the economics major.

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1. Introduction

When students enter college, they begin taking classes in all sorts of subjects. As grades come in, students update themselves on their ability in each subject (Altonji et al., 2015). Then, students make decisions such as major choice based on their ability in that class. Students balance their ability with the future earning potential of the major and their preferences to make a final decision (Altonji et al., 2015).

Students are motivated by grades. Students want to do well and will make decisions about their major choice based on their grades (Rask and Tiefenthaler, 2008). Most often, though, it is hard to know whether the grade represents the student's actual ability in a subject, or if the grade is just signaling to the student about their ability. In this paper, I will continue to study how students' major choice changes in response to the letter grade that they see on their transcript.

I will observe the effect of the introductory economics course at Wellesley College. At Wellesley, all students must take Economics 101 in order to major in economics, since Econ 101 is a prerequisite for all other economics courses. Prior literature has shown that grades students receive in their introductory courses influence them on whether or not they want to continue to study that subject, which is part of the incentive to focus on the effect of the grade in Econ 101 at Wellesley (Rask and Tiefenthaler, 2008). Women, in particular, are especially influenced by the grade in their introductory economics courses (Goldin, 2015). Hence, I will be focusing on the introductory economics course and its influence.

The focus of this paper is solely on the effect of the grade that students see on their transcript, rather than their ability in a certain class. To do this, I will be using a regression discontinuity design, analyzing the effect of the grade in Econ 101 on the student's probability of majoring in economics, along with other effects.

At the end of every semester, students have a final number grade that is the numerical weighted average of all assignments completed during the semester. Professors use those number grades to determine letter grades for students. Realistically, there should be cutoffs at each letter grade, where students with similar number grades receive different letter grades. Since these students have similar number grades, they should be similar in ability, yet they receive different letter grades. I will compare the influence of the actual grade students see on their transcript rather than their actual ability in a subject. The grade on their transcripts acts as a signal for their ability in that class and so I will observe how that signal changes the path that students will take. To do this I will use Wellesley College administrative data and Wellesley professor grading data.

I will be focusing on the effect of this signal on a student's probability of completing the economics major. I also will look at the number of economics courses, whether the student minors in economics, and if students are more likely to major in other departments if they are above the cutoff (either through double-majoring with economics or through choosing a different major altogether).

What I found was that the signal of the letter grade has a significant effect. Students above a cutoff, are 50% more likely to major in economics than those right below the cutoff who receive lower letter grades but are at same ability level. Those above the cutoff also take more economics courses. However, the rate of minoring is the same on both sides of the cutoff. The higher letter grade either gives those above the cutoff a positive incentive to keep going or gives those below a disincentive to stop. The signal has an influence.

The paper is organized as follows. Section 1 will include a literature review of all relevant studies regarding major choice and the effect of grades. Section 2 will discuss background of Wellesley that is relevant to this study. Section 4 describes the data used, including descriptions of Wellesley College administrative data. Section 5 reviews the empirical design of the regression discontinuity. Section 6 will first look at the results for a pooled sample of all cutoffs, focusing on the effect on the decision to major in economics, the number of economics classes taken, and the decision to minor in economics. There will be a brief look at the choice to major in science and math, humanities, or non-economics social sciences. Then I observe the effect on probability of economics major for letter grade cutoffs and non-letter grade cutoffs. Section 7 is a discussion of the implications of my results. Finally, sections 8 and 9 are all tables and graphs.

2. Literature Review

2.1 Major Choice

2.1.1 Theory

How do students pick their major? What factors do they consider when deciding their future? It is important to understand what goes into major choice before I try to understand how a letter grade signal might affect the choice. In what way might the letter grade interact with the factors influencing major choice?

Altonji et al. (2015) emphasized that the key factors influencing major choice are student's ability and the labor market returns to majors and related occupations. Going into and throughout college students are uncertain about both of them. Students then update their knowledge of their ability and understanding of labor market returns to majors to finally pick one major that best fits them. When deciding on a major, students come into college with some idea about their ability using SAT or ACT scores and high school grades. Then, as they take classes in college, they then update themselves on how well they will actually perform in the major in the long run. Altonji et al. (2015) theorized that students who do not perform as well as they expected may find it optimal to change their major. Altonji et al. (2015) also believed that students considered how their major could affect their future jobs in terms of occupation choice, wages, and the supply of jobs.

The process of choosing a major is all about students updating themselves on their ability and the future earnings relative to that major. Students come into school with an idea about their ability and the returns to the majors they are considering and then throughout college as they get their first grades, apply to internships, etc. they update themselves about their ability and the actual market return.

2.1.1.1 Ability

Students are making decisions about their major choice based on their comparative advantage in a subject. Arcidiacono et al. (2011) showed that students believe that they are the most able in the major that they chose and would not do as well in another major. Arcidiacono et al. (2011) surveyed students to understand how they view their ability in their major against their ability in other majors. Grades are a way to represent how well a student is doing in one subject versus another. Students take a variety of classes, especially in their first year as they try to find their major. Then, they can view those grades and see where their comparative advantage lies.

Stinebrickner and Stinebrickner (2014) did a similar study of student's expectations and perceptions of their ability. Stinebrickner and Stinebrickner (2014) were able to survey students over a number of years in order to see how students' perceptions change. They found that students are open to any major when they enter college but update themselves on their ability as they go through college. This update on ability forces the students to choose a major that best matches their ability, especially if they are not willing to put in the effort for more difficult majors (such as STEM majors). The ability of a student to complete one major or another has a large influence on their choice. Stinebrickner and Stinebrickner (2014) hypothesized that if students were better prepared before college for more difficult majors, then more would major in math and science.

Wiswall and Zafar (2015) did an experiment where they surveyed students about their beliefs on future earnings and their ability in certain majors, then gave the students more information on true future earnings. They then observed how students' preferences and ideas about their ability changed. They found that students believe certain majors have a higher premium, such as business and natural sciences, but that students believed they were less able to do those majors, relative to the humanities. When taking into account students' perceived ability, their probability of majoring in business, natural sciences, and engineering decreased relative to the humanities, despite the fact that those majors have higher future earnings (Wiswall and Zafar 2015). Students balance their own abilities with future earnings and try to take into account all information possible to determine what to major in.

Arcidiacono (2004) created a dynamic model of college and major choice. Students begin by choosing a college and an initial major. Once the student has been in college for a time, they update whether they want to stay in college and what they major in. Finally, once students are out of college and in the labor force, their earnings are affected by the final choices they made regarding both college and major. Arcidiacono (2004) tested this model on NSLY data, which has information about student choices throughout college. However, his model only observed the results of these choices rather than the reasons the students made the choices. Ardiciacono (2004) allowed students to switch their major once they realized that their ability level was not up to par with what was necessary to complete the major. In that way, his model was able to account for students sorting into different majors by ability. Even when he took ability into account, he found that certain majors have higher premiums relative to other majors and to no college. Business and natural science majors have the highest premiums of all major types, even when accounting for the ability of a student.

Student ability—or at least their perceived ability—matters. It is difficult to know if students are sorting based on their actual, inherent ability or if they are relying on tests and grades that supposedly represent their ability. Many of these studies rely on surveys of students. In those surveys I can learn how students are changing based on their idea of their ability. I do not know the signals that are telling them their ability and how accurate the signals are, and how accurate students' views of their ability are. Already, there is a clear issue of the student's ability versus the signals that inform them of their ability.

2.1.1.2 Labor Market Returns

Labor market returns can include anything from occupation choice to the non-pecuniary benefits of certain jobs. However, the most important return of major choice to many students is future earnings. Students care about how much money they will make. Many economists have attempted to model and study this. However, what happens when the most lucrative of majors is not the major in which the student does best? Does the student pick the subject in which they get the highest grades while passing up more lucrative majors?

Berger (1988) confirmed that students are making choices about major based on the present value of future earnings streams. He estimated that when the present value of the earnings of a major increases, the probability of a student majoring in that subject increases. His paper was one of the first to estimate major choice as a function of the present value of future earnings streams. However, his paper only looked at men and did not take into account the ability of students to complete one major versus another. Berger (1988) assumed that the ability level of a student affected these future earnings streams. So, students with higher ability have higher returns. Unfortunately, Berger (1988) used a constant measure of ability, but students are constantly updating themselves on their ability using grades.

Montmarquette et al. (2002) also studied the influence of future earnings on major choice. They observed that students determined their major choice both by their probability of success in a major, and factors that can influence that probability, and the earnings streams associated with that major. Montmarquette et al. (2002) then allowed these ideas to be updated over time, as a student's probability of success and ideas about future earnings are not static. They found that expected future earnings do influence major choice, but this influence varies by certain characteristics: women are less responsive to future earnings than men and those who are non-white are less responsive relative to those who are white.

Arcidiacono et al. (2011) surveyed students, asking what they thought about the future earnings of certain majors. They discovered that students believed that they would make the most money in the major that they had chosen. Students compared how much money they would make in their own major against their ability to do the other major. Students tried to balance their ability with future earnings (Arcidiacono et al., 2011). Students wanted to optimize both their grades and future earnings.

2.1.1.3 Preferences

Along with ability and future earnings, students have preferences that influence their major choice. Preference for one subject over another, according to Wiswall and Zafar (2015), is one of the largest influencers of major. Wiswall and Zafar (2015) found by surveying students that "tastes" play a larger role in major choice as a student gets older and switching costs increase. However, even when students are earlier in their college career, they have preferences for one major versus another. Wiswall and Zafar (2015) measure these "tastes" by surveying students and asking them about their preferences and then observing the effects of these "tastes" on major choice when the researchers ran their regressions.

In particular, Gemici and Wiswall (2014) discovered that, especially across genders, there were larger differences across majors in terms of preferences rather than ability. They created a preferences variable based on majors chosen by women and men over time. However, this does not allow them to get at the specific preferences before major choice—only after, once students have received grades and graduated college. Zafar (2014) found that enjoying coursework and gaining parents' approval are the most important factors for students when choosing a major after he interviewed Northwestern sophomores. Rask (2010) found significant results that pre-collegiate major preference, which he included as a variable in his regressions, influenced the major that students eventually chose. Students are 30 percentage points more likely to major in something that they listed as a preference before they came to college than someone who did not list that department as a preference (Rask, 2010).

Students have to want to study a subject to major in it. They have to have some desire to keep going in the subject and learn more. Grades can influence those preferences, though. For instance, one could perhaps be on the fence about a subject and then decide that they like it once they get a higher grade, or vice versa. Preferences can be influenced by grades and preferences can influence grades.

2.1.2 Empirical Evidence

2.1.2.1 Sorting Along Characteristics

There is explicit evidence of students sorting into majors based on a variety of observable characteristics. Students care about their ability in their major when making the final decision, but there is also clear sorting based on observable measures of ability such as SAT and ACT scores. Students sort into majors based on a variety of other factors as well: gender, race/ethnicity, and even citizenship status.

Bartolj and Polanec (2012) found that students chose major based on ability, measured using high school grade point average. They found that those with higher general ability are more likely to be economics majors. Unfortunately, they used students from Slovenia, so these results may not be as applicable to students in the U.S. In general, STEM majors have higher math SAT scores relative to other majors (Arcidiacono, 2004; Altonji et al., 2012; and Turner and Bowen, 1999). Polachek (1978) found that those with greater quantitative ability, measured using the SAT math score, tended to major in math, science, and engineering. However, the SAT is not the best measure of ability as SAT score is highly correlated with family wealth (Goldfarb, 2014). In all, students are sorting themselves according to their ability, especially their mathematical ability.

Unfortunately, in almost all of these studies, researchers take for granted that students understand their own ability. The SAT and ACT are only one measure of ability: grades are another. These tests and measures tell students something about their ability: where they fall within a distribution of other students, how well they understand the material, etc. However, it is hard to measure exactly what it is that students are perceiving from their grades. How much influence do these measures of ability have on students' views of themselves? That is what these papers fail to measure, while my study will be able to fill that gap.

Students also sort themselves based on race/ethnicity. Wiswall and Zafar (2014) found that if a student is Asian, they have a stronger preference against the humanities. Gender and race interplay in affecting students' preferences for majors. Black, Hispanic, and Asian women are 10 to 14 percentage points less likely to major in engineering compared to white men, while black, Hispanic, and Asian men are 6 to 8 percentage points more likely to major in engineering compared to white men (Dickson 2010). In addition, white women, Hispanic men and women, and Asian men are significantly less likely to major in business compared to white men (Dickson 2010). Montmarquette et al. (2002) found that those who are non-white are less influenced by expected earnings compared to white people. Unfortunately, many papers do not look at the differences between races and ethnicities, only the differences between genders (Polachek 1972; Blakemore and Low 1984; Daymont and Andrisani 1984; Turner and Bowen 1999; Zafar 2009).

Another factor that influences major preference is citizenship status. Nores (2010) argues that those who are foreign-born may have different assumptions about expected returns to their degree and labor market options after graduation. Nores uses a change in policy at state colleges in Texas which allows undocumented students to gain access to financial aid to observe whether foreign-born students behave differently in terms of major choice after Texas put the policy in place. The ideas was that the law may open up after-college opportunities and change foreign-born students' perceptions about the labor market opportunities of their degree. Nores (2010) finds that before the legislation was put in place, major choice differed significantly across citizenship status. Non-citizens were 6 to 9 percentage points more likely to major in science, engineering, and math relative to citizens. Then, after the legislation was put in place, there was no difference between citizens and noncitizens (Nores 2010).

One of the most important factors that influences preference for major is gender. Many economists have attempted to study the gender gap by looking at differences in major choices. Polachek (1978) was the first paper to observe the differences between genders in terms of major. Polachek noted significant sex differences by major: men are more likely to major in engineering and business, while women are more likely to major in education, home economics, and nursing. Polachek (1978) used data from the 1950s, so his results may not be as applicable today. Daymont and Andrisani (1984) found that differential preferences for occupational roles, which lead to different fields of studies, explained about one-third to two-thirds of the gender gap. A difference between the sexes in terms of major choice has also been measured in many subsequent papers (Blakemore and Low 1984; Daymont and Andrisani 1984; Bowen and Turner 1999; Zafar 2009; Bartolj and Polanec 2012; Dickson 2010; Gemici and Wiswall 2014; Wiswall and Zafar 2014; Montmarquette et al. 2002).

Economists have also found that that gender has a large effect on major preferences. Dickson (2010) found that gender differences in major are much more substantial than racial and ethnic disparities. Dickson found that white, black, Hispanic, and Asian women are 2 to 7 percentage points more likely to major in the humanities relative to white men, after controlling for initial major preference. Gemici and Wiswall (2014) stated that women were two-thirds as likely as men to major in business or science.

Blakemore and Low (1984) wanted to understand why women had different preferences than men. Blakemore and Low used survey data that asked women and men about their future expectations of families and jobs. They found that the decision to raise children and the number of children women want to have negatively influence their probability of majoring in the physical sciences and engineering. Zafar (2014) found that the preferences for the workplace affected men and women differently in terms of major choice. Men care more about the pecuniary benefits of a job, which include the hours worked per week of a job related to that major, the number of available jobs, and the income at age 30, compared to women. Zafar (2014) however only looks at a small group of students at an elite institution.

One question that often comes up when examining gender differences in major is whether the differences actually lie in ability. Turner and Bowen (1999) found that women lag behind men in math SAT scores by about 50 points but are equal in terms of verbal SAT scores. These differences do not necessarily mean women are not majoring in subjects such as engineering and math because they are not able. Turner and Bowen (1999) found that even women with high SAT scores were still majoring in life sciences and humanities rather than engineering, math, or other more quantitative-heavy majors. Dickson (2010) found differences in preferences even when controlling for ability using SAT scores, as did Polachek (1972) and Gemici and Wiswall (2014). Even when accounting for ability, men and women have different preferences for majors.

Women’s preferences can change depending on the environment of their school. It is believed that women who see themselves as a “token” in a certain field are likely to underachieve (Alexander and Thoits, 1985). Solnick (1995) attempted to identify, then, if women were majoring in different subjects once the threat of tokenism was removed, i.e. looking at women who went to a women's college. At women's colleges, 36% of women who intended to major in a female-dominated field, such as education, social work, and the humanities, graduated in it, compared to 75% at co-ed schools (Solnick 1995). The net effect of women's colleges is that they produce more women graduating into male-dominated fields and fewer into female-dominated fields than co-educational schools (Solnick 1995). It is difficult to make definitive answers about the effect of women's colleges since women choose to go to women's colleges before they choose their major. Women could be sorting on some unobservable that makes them more likely to go to women's colleges and thus more likely to major in more male-dominated fields compared to women who go to co-ed institutions.

While the type of school matters, the gender composition of the department does not (Canes and Rosen, 1995; Anelli and Peri,2014). Whether or not a woman has a female professor in a male-dominated field does not matter (Canes and Rosen, 1995; Anelli and Peri, 2013). Having female professors does not make students any more likely to major in male-dominated fields.

Gender can drastically influence what students are majoring in. Women are less likely to major in STEM and more likely to major in the humanities. Women are no less able than men, yet they major in totally different subjects. Could women view themselves as less able, then? Do grades or test scores have greater influences on women than on men? In that case, a lower grade than expected could convince women to not major in a subject. So, for more difficult subjects, such as STEM, women might receive lower than expected grades and then have a more negative view of their ability and choose to not major. Grades and their influence, especially on women, will be discussed in the next section.

2.2 Grades

2.2.1 Influences on Choices and Future

James et al. (1989) found that GPA, or grade point average, affects a student's future earnings alongside their major. If a student has higher grades, then they will have higher future earnings. GPA had a significant and positive effect on future earnings. Jones and Jackson (1990) found a similar result. Higher GPAs mean that students can get into more graduate school programs and receive more job offers, since graduate schools and employers take GPA into account when deciding who to hire (Wongsurawat, 2009; Chan et al., 2007). Having a high GPA is a relevant concern to students.

Students want to receive higher grades. When students receive higher grades, they give professors more positive student evaluations (conversely, when they receive lower grades they evaluate professors much more harshly) (Lin, 2011; Butcher, McEwan, & Weerapana, 2014). Students want higher grades and are appreciative when they get them, however they are upset and place blame on professors when they do not (Lin, 2011; Butcher, McEwan, & Weerapana, 2014).

Students are also receptive to their grades in other ways. In an evaluation of a policy at Cornell, in which the average grades for each course were listed, Bar et al. (2009) found that students were more likely to take classes that had higher average grades. Students want to get higher grades and want to take classes that will lead to them getting higher grades (Bar et al., 2009). Students care about the grades they receive and they respond by taking classes where they will get easier grades and switching out of majors that once graded easily and no longer do so.

Sabot and Wakeman-Linn (1991) noted that, to a student, higher grades mean a comparative advantage in a certain field over other fields. They found that when a student receives a grade in an introductory class in a certain department that is higher than their current GPA then the student is more likely to take a second class in that department. Students respond to the signal of comparative advantage (Sabot and Wakeman-Linn, 1991). Students are also influenced by the incentive of the absolute grade in a class. The comparative advantage of doing well in an introductory class increases a student's probability of taking another class by 4.5 percent while the incentive of the high grade increases the probability by 15 percent (Sabot and Wakeman-Linn, 1991). In addition, Sabot and Wakeman-Linn (1991) found that students' need for achievement significantly influences the probability of a student's success, especially in lower-graded departments (departments where the grading criteria is more stringent, such as economics). Students want to take classes where they do well, both for their comparative advantage in that department versus others and for the incentive and absolute advantage it gives them.

Both the major of the student and the grades they receive in college impact a student's future. Now the question is: how do grades influence major? Students are choosing a major based, at least partially, on their ability to complete that major and students are also choosing what classes to take based on their comparative advantage in one versus another, i.e. they are picking the classes where they will get the highest grades (Sabot and Wakeman-Linn, 1991). Higher ability leads to higher grades, which makes students more likely to major in one subject over another.

Butcher, McEwan, and Taylor (2014) showed that when an anti-grade inflation policy is put into place, students are less likely to major in departments more heavily affected (those whose average grades were high before the policy was put in place such as the humanities and non-economics social sciences) and more likely to major in departments that were not as affected (STEM and economics). Stinebrickner and Stinebrickner (2014) discovered that future grade performance is more important to students than future income when it comes to determining their major. Students will leave majors where they are not doing as well to major in something that they will do better in. Grades clearly have some effect on major choice.

Many papers have attempted to look at the effect of grades on various outcomes, however an issue arises when observing a student's GPA: separating ability from signal. These papers are unable to separate ability, whether it is measured or unmeasured, from the signal that the grade might send to students, employers, professors, etc. This issue of the signal of the grade and how it reflects the ability of the student is especially relevant in a time where grade inflation is common at many institutions. The papers are not able to claim causality of the effect of GPA since they cannot separate ability from the signal but it is important to understand how much students use grades as an indicator of their abilities.

Two papers have attempted to mitigate this issue when looking at the effect of grades on major choice (Owen, 2010; Main and Ost, 2014). Both papers used a regression discontinuity design, similar to the one I will use in this paper, looking at the impact of the grade students get in introductory economics courses on the students' probability of majoring in economics. In the regression discontinuity, Owen (2010) looked at the numerical weighted average professors assigned, found the point at which professors assigned letter grades, and then compared students with similar averages but different letter grades. Main and Ost (2014) had a similar design, but also included individual test scores, looking at those with similar test scores who got different letter grades. Owen (2010) found that women are more likely to major in economics if they receive an A while Main and Ost (2014) papers found no result of the grade on students' chance of majoring in economics. Both studies used data from co-educational schools.

2.2.2 How Women Respond to Grades

The study that I will be performing will attempt to add to the growing literature on major choice and the effect of letter grades. I will be using similar methodology to Owen (2010) and Main and Ost (2014), however my sample will be very different. In my study, I will be using data from a women's college, where there is no worry of stereotype threat in the classroom.

Stereotype threat is the idea that those of a certain demographic will confirm the ideas others have about that demographic (Cromely et al., 2013). The worry is that women who are taking more classes in more quantitative fields, such as STEM and economics, will confirm the idea that their male classmates have of women's quantitative ability. Steele (1997) believed that women in quantitative fields, including economics, might face stereotype threat. Ramsey and Sekaquaptewa (2011) found that in a college-level math classes, stereotypes about women's poorer math ability became a self-fulfilling prophecy. They survey students throughout a course and found that, as time went on, the stereotypes of women's ability became stronger, so women did more poorly (Ramsey and Sekaquaptewa, 2011). If women are told that they are not able, or if that is the idea people have about them, then women will not want to study that subject. Stereotype threat could prevent women from continuing on in STEM.

This threat is also relevant for economics. Ballard and Johnson (2005) showed that negative stereotyping exists for women in intro economics courses. Women have low expectations for how they will do in introductory economics courses. This low expectation can cause them to do more poorly than they might without the negative stereotype. Then, their grade does not accurately reflect their ability in the subject. Women may not want to continue on in economics if they will feel like they are not good enough.

Rask and Tiefenthaler (2008) found that women are less likely to take introductory economics classes and if they do, they are less likely to continue on taking economics courses if they do not do well, specifically at liberal arts colleges. Men do not have these same issues. The grade of the introductory economics course influences women much more than men. Goldin (2015) fond that at many elite institutions men major in economics more than twice as often as women, even when many elite institutions are majority women. Goldin (2015) found that women are less likely to take the introductory economics course than men and when they do, they must do relatively well, i.e. an A or A-, in order to continue studying economics. Both Rask and Tiefenthaler (2008) and Goldin (2015) found that the final letter grade in the introductory economics course at two different universities has a large influence on women and their probability of continuing on in the economics major. Women feel a need to do well if they want to continue studying economics, and so lower letter grades can convince them to not major.

Both Rask and Tiefenthaler (2008) and Goldin (2015) observed students once they graduated, viewing grades the students got in introductory economics and viewing the choices they made from there. Unfortunately, Rask and Tiefenthaler (2008) and Goldin (2015) had to assume how the signal of the grade was influencing students, but were unable to know how much that grade represented their true ability. In my study, I will be able to directly measure the influence of the signal.

Wellesley is a different institution than many studied, since not only is it a women's college, but also an economics-heavy college, with economics the most popular major and a large portion of students taking the introductory economics course. Our study will be able to examine how women make choices about majors and how their grades affect major choice in an environment that is dedicated to the empowerment of women. There is no worry of stereotype threat at Wellesley. At Wellesley, there are no men to whom Wellesley women can compare themselves. In addition, Wellesley has an anti-grade inflation policy that was put in place to have grades represent a student's true ability (Butcher, McEwan, & Weerapana, 2014). It will also be interesting to flip the script on many studies about major choice that have only looked at men in order to do a study that only looks at women (Berger, 1988; Arcidiacono, 2011).

It is important to understand more than just ability and how that influences students. I have to understand how people view their own ability. How does the signal letter grade on a transcript change people's choice? Our paper will be attempting to answer that question.

3. Background

Wellesley College is a liberal arts college located approximately 13 miles outside of Boston. Historically, it is one of the "Seven Sisters" colleges, which are seven liberal arts colleges located in the Northeast that are also historically women's colleges. To this day, Wellesley is still a women's college. Hence, all students in my sample will be of the same sex.[1]

Wellesley has implemented two important policies in the past 12 years that could have changed the way students view their grades. In 2004, Wellesley implemented a new grading policy in which all introductory and intermediate level classes with more than eleven students are required to have an average of a B+. This was in an attempt to prevent grade inflation at Wellesley. The administration wanted to increase the value of student grades. The administration wanted employers, graduate schools, and others to know that when they look at a Wellesley student's transcript that the grades they see represents the actual ability and effort of the student. This policy has not changed since being implemented. In the fall of 2014, Wellesley implemented a shadow-grading policy for first-year students. First semester grades are not shown on students' transcripts. All that is shown is whether the student passed or failed. In order to pass, a student must get at least a D. Students are able to see their grades, but it will not affect their grade point average or be visible to employers or grad schools.

Another important aspect about Wellesley is that when each new Wellesley student arrives to campus, whether they are a first-year student or a transfer, they must take the quantitative reasoning exam, which hereafter will be known as the QR exam. The exam tests basic mathematical skills and passing the QR exam is necessary in order to take Econ 101. If a student does not pass the exam, then the student must take a quantitative reasoning course in order to take any math-based course, including Econ 101. The QR score is out of 18 and students must receive a 9.5 in order to pass. The QR exam has not changed over the years at Wellesley, meaning that it is a good proxy for math skills for Wellesley students.[2]

For this study, I am focusing specifically on the economics major and economics students. Economics is the largest major at Wellesley: approximately 13% of all students graduate as economics majors in any given class. Additionally, I had to individually ask professors for their grading data. To ask professors outside of the economics department would have taken large amounts of time and effort. There is also no guarantee that professors in other departments consistently kept track of all of their grading information. Other departments might

[1] Note that Wellesley has trans men and non-binary, designated-female-at-birth students, however for this study I will be treating all students as of the same sex since I do not have data on sex or gender. In addition, trans men and non-binary students are an extremely small minority.

[2] A paper was written in Butcher, McEwan, & Taylor (2010) about the effects of the exam.

also not have an introductory class in the same way that the economics department does. Hence, I chose to focus specifically on the economics department.

In order to major in economics, a student is required to take nine classes. They must take introductory and intermediate micro- and macroeconomics, an introductory statistics course, econometrics, two elective advanced economics courses, and one elective intermediate or advanced course. To minor in economics, a student must take introductory micro and macro, introductory statistics, and two elective intermediate economics classes. In addition, there is a track within the international relations major that is economics related. It is known as International Relations - Economics. All students hoping to major in IR-Econ must take introductory economics courses and a few elective economics courses. I will consider the economics major as both Economics and IR-Econ.

The introductory class to the economics major and minor is Economics 101, formally called Principles of Microeconomics. Economics 101 is prerequisite for almost every class in the economics department. Students must take Econ 101 in order to take Econ 102, or Principles of Macroeconomics. Both Econ 101 and Econ 102 are prerequisites for more advanced economics courses, including elective economics courses and intermediate and advanced micro- and macroeconomics. Every new student to the economics department must take Econ 101, unless they test out of it, however, very few students test out. Most must take the class in order to major.

4. Data

For this study, I am using both Wellesley College administrative data and professor grading data. The data is comprised of students from the fall of 2004 to the spring of 2014. I wanted to avoid any changes in grading policies that might affect the way students view their grades. I thus then restricted my data to the fall of 2004 to the spring of 2014.

The Wellesley College administrative data includes comprehensive transcript-level data and admissions information. The transcript-level data includes each class a student has taken, the grade in that class, the class average, and a student's major at the time of the class. The admissions information includes student race/ ethnicity, SAT and ACT scores, and whether or not the student is a first generation college student. In addition, the data includes the student's admissions rating, which is a value Wellesley admissions counselors assigns to students to indicate how much they want to accept that student. A lower admissions value indicates that the student is more desired by Wellesley. The Wellesley College administrative data includes a score for a quantitative reasoning exam that each student must take upon entering Wellesley.[3] I also have the students major at the time of acceptance, which I will call their admissions major. Overall, the administrative data provides the background information on the students of interest. Table 1 has summary statistics based on the data.

Along with the administrative data I am using professor grading data. This data includes information from Wellesley College professors who taught the introductory economics course, Economics 101, between fall of 2004 and spring of 2014. In order to test my hypothesis, I must know not only the letter grade a student received but the numerical weighted average of assignments that the professor based the student's letter grade. At the end of every semester, students receive a final number grade, where the final number grade is the culmination of all grades received on exams, homework assignments, attendance, and whatever else the professor decided to determine grades with. The professor uses this number grade to assign letter grades, which appear on transcripts.

The professor grading data gives the study its assignment variable. I care about what the actual numerical grade the student received and where that student fell within the distribution of the other students in the class. Our sample then only includes students who have not only taken Econ 101 but also have the assignment variable, i.e. students for whom I have their professor's grading data.

One drawback of my data is that the sample is not as large or as inclusive as it could be. There could be something particular about students who decide to take Economics 101. Additionally, I were unable to gather data from every professor, as some professors the department no longer had connections with and others who did not keep their grading information. In total, I have about two-thirds of professor grading data for a total of 68 sections. I will restrict my sample to only those for whom I have professor grading information, leading to approximately 1800 total observations over 10 years.

[3] The QR exam is discussed in the Background section.

5. Empirical Design

In each section of Econ 101, there are different letter-grade cutoffs. These cutoffs are not recorded by professors, instead, I created cutoffs based on the data. To decide my cutoffs, I first ranked the students in terms of their final number grade, i.e. the weighted average of all assignments completed throughout the semester including exams and homework grades. I then took the final number grade associated with the highest rank of every letter grade and averaged it with number grade associated with the rank right above. For example, at the A-/B+ cutoff I observed the number grade of the highest ranked B+ and identified the number grade of the next-highest rank, i.e. the lowest A-. The cutoff was created by averaging the two number grades. This process was repeated for every possible letter grade cutoff from A/A-, A-/B+, B+/B, etc.

In a given section, I grouped students into individual cutoff samples. To start, all those with number grades above the A/A- cutoff were grouped into the A/A- sample. Students who were below the A/A- cutoff but above the midpoint between the A/A- cutoff and the A-/B+ cutoff were grouped into the A/A- sample and those who were below the midpoint are grouped into the A-/B+ sample. This process continued on until all students were grouped into one, unique cutoff sample within their given section.

In order to create a pooled sample, I standardized student's number grades by subtracting the cutoff to which each student was assigned.[4] I will call this variable the score, where zero is the standard cutoff in every sample. If the score is positive, then the student is above the cutoff while if the score is negative, the student is below the cutoff. A smaller absolute value of the score indicates that the student is closer to the cutoff. Ultimately the running variable looked like the following where i is the student, j is the semester, and k is the section:

- $s_i = grade_i - cutoff_{jk}$

I pooled each letter grade cutoff in order to have a larger sample size and more statistical power. Ultimately, I am examining the effect of being above or below a letter grade cutoff. I will also focus on cutoffs that change the letter grade, such as the A-/B+ and the B-/C+ cutoffs versus those that do not change the letter grade such as the A/A- and the B+/B. Additionally, I will look at each individual letter grade cutoff. However, both looking only at letter grade changes, cutoffs that do not change the letter grade, and individual letter grade cutoffs restrict the sample size and thus are subject to more noise.

[4] A similar process can be found in Lucas and Mbiti (2014).

I have grades for the introductory economics class, so it only makes sense to measure how the letter grade influences a student's probability of majoring in economics. I will also observe the number of economics courses taken and the probability of minoring in economics. In addition, I will be looking at the effect on other kinds of majors, to see whether being above or below the cutoff influences a student's probability in majoring in another kind of subject. These include: science and math, non-economics social sciences, and the humanities.[5] Finally, I will look at the influence of the letter grade in Econ 101 on whether or not students double major. I will call the dependent variable M_i.

For this study I will be using three different regression specifications. First, for my baseline model I will be using the following:

$$(1)\ M_i = \delta_0 + \delta_1 1\{s_i > 0\} + f(s_i) + \varepsilon_i$$

Where $1\{s_i > 0\}$ is an indicator variable that takes a value of 1 if a student is above the letter grade cutoff and 0 if a student is below the cutoff, i.e. the weighted average is greater than the cutoff[6]. δ_1 will be my coefficient of interest. Then, $f(s_i)$ is a function of the running variable that allows the variable to vary on either side of the cutoff. In this case $f(s_i)$ is a piecewise linear specification that varies discontinuously at $s_i = 0$. Other order polynomials could be observed, however I have decided to use a linear specification for the sake of time and convenience.

Another control that I will be including is section by cutoff fixed effects:

$$(2)\ M_i = \delta_0 + \delta_1 1\{s_i > 0\} + f(s_i) + \theta_{ijk} + \varepsilon_{ijk}$$

Here θ_{ijk} represents section by cutoff fixed effects. For section by cutoff fixed effects I created a dummy for each cutoff sample, which I created previously, within a certain section during a given semester. First, it is important to include section fixed effects. I need to account for the professor since each professor has a unique style of teaching, difficulty level, and other characteristics that can drastically influence a student's experience in Econ 101. Additionally, I have to account for classroom effects, such as construction noise, disruptive students, etc. that are all unique to that section. Students are then grouped based on the cutoff that their score is relative to, which was defined previously. I want to ensure that any constant characteristics about students that are around a given cutoff get absorbed. It is more than possible that in any given

[5] Note that this is not an exhaustive list. There is an additional category of "other" types of majors, which often include interdepartmental and individualized majors, but I will not be focusing on those. In addition, students are able to major in more than one subject.
[6] Note that I will not have any s_i equal to the cutoff due to the way the cutoff was defined above.

section, students who received the same weighted averages were in the same study group or did their homework together. I want to account for those issues and relationships. Thus, I will be adding in section by cutoff fixed effects.

Finally, I will add in my controls:

$$(3)\ M_i = \delta_0 + \delta_1 1\{s_i > 0\} + f(s_i) + \theta_{ijk} + \square_i + \varepsilon_{ijk}$$

In this case, $\square_i$ is a vector of student-level controls. These controls include SAT and ACT scores, QR score, race dummy variables, a dummy variable for whether or not a student is a first generation college student, and finally a student's admissions rating.

The assumption of the regression discontinuity design is that the assignment variable, or the score in my case, is smooth across the cutoff. Students on either side of the cutoff are getting similar number grades. Since there is smoothness around the cutoff of the score, students on either side of the cutoff are at the same ability level. Since the two students are at nearly the same ability level, with final number grades differing by small amounts, assignment on either side of the cutoff is random. Because of this random assignment, the students should differ only by letter grade. The idea is that if students did not receive different letter grades, then their outcomes would be the same. I will then compare students at the same ability level but different letter grades, so I can observe the signal of the letter grade as I control for ability. What I want is to observe if there is a discontinuous jump at the cutoff of my dependent variable of choice, which would indicate that the letter grade signal is influencing the student's choices.[7]

In a regression discontinuity, one wants to focus on students who are closer to the cutoff rather than those who are farther away. Right near the cutoff, being on either side is functionally random. Students closer to the cutoff are more similar to one another in ability, yet, as one departs from the cutoff, the students are less and less on either side by chance and differ more greatly in ability. To focus on those closer to the cutoff I used four different bandwidths. In this case, a bandwidth means that I am restricting the sample to only scores whose absolute values are less than or equal to the bandwidth value. I start by using a bandwidth of 5, in which I am parsing down the extreme outliers, and gradually decrease the bandwidth to 4, then to 3, and finally the tightest bandwidth of 2. A smaller bandwidth often yields larger and more localized results. However, when there is a smaller bandwidth, there is a decrease of external validity,

[7] A similar reasoning is discussed in Lucas and Mbiti (2014).

since the results are only relevant to those closer to the cutoff. There is also a loss of precision since the sample size is smaller.

In addition, I also used triangular weights in my regressions. [8] With triangular weights, I assign more value onto students more influenced by the letter grade, i.e. those who are closer to the cutoff. When using triangular weights, I take the absolute value of the score and divide it by the bandwidth. This allows us to order the values in terms of distance from the cutoff. So, the smaller the score, which means the grade is closer to the cutoff, the smaller the value will be. Then, I subtract that value from 1. This gives us the weight, since those closer to the cutoff will have a smaller score divided by bandwidth and thus a larger weight. Note that all regressions in this study use triangular weights.

One of the greatest benefits of regression discontinuities is that right around the cutoff, they can be viewed as a sort of random experiment.[9] Students above or below the cutoff should be nearly identical, since the score is smooth across the cutoff. At that point, students are only above or below the cutoff by chance. Perhaps one student had a cold on the day of an exam or another took a lucky guess. Then, being above or below the cutoff is equally likely; students end up on either side by chance. This randomization on either side of the cutoff then gives the design high internal validity.

However, the randomness of the design can be affected if there is explicit manipulation of the cutoff.[10] One plausible case is that when professors are assigning grades, they may bump students up who show interest in economics. Then, students above the cutoff share some unobservable trait in which they have a stronger preference for economics. On the other hand, professors could bump students down who show no interest in the class or subject. Then, students below the cutoff are less interested in economics. Issues like this could affect the internal validity since assignment is no longer random and students above or below the cutoff have some trait in common that is not observed.

If my initial assumption of the regression discontinuity, that the relationship between the score and my outcome variable of interest is continuous at the cutoff, is true, then it should be true that all covariates are smooth across the cutoff. One worry with the regression discontinuity

[8] A brief discussion of triangular weighting, alternately known as triangular kernels, can be found in Lee and Lemieux (2010).

[9] Refer to Lee and Lemieux (2010) for a discussion of the randomness of regression discontinuities.

[10] Refer to Lee and Lemieux (2010) for a greater discussion of cutoff manipulation.

is non-random sorting across the cutoff. Non-random sorting can be indicative of greater issues such as manipulation of the assignment variable in relation to the cutoff. For example, as discussed previously, professors could bump up certain students who were initially going to get the lower letter grade to get the higher letter grade. The professors could do this to encourage students they favor to continue taking economics courses, or to give a boost to students they like in general. Then, since I created the cutoffs, professors could have active manipulation over who ends up on either side due to non-random assignment.

To test for non-random assignment and explicit manipulation of the score, I tested observable characteristics, my covariates, to check for smoothness across the cutoff. This checks the validity of my design. Since assignment on either side is assumed to be random, then there should be random assignment in terms of baseline characteristics. [11] I will discuss covariate balance checks in the results section.

6. Results

6.1 Pooled Estimates

6.1.1 First Stage

When first testing the regression discontinuity, I want to check the first stage: the effect of the score on the letter grade a student receives. Note that the letter grade will be enumerated: an A gives a 4.0, an A- gives a 3.67, a B+ gives a 3.33, etc. Table 2 shows the effect of the running variable on the letter grade. The main argument of this paper is that students are responding to the signal of the letter. In order to do test that using a regression discontinuity design, I must ensure there is a discontinuity of the letter grade at the cutoff of the score. All results will be relative to a .33, which is the change from one grade to another.

In the baseline model, with the running variable, a linear spline,[12] and a bandwidth of 5, Table 2 panel A column 1, the regression yields a .266. The student above the cutoff has a letter grade that is .266 points higher than those below. When I include section by cutoff fixed effects, controls, and tighten the bandwidth my results are stronger, i.e. closer to .33. In panel A column

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[11] Covariate balance is discussed in Lee and Lemeiux (2010)

[12] Refer to equation (1) in the Empirical Design section.

3, in which I add section by cutoff fixed effects and controls,[13] the value increases to .312, which means that students above the cutoff receive grades that are .312 points higher than those below the cutoff. The results also improve as I tighten the bandwidth. Panel D column 3, in which a bandwidth of 2 is used and section by cutoff fixed effects and controls are included, the value is .324. Then, students who are above the cutoff receive letter grades that are .324 points higher than those below. The relationship is very statistically significant with a p-value of below .01. In addition, the r-squared for panel D column 3 is .975. So, I have very strong predictors of letter grades. For a visual representation of the discontinuity refer to Graph 1.

In my case, all fuzziness occurs below the cutoff. In general, students with lower grades will be bumped up by professors. Professors can play favorites and give students with lower number grades higher letter grades and in that case there will be some fuzziness. Fortunately, there is minimal fuzziness in my design, since the results of the tightest bandwidth using regression specification (3) is .324, which is extremely close to the desired result of .33. Hence, I will be using a reduced form.

6.1.2 Impact on Probability of Majoring in Economics

Table 3 provides estimates of the effect of being above the cutoff on the probability of majoring in economics. In each panel, I report the results with different bandwidths. For a visual representation of the discontinuity in the probability of majoring in economics refer to Graph 2.

In panel A, I use a bandwidth estimate of 5, where the absolute value of the score must be less than or equal to 5. This yields a result of .147 in the baseline model, with only the running variable and a linear piecewise function, which means that students are 14.7 percentage points more likely to major in economics if they are above the cutoff. Then, the result increases to .165 when I add section by cutoff fixed effects.

Finally, in my complete model with all covariates I get a result of .17. Since the grade of the student is .312 points higher if they are above the cutoff,[14] and the effect is 17 percentage points, this means that the student who is above the cutoff is about 54% more likely to major in economics than the student below the cutoff. This result is highly statistically significant at the 1% level.

[13] Refer to equation (3) with a bandwidth of 5.
[14] Table 2 Panel A Column 3

The results remain generally consistent across different bandwidths. At each bandwidth, the result is statistically significant and between .13 and .17. In my most centralized estimate, with a bandwidth of 2 in panel D column 3, the result increases to .176, where students above the cutoff are 17.6 percentage points more likely to major in economics. This result is also statistically significant at the 1% level.

Students who are above the cutoff are much more likely to major than students below the cutoff. Either the higher letter grade provides an incentive for students to continue on in the major or students who are right at the threshold of the cutoff, but ultimately fall below, see the lower letter grade and are then negatively incentivized to major. The letter grade has a clear impact on major choice.

6.1.3 Number of Economics Classes

In addition to the economics major, I wanted to observe the impact on the number of economics classes that students take. Table 4 reports my results, with each panel representing a different bandwidth. For a visual representation of the discontinuity in the number of economics courses refer to Graph 3.

At the largest bandwidth of 5, panel A, in the baseline model, column 1, being above the cutoff results in a coefficient of .953, i.e. a student who is above the cutoff takes .953 more classes than a student who is below the cutoff. The results increase slightly to 1.019, in column 2 with section by cutoff fixed effects, and 1.049, in column 3 with controls and section by cutoff fixed effects. All results are significant at the 1% level.

In the tighter bandwidths, the results decrease slightly and are less statistically significant. In panel C, with a bandwidth of 2, the results are statistically significant at the 5% level and are slightly smaller at .849 in column 1, .889 in column 2, and .977 in column 3. In panel D column 1, the baseline model with a bandwidth of 2, there results are only statistically significant at the 10% level and decrease even further to .814. However, once I add in controls and section by cutoff fixed effects the results increase back to 1.065 and are significant at the 5% level.

A student who is above the cutoff takes approximately one more class, which most likely means that being above the cutoff incentivizes the students to continue on in the department. The students, once they get the higher letter grade, are more likely to continue trying out economics courses. The student above the cutoff is most likely incentivized at that point to continue on and try the next introductory economics course, Principles of Macroeconomics (or Econ 102 as it is known).

6.1.4 Economics Minor

I observed how the letter grade affects the probability of majoring in economics, but I also wanted to see if there is an effect on the probability of minoring. As discussed previously, minoring requires students to take fewer classes in the economics department and avoid taking upper level courses, including Intermediate Microeconomics, or Econ 201, which is the next level of microeconomics available to students. For a visual representation of the effect on the probability of minoring in economics refer to Graph 4.

Table 5 reports my results, with each panel representing a different bandwidth. At the largest bandwidth of 5 in the baseline model, panel A, column 1, being above the cutoff results in a coefficient of -0.0349, i.e. a student who is above the cutoff is 3.49 percentage points less likely to minor in economics than a student who is below the cutoff. Howeve this result is not statistically significant. The results are similar once you add in section by cutoff fixed effects and then controls.[15] The results are all similar for all specifications for bandwidths 4 and 3.[16] None are statistically significant. In the tightest bandwidth of 2, the results increase slightly to -0.018 in the baseline model in column 1, -0.0176 when I include section by cutoff fixed effects in column 2, and finally to -0.0218 once I include controls in column 3. Again, the results are not statistically significant.

A student who is above the cutoff is no more likely to minor in economics than a student who is below the cutoff. The letter grade has no effect on the student's incentive to minor, only to major. To major in economics, you must take more difficult economics courses at both the intermediate and advanced level. Potentially students who are below the cutoff believe they can still take the other intermediate and introductory classes but they are not cut out for the more advanced economics courses.

6.1.5 Other Major Choice

[15] Table 5 panel A columns 2 and 3.
[16] Table 5 panels B and C.

In addition to observing how the grade in Econ 101 influenced future economics- related decisions, I wanted to see if the grade had any influence on the other kind of courses taken, i.e. other kinds of subjects majored in. I first looked at the influence on the probability of majoring in science and math.[17]

Table 13 reports my results, with each panel representing a different bandwidth. At the largest bandwidth of 5 with model specification (1), panel A column 1, being above the cutoff results in a coefficient of -0.0597, i.e. a student who is above the cutoff is 5.97 percentage points less likely to major in science and math than a student who is below the cutoff. However this result is not statistically significant. The results are similar once you add in section by cutoff fixed effects and then controls. The results are all similar for all specifications for bandwidths 4 and 3. None are statistically significant.

I then observed the effect on the probability of majoring in non-economics social sciences.[18] Table 14 reports my results. At the largest bandwidth of 5, with model specification (1) I find that students are 4.33 percentage points more likely to major in a non-economics social science if they are above the cutoff. Unfortunately, this result is not statistically significant. This result decreases slightly once section by cutoff fixed effects and controls are added in and then as the bandwidth decreases. However, at no bandwidth, with no model specifications are the results significant.

In addition, observed the effect on the probability of majoring in the humanities.[19] Table 15 reports my results. With a bandwidth of 5 and model specification (1) I find that students are 3.04 percentage points more likely to major in a non-economics social science if they are above the cutoff, but this result is not statistically significant. This result decreases slightly once section by cutoff fixed effects and controls are added in and then as the bandwidth decreases. However, at no bandwidth, with no model specifications are the results significant.

If the major is not economics, then being above or below the cutoff has no influence over the student's major choice. The letter grade has a negative influence on students below the cutoff to not continue on in econ, but it doesn't indicate what other subject they should go into. Students are not viewing the letter grade in economics as a signal of their ability to do any

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[17] This includes: Mathematics, Biology, Biochemistry, Chemistry, Physics, Astrophysics, Geology, Neuroscience, Astronomy.
[18] This includes: Sociology, Political Science, Anthropology, International Relations – Poli Sci, Psychology.
[19] This includes: English, Classics, History, Spanish, French, Russian, German, Italian, Chinese, Religion, Art History, Art Studio, Music, Philosophy, Theatre Studies, Classical Civilization, Comparative Literature.

subject other than economics. Note, though, that when observing students' major choices, I observe not only students who chose another major instead of economics but also students who chose a second major in addition to economics.

Finally, I wanted to see if students who were above the cutoff were more likely to double major. Table 16 reports these results. I found that at the largest bandwidth with model specification (1), students that are above the cutoff are 12.3 percentage points more likely to double major, which means students are about 30% more likely to double major if they are above the cutoff. This result is significant at the 1% level. The results stay around the same value and same significance level for specifications (2) and (3). When I decrease the bandwidth to 4 and 3, the results stay around the same magnitude and are statistically significant. However, once I decrease the bandwidth to 2 the results decrease to students being only 9.3 percentage points more likely to double major if they are above the cutoff and are no longer statistically significant.[20]

6.2 Letter Grade vs. Non-Letter Grade

When examining letter grade cutoffs, there is also the potential for a difference between when the cutoff differentiates between half steps of the same letter grade, such as a B+ and a B, and when the cutoff differentiates between two different letter grades, such as between an A- and a B+. Students might view the boost in letter grade as a greater value than just the improvement in overall grade. I wanted to test this hypothesis on the student's' probability of majoring in economics. Students might see the higher letter grade and focus on that as a signal to keep going in the major, rather than just the improvement in their grade.

The "letter grade" cutoff includes the A-/ B+ cutoff and the B-/C+ cutoff, while the "non-letter grade" cutoff includes the A/A-, B+/B, B/B-, etc. cutoffs. Table 6 displays results for letter grade cutoffs while Table 7 displays results for non-letter grade cutoffs. I found that results were larger and more statistically significant for the letter grade cutoffs than the non-letter grade cutoffs. In the baseline model with a bandwidth of 5, Table 6 Panel A column 1, being above the cutoff at a letter grade cutoff yields a result of .239, which is significant at the 1% level. This means that students are 23.9 percentage points more likely to major in economics if they are above the cutoff. They are about 80% more likely to major in economics. However, when I look

[20] This is for specification 3, so Table 16 panel D column 3.

at the non-letter grade cutoffs with bandwidth 5 with the baseline model, Table 7 Panel A column 1, the coefficient is .108, which means that students are only 10.8 percentage points, or about 30%, more likely to major in economics if they are above the cutoff. This result is only significant at the 10% level.

When I look at a bandwidth of 2 and add in controls and section by letter grade fixed effects, Table 6 Panel D column 3, then I get that students are 23.9 percentage points more likely to major in economics. However, this result is only significant at the 5% level. Note that this may be due to the fact that my sample size is now less than one-third of what it is when I have a pooled sample. The data is then subject to more noise and the standard errors are larger. At a bandwidth of 2 for the non-letter grade cutoffs, Table 7 Panel D, when I add in section by cutoff fixed effects and controls, column 3, the results show that students are 16 percentage points more likely to major in economics if they are above the cutoff. This is significant at the 5% level, however again my sample is about two-thirds of what it is when I observe the pooled sample, so the data are subject to more noise.

Overall, there are larger effects when looking at the letter-grade cutoffs. At the letter grade cutoffs student are more likely to major in economics if they are above the cutoff than at the non-letter grade cutoffs. The change in the actual letter of the letter grade, rather than just the sign, can impact a student's view of their ability. They may see that change as getting over some hurdle and into the next level of ability. However, there are still incentives at non-letter grade cutoffs, so, students are still influenced by the increased grade, no matter whether the actual letter changes or not.

One concern is that individual cutoffs are driving the results. In the Tables 8-12 you will see a breakdown of all results regarding individual cutoffs from the A/A- cutoff to the B-/C+ cutoff. Note that many of the cutoffs have small sample sizes, which, as mentioned earlier, leads to more noise in the data and larger standard errors. These larger standard errors make it more difficult for results to be statistically significant. In only the A-/B+ and the B-/C+ cutoffs are results significant. With a bandwidth of 2, section by cutoff fixed effects and controls, Table 9 Panel D column 3, the A-/B+ cutoff results in students above the cutoff being 24.3 percentage points more likely to major in economics. For the B-/C+ cutoff with a bandwidth of 2, section by cutoff fixed effects and controls, Table 12 Panel D column 3, students above the cutoff are 51.8 percentage points more likely to major in economics. At the B-/C+ cutoff students are nearly

160% more likely to major in economics if they are above the cutoff. Potentially the letter "C" is a large deterrent from continuing on in the major. These results show that greater emphasis is again put on the letter grade cutoffs versus the non-letter grade cutoffs.

6.3 Covariate Balance

In order to test whether or not the covariates are smooth across the cutoff I used regression specifications (1) and (2) with each individual covariate as the dependent variable. The goal is that the only student characteristic that varies across the cutoff is the letter grade. For a visual representation of the effect on the QR score refer to Graph 5.

I focused on the QR score, since the QR score is a test that all students must take and is an indicator of math ability in Wellesley students. [21] It is an unbiased estimator that has stayed consistent over the years. No student is missing their QR score. In Table 17 the values are reported. No result is significant and all are small and around one tenth to one twentieth of a point on the exam. Graph 4 gives a visual representation of the smoothness across the cutoff. QR score is smooth across the cutoff.

For overall results with other covariates refer to Table 18.

7. Discussion and Conclusion

There are three main components to major choice: ability, future returns, and preferences. Throughout college students update themselves on their ability to complete one major versus another (Altonji et al., 2015). Students try to major in the subject in which they are most able, so there is clear evidence of sorting into major based on observable measures of ability, such as SAT and ACT scores (Polachek, 1978). Students perceive certain majors as being more lucrative, or having a higher premium; however, students must be able to actually complete that major and so they balance their ability to complete the major with the future payout of the major (Wiswall and Zafar, 2015). Finally, students want to enjoy the subject they major in and again balance that with how able they are to complete the major (Wiswall and Zafar, 2015).

Grades interplay with major choice since grades are a way that students update themselves on their ability once they enter college. Stinebrickner and Stinebrickner (2014) found that in fact students care more about their ability to do well in a major than the future payout of a

[21] Butcher, McEwan, & Taylor (2010)

major. Sabot and Wakeman-Linn (1991) found that when students do well in an introductory course to a major, they are more likely to continue taking classes in that department. The major choice of a student is heavily influenced by the grades that they receive. Students want to do well, and when they do well they are incentivized to continue in a particular subject.

What I have shown is that it does not matter if a student is actually able; it only matters that they perceive themselves as able. Measures of ability, such as grades, influence student choices and so students view their letter grades as determinants of their ability. Students believe that the final grade culminates their overall ability, even if the grade is not a totally accurate representation of their ability, like with those at the cutoff. Most students do not take this into account. Even when students are just as able as others, if they are on different sides of the cutoff, they still choose different majors.

When students are above the cutoff and receive the higher letter grade in Econ 101, they are nearly 50% more likely to major in economics. That higher letter grade may give them the push that they need to pursue additional economics classes and to major. On the other side, students below the cutoff may now have a negative view of their ability and not want to continue. Students below the cutoff may have believed they would do better, that instead they would get the higher letter grade, and are disappointed by the lower grade. This disappointment may deter them from the major.

It is especially fascinating that these results strengthen when I look at cutoffs that change the letter grade, such as the A-/B+ letter grade. At letter grade cutoffs, such as A-/B+, students are about 80% more likely to major if they are above the cutoff while at non-letter grade cutoffs, such as the B+/B cutoff, students above the cutoff are still about 50% more likely to major. Clearly a change in letter grade is a large motivator. Getting a better actual letter, rather than just sign on the letter, has a larger impact on students. When students look at their grades at the end of the semester, often the first part that they focus on is the actual letter of the grade; the sign is considered secondary. Students respond more positively to A's against B's, and B's against C's. This study has shown that students want to see higher letters, the higher letters are what the students care more about, and students respond in significant ways to the incentive of the higher letter grade.

Being above the cutoff also influences the student to at least try other courses in the department. As mentioned before, Sabot and Wakeman-Linn (1991) found that students who do well in introductory courses are more likely to take other classes in the department and my results confirm this finding. Students above the cutoff, in general, take at least one more course in the economics department. They also give themselves another chance to test economics classes and determine if it is a subject they want to study, while students below the cutoff may not give themselves that opportunity.

However, students who are above the cutoff are not more likely to minor. One would expect that students see the lower letter grade and do not want to continue in the subject. Yet, that does not seem to be the case. Minoring occurs at the same rate on both sides. With the minor the student is exempt from many of the advanced economics courses. This includes intermediate microeconomics, which is colloquially known as Econ 201. It is the second level of micro taught at Wellesley, so if the student did poorly in Econ 101, or not as well as they had hoped, they can minor and avoid having to learn more microeconomic theory. Perhaps, it is the intimidation of continuing on with the material of Econ 101 that prevents those below the cutoff from majoring but they are still willing to minor.

It is also interesting that across the cutoff there is no change in QR score. It is known that students sort themselves into majors based on mathematical ability (Polachek, 1978). However, there is no difference for students on either side of the cutoff. Students have similar SAT math scores as well. Students with same mathematical ability make completely different decisions regarding their major choice. They disregard that ability and focus instead on the letter grade signal to determine their ability in economics.

Being above the cutoff or below the cutoff only influences whether or not the student continues in the economics major. The grade signals to students their ability exclusively in economics. Students do not consider it a signal for other subjects like other social sciences or mathematics, both of which are fields related to economics. Students who are below the cutoff and choose not to major in economics are not influenced by the letter grade to go into a particular subject. Students above the cutoff, who do not major in economics or who double major with economics, do not flock to certain departments. The letter grade in Econ 101 could also indicate to students their ability in economics relative to other subjects, so students who are below the cutoff may get higher letter grades in other introductory courses, which would prompt them to major in that subject instead. However, to measure this I would have to compare relative ability signals between intro classes in multiple departments to determine if there is an effect. For now, what I understand about the Econ 101 letter grade signal is that it is only informing students about their ability to complete the economics major.

Fascinatingly, being above the cutoff increases the probability of double majoring by about 30%, at least for the first three bandwidth specifications. This value is no longer significant once I use the tightest bandwidth of 2, which means that students that are closer to the cutoff are just as likely to double major to those on the other side of the cutoff. Maybe, those with higher scores, who are farther above the cutoff, have higher general ability and thus are motivated to double major. Students above the cutoff may also believe that their absolute ability to complete the economics major is higher than those on the other side of the cutoff. In this case, they are capable of adding the pressure of another major.

Clearly, students are responding to the grades that they see on their transcript. They are taking it as an indicator of their ability and basing future decisions off of their grades. When students see the grades on their transcripts they are updating their idea of their ability, whether or not it is a correct update. Students below the threshold are just as able as those above, but they perceive themselves as less. Students do not see the letter grade in Econ 101 as an indicator of their overall, general ability, but rather as an indicator of their ability to complete the economics major. They perceive the letter grade as a signal of their ability to do well in more economics courses and to complete the major, especially if they are at the cutoff for a letter change.

Students ultimately want to receive higher grades. They want to have higher grade point averages since higher grade point averages have been shown to lead to higher wages in the future (James et al., 1989). Students care more about getting higher grades and being more able to complete their major than they do about the future earnings of the major they choose (Wiswall and Zafar, 2015). Economics, which at a liberal arts college is seen as the “business” major, is considered one of the more lucrative majors, even when accounting for the ability of students to complete the major (Wiswall and Zafar, 2015). Economics majors have high future earnings potentials, which might be one of the reasons that economics is such a popular major at liberal arts colleges like Wellesley. On the other hand, humanities majors are believed to have the lowest future earnings potentials (Wiswall and Zafar, 2015). Students who are below the cutoff, and who choose not to major because they are below, could lose out on opportunities and lower their future earnings potential. This is especially true if they decide to major in the humanities. This one letter grade can influence decisions that could affect the students for the rest of their lives. There could be a serious loss in overall wealth by believing too strongly in the signal. At that point, students have chosen to take more into account the signal of the letter grade on their transcript than the potential labor market returns when determining their major.

The signal of the grade is holding back students just below the cutoff from opportunities, such as higher future earnings. Is there a way to inform students of their true ability and convince those right below the cutoff to take more economics courses and to major? Perhaps there are interventions that could be tried. One way would be to show those students who are right at the cutoff where they fall within the distribution. Then, they would know that their lower letter grade was by chance rather than their innate ability, and that they are just as able as those above.

Perhaps, this is an argument for changing the way schools distribute grades. Are hard letter grades with minimal leeway truly the best way to represent a student's ability both to themselves, to employers, and to grad schools? Instead should schools tell students where they fall in the overall distribution of grades on their transcript? Then, it would be apparent where students are relative to others in the class. Schools could put numerical grades and report the class average on transcripts, so students know how far above or below their grade was from the average. Changing how schools give grades is definitely something to consider.

One final piece about this study is that perhaps these results are unique to Wellesley College. In other papers with similar designs there were little to no results (Owen, 2010; Main and Ost, 2014). However, literature shows that women in general are more susceptible to grades than men (Rask and Tiefenthaler, 2008; Goldin, 2015). Since my sample is exclusively women, my results may tend to be geared to those who are already more inclined to believe their grades over their own personal ideas about their ability. In addition, Wellesley is known for its anti-grade inflation policy, which was discussed previously. Wellesley has worked to ensure that grades on transcripts represent students' ability and effort in a class and that students are not just given high grades to make the student and institution look good. Wellesley has ingrained into students that the grades on their transcripts are clear indicators of their ability. The anti-grade inflation policy requires that the class average of introductory courses must be a B+ or below, so when students see that they got above a B+ they inherently know that they are above average and that they did better than the average student in the class. Wellesley students then may be more inclined to believe the letter grade that they see on their transcript because of this policy and perhaps this is part of what is driving the effect.

Students care about their grades on their transcript and are reacting to them. They are using the grades to update themselves on their capabilities. The letter grade is considered an informant of ability in the subject of the class. Students change their perceptions about themselves and their ability to complete a major in that subject once they see the letter grade. The letter grade has influence.

8. Tables

Table 1 – Summary Statistics

Variable	Mean	Standard Deviation
Grade in Econ 101	3.137	.584
% Econ Majors	33.5%	--
% Non-Econ Social Science Majors	43%	--
% Science and Math Majors	24.4%	--
% Humanities Majors	28%	--
Number of Economics Classes Taken	4.54	3.5
Cumulative GPA	3.367	.329
SAT Math Score	695.37	66.35
SAT Verbal Score	691.83	68.44
ACT Score	30.326	2.67
% With Admissions Major of Economics	16.02%	--
% White Students	38.11%	--
% Black Students	4.37%	--
% Asian Students	29.09%	--
% Latina/ Hispanic Students	5.14%	--
% International Students	12.58%	--
% Biracial Student	5.9%	--
% Other Race Student	2.9%	--

% First Generation Students Students	9.9%	--

Notes: The sample only includes those who both took Economics 101 and have the running variable. The total number of observations is 1,821.

Table 2 – First Stage: Letter Grade with Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.266***	0.314***	0.312***
	(0.0409)	(0.00723)	(0.00744)
Observations	1,457	1,449	1,448
R-squared	0.104	0.978	0.978
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.279***	0.316***	0.314***
	(0.0432)	(0.00742)	(0.00770)
Observations	1,422	1,414	1,413
R-squared	0.104	0.978	0.978
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.299***	0.320***	0.317***
	(0.0472)	(0.00763)	(0.00802)
Observations	1,334	1,329	1,328
R-squared	0.106	0.977	0.977
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.303***	0.327***	0.324***
	(0.0560)	(0.00801)	(0.00866)
Observations	1,105	1,102	1,101
R-squared	0.116	0.975	0.975

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is the letter grade received in Econ 101 enumerated. For a greater description refer to the data section. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls, which are SAT verbal and math scores, ACT scores, race dummies, a first gen dummy, a dummy if the admissions major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 3 – Economics Major with Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.147***	0.165***	0.170***
	(0.0473)	(0.0479)	(0.0463)
Observations	1,450	1,442	1,441
R-squared	0.016	0.259	0.318
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.141***	0.160***	0.168***
	(0.0505)	(0.0503)	(0.0488)
Observations	1,415	1,407	1,406
R-squared	0.017	0.266	0.323
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.132**	0.147***	0.160***
	(0.0560)	(0.0547)	(0.0531)
Observations	1,328	1,323	1,322
R-squared	0.018	0.280	0.335
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.131*	0.160**	0.176***
	(0.0681)	(0.0651)	(0.0636)
Observations	1,099	1,096	1,095
R-squared	0.018	0.303	0.357

	(1)	(2)	(3)
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 4 – Number of Economics Classes with Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.953***	1.019***	1.049***
	(0.343)	(0.349)	(0.337)
Observations	1,457	1,449	1,448
R-squared	0.017	0.262	0.326
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.943**	1.009***	1.062***
	(0.366)	(0.367)	(0.356)
Observations	1,422	1,414	1,413
R-squared	0.017	0.269	0.331
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.849**	0.889**	0.977**
	(0.405)	(0.398)	(0.387)
Observations	1,334	1,329	1,328
R-squared	0.018	0.282	0.342
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.814*	0.938**	1.065**
	(0.490)	(0.468)	(0.461)
Observations	1,105	1,102	1,101
R-squared	0.017	0.302	0.357

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a count of the number of economics classes that students have taken. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 5 – Economics Minor with Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	-0.0349	-0.0367	-0.0368
	(0.0293)	(0.0322)	(0.0321)
Observations	1,457	1,449	1,448
R-squared	0.002	0.203	0.217
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	-0.0323	-0.0349	-0.0358
	(0.0313)	(0.0342)	(0.0340)
Observations	1,422	1,414	1,413
R-squared	0.001	0.209	0.224
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	-0.0337	-0.0355	-0.0372
	(0.0347)	(0.0376)	(0.0371)
Observations	1,334	1,329	1,328
R-squared	0.001	0.223	0.240
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	-0.0181	-0.0176	-0.0218
	(0.0423)	(0.0455)	(0.0444)
Observations	1,105	1,102	1,101
R-squared	0.001	0.251	0.268

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student minored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6 – Economics Major for Cutoffs at Letter Grades

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.239***	0.195**	0.203**
	(0.0853)	(0.0864)	(0.0835)
Observations	424	424	424
R-squared	0.032	0.289	0.341
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.231**	0.201**	0.205**
	(0.0902)	(0.0888)	(0.0858)
Observations	418	418	418
R-squared	0.033	0.296	0.348
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.186*	0.186**	0.189**
	(0.0981)	(0.0930)	(0.0899)
Observations	400	400	400
R-squared	0.037	0.311	0.362
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.174	0.228**	0.239**
	(0.119)	(0.108)	(0.104)
Observations	347	347	347
R-squared	0.036	0.340	0.394

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 7 – Economics Major for Cutoffs not at Letter Grades

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.108*	0.136**	0.140**
	(0.0574)	(0.0582)	(0.0556)
Observations	1,018	1,018	1,017
R-squared	0.011	0.250	0.334
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.102*	0.128**	0.139**
	(0.0614)	(0.0616)	(0.0590)
Observations	989	989	988
R-squared	0.012	0.256	0.339
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.107	0.122*	0.142**
	(0.0683)	(0.0676)	(0.0650)
Observations	922	922	921
R-squared	0.011	0.269	0.353
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.110	0.128	0.160**
	(0.0826)	(0.0810)	(0.0784)
Observations	750	750	749
R-squared	0.011	0.289	0.372

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 8 – Economics Major at the A/A- Cutoff

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.201**	0.215**	0.161*
	(0.0964)	(0.0927)	(0.0949)
Observations	435	435	435
R-squared	0.019	0.224	0.310
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.193*	0.204**	0.144
	(0.104)	(0.0994)	(0.103)
Observations	405	405	405
R-squared	0.021	0.241	0.329
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.180	0.191*	0.102
	(0.117)	(0.111)	(0.117)
Observations	338	338	338
R-squared	0.024	0.274	0.375
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.181	0.214	0.0567
	(0.144)	(0.140)	(0.160)
Observations	232	232	232
R-squared	0.026	0.313	0.438

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 9 – Economics Major at the A-/B+ Cutoff

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.183**	0.178**	0.194**
	(0.0779)	(0.0754)	(0.0755)
Observations	653	653	652
R-squared	0.016	0.144	0.201
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.166*	0.172**	0.187**
	(0.0848)	(0.0808)	(0.0811)
Observations	597	597	596
R-squared	0.017	0.163	0.216
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.126	0.143	0.162*
	(0.0975)	(0.0914)	(0.0927)
Observations	492	492	491
R-squared	0.020	0.201	0.247
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.170	0.217*	0.243**
	(0.124)	(0.110)	(0.111)
Observations	350	350	350
R-squared	0.019	0.278	0.312

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 10 – Economics Major at the B+/B Cutoff

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.0718	0.0896	0.0995
	(0.0774)	(0.0774)	(0.0745)
Observations	692	692	691
R-squared	0.008	0.155	0.232
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.0709	0.0906	0.108
	(0.0868)	(0.0859)	(0.0831)
Observations	599	599	598
R-squared	0.009	0.165	0.240
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.0645	0.0822	0.123
	(0.102)	(0.0982)	(0.0964)
Observations	497	497	496
R-squared	0.007	0.179	0.263
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.0757	0.0988	0.175
	(0.130)	(0.121)	(0.123)
Observations	345	345	344
R-squared	0.009	0.208	0.314

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 11 – Economics Major at the B/B- Cutoff

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.0807	0.0859	0.0763
	(0.0855)	(0.0870)	(0.0792)
Observations	549	549	549
R-squared	0.008	0.164	0.304
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.0907	0.109	0.0994
	(0.0948)	(0.0971)	(0.0883)
Observations	494	494	494
R-squared	0.007	0.188	0.327
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.0916	0.135	0.118
	(0.113)	(0.118)	(0.107)
Observations	392	392	392
R-squared	0.006	0.234	0.365
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.0576	0.0626	0.0640
	(0.143)	(0.154)	(0.140)
Observations	274	274	274
R-squared	0.006	0.280	0.425

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 12 – Economics Major at the B-/C+ Cutoff

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.271***	0.259***	0.249**
	(0.0945)	(0.0993)	(0.0965)
Observations	311	311	310
R-squared	0.042	0.223	0.347
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.324***	0.301***	0.288***
	(0.105)	(0.109)	(0.108)
Observations	279	279	278
R-squared	0.060	0.249	0.381
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.395***	0.366***	0.354***
	(0.125)	(0.127)	(0.128)
Observations	229	229	228
R-squared	0.080	0.284	0.445
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.523***	0.504***	0.518***
	(0.157)	(0.158)	(0.162)
Observations	166	166	165
R-squared	0.121	0.357	0.556

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in economics. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 13 – Science Major Pooled

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	-0.0597	-0.0637	-0.0456
	(0.0407)	(0.0403)	(0.0387)
Observations	1454	1446	1445
R-squared	0.002	0.230	0.291
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	-0.0577	-0.0652	-0.0475
	(0.0436)	(0.0427)	(0.0409)
Observations	1419	1411	1410
R-squared	0.002	0.239	0.299
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	-0.0538	-0.0637	-0.0460
	(0.0486)	(0.0469)	(0.0450)
Observations	1331	1326	1325
R-squared	0.002	0.258	0.316
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	-0.0721	-0.0726	-0.0479
	(0.0595)	(0.0573)	(0.0550)
Observations	1102	1099	1098
R-squared	0.004	0.288	0.349

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in science or math. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 14 – Non - Economics Social Science Majors Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.0422	0.0263	0.0195
	(0.0405)	(0.0427)	(0.0425)
Observations	1450	1442	1441
R-squared	0.001	0.216	0.244
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.0462	0.0288	0.0212
	(0.0429)	(0.0446)	(0.0443)
Observations	1415	1407	1406
R-squared	0.001	0.223	0.252
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.0533	0.0335	0.0241
	(0.0470)	(0.0481)	(0.0477)
Observations	1328	1323	1322
R-squared	0.002	0.233	0.264
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.0502	0.0205	0.00464
	(0.0566)	(0.0565)	(0.0558)
Observations	1099	1096	1095
R-squared	0.004	0.260	0.294

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in non-economics social sciences. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 15 – Humanities Major Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.0304	0.0268	0.0260
	(0.0427)	(0.0442)	(0.0433)
Observations	1454	1446	1445
R-squared	0.001	0.223	0.266
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.0284	0.0287	0.0276
	(0.0454)	(0.0462)	(0.0453)
Observations	1419	1411	1410
R-squared	0.001	0.234	0.273
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.0201	0.0218	0.0198
	(0.0501)	(0.0502)	(0.0492)
Observations	1331	1326	1325
R-squared	0.002	0.241	0.285
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.0143	0.00532	0.00774
	(0.0604)	(0.0591)	(0.0582)
Observations	1102	1099	1089
R-squared	0.003	0.270	0.324

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student majored in the humanities. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 16 – Double Major Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)	(3)
Above the Cutoff	0.123***	0.119***	0.118***
	(0.0431)	(0.0441)	(0.0443)
Observations	1450	1442	1441
R-squared	0.010	0.224	0.234
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel B: Bandwidth of 4	(1)	(2)	(3)
Above the Cutoff	0.118**	0.122***	0.121***
	(0.0458)	(0.0463)	(0.0465)
Observations	1415	1407	1406
R-squared	0.011	0.231	0.244
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel C: Bandwidth of 3	(1)	(2)	(3)
Above the Cutoff	0.106**	0.113**	0.112**
	(0.0507)	(0.0505)	(0.0508)
Observations	1328	1323	1322
R-squared	0.013	0.242	0.258
Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Panel D: Bandwidth of 2	(1)	(2)	(3)
Above the Cutoff	0.0857	0.0883	0.0930
	(0.0613)	(0.0599)	(0.0608)
Observations	1099	1096	1095
R-squared	0.015	0.273	0.295

Section by Cutoff FE	NO	YES	YES
Controls	NO	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is a dummy variable indicating whether or not a student double majored. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Columns (2) and (3) include section by cutoff fixed effects. Column (3) includes controls such as SAT scores, ACT scores, race dummies, a first gen dummy, a dummy if the admission major was economics, and admission rating. Triangular weights are used in each regression

*** p<0.01, ** p<0.05, * p<0.1

Table 17– QR Score Balance with Pooled Sample

Panel A: Bandwidth of 5	(1)	(2)
Above the Cutoff	-0.135	-0.158
	(0.228)	(0.217)
Observations	1,457	1,449
R-squared	0.002	0.322
Section by Cutoff FE	NO	YES

Panel B: Bandwidth of 4	(1)	(2)
Above the Cutoff	-0.0998	-0.150
	(0.243)	(0.229)
Observations	1,422	1,414
R-squared	0.001	0.324
Section by Cutoff FE	NO	YES

Panel C: Bandwidth of 3	(1)	(2)
Above the Cutoff	-0.0526	-0.132
	(0.272)	(0.251)
Observations	1,334	1,329
R-squared	0.002	0.327
Section by Cutoff FE	NO	YES

Panel D: Bandwidth of 2	(1)	(2)
Above the Cutoff	-0.149	-0.193
	(0.336)	(0.312)
Observations	1,105	1,102
R-squared	0.003	0.336
Section by Cutoff FE	NO	YES

Notes: Robust standard errors in parentheses. The dependent variable in each column is the QR score variable. For a greater description refer to the data section. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Triangular weights are used in each regression. Column (2) includes section by cutoff fixed effects. Note that I cannot include controls since QR score is a control.

*** p<0.01, ** p<0.05, * p<0.1

Table 18 – Covariate Balance within the Pooled Sample

Regression Covariate	(1)	(2)
SAT Math Score	-30.19	-29.22
	(25.12)	(25.72)
SAT Verbal Score	-21.80	-17.40
	(25.00)	(25.58)
ACT Score	0.856	0.381
	(1.436)	(1.499)
Admissions Major	0.0327	0.0336
Economics	(0.0357)	(0.0363)
White Student	0.0210	0.0267
	(0.0477)	(0.0490)
Black Student	0.0223	0.0309*
	(0.0161)	(0.0168)
Asian Student	-0.0826*	-0.0966**
	(0.0455)	(0.0483)
Latina/ Hispanic Student	0.0576	0.0626
	(0.143)	(0.154)
International Student	-0.0159	-0.0122
	(0.0337)	(0.0348)
Biracial Student	0.0324	0.0225
	(0.0212)	(0.0205)
Other Race Student	-0.0140	-0.00862
	(0.0143)	(0.0154)
First Generation	-0.0344	-0.0250
Student	(0.0268)	(0.0266)
Admissions Rating	-0.0227	-0.0392
	(0.0793)	(0.0796)
Section by Cutoff FE	NO	YES

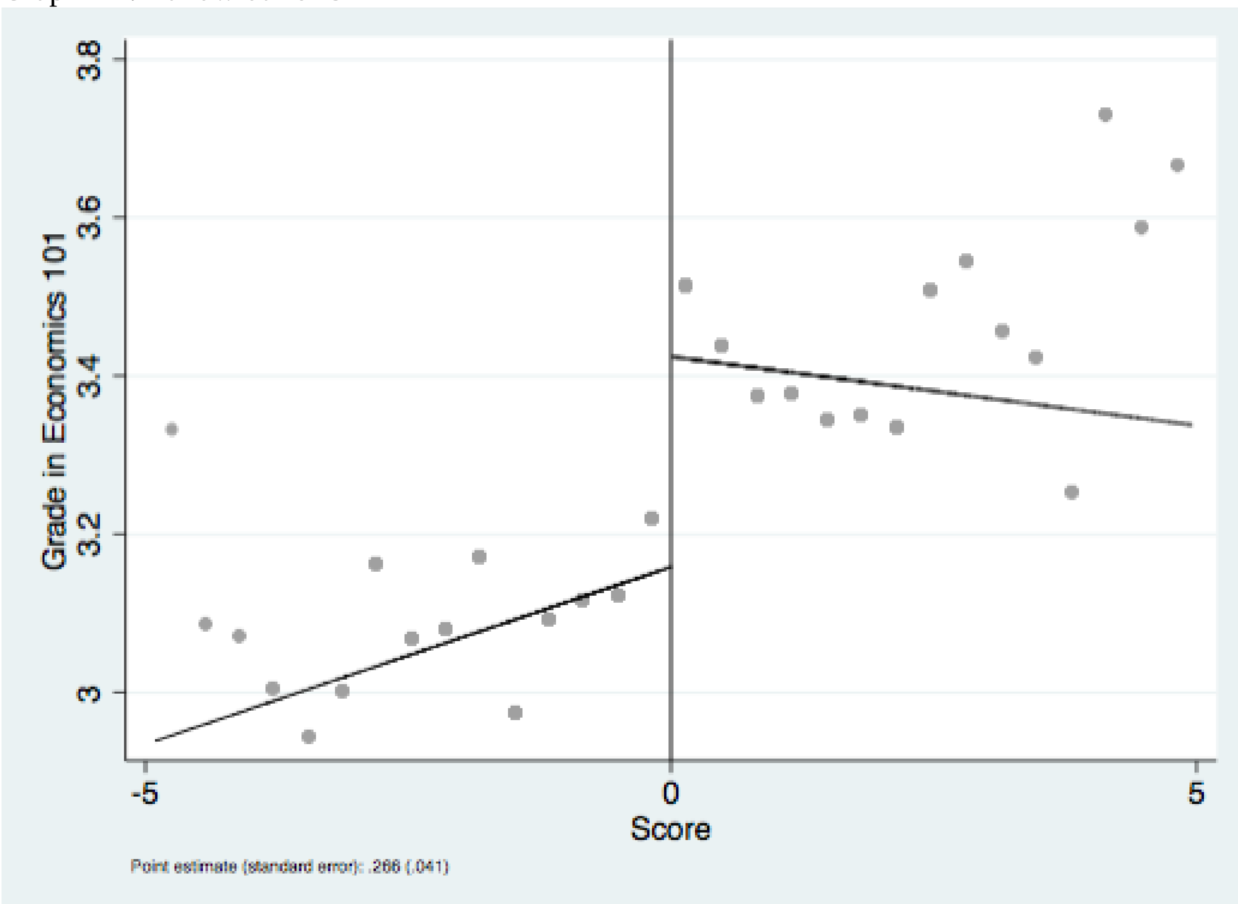
Notes: Robust standard errors in parentheses. Reported is the coefficient on the dummy variable if the student is above the cutoff or not. The covariate listed is the dependent variable in each column. Each column includes the score and a piecewise linear function variable that allows the score to vary on either side of the cutoff. Column (2) includes section by cutoff fixed effects. Each column has a bandwidth of 5 and uses triangular weights.

*** p<0.01, ** p<0.05, * p<0.1

9. Graphs

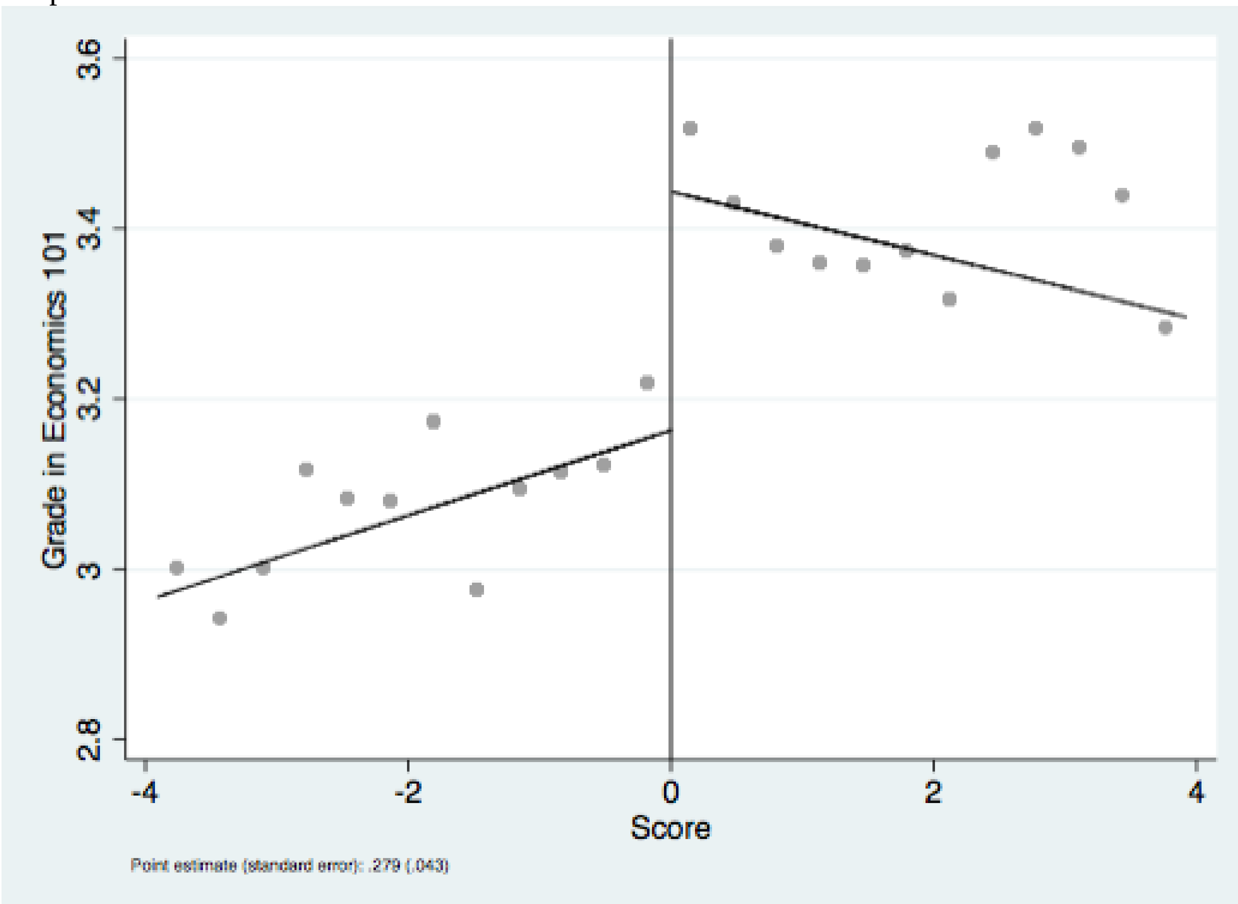
Graph 1: Letter Grade with Pooled Sample

Graph 1A: Bandwidth of 5



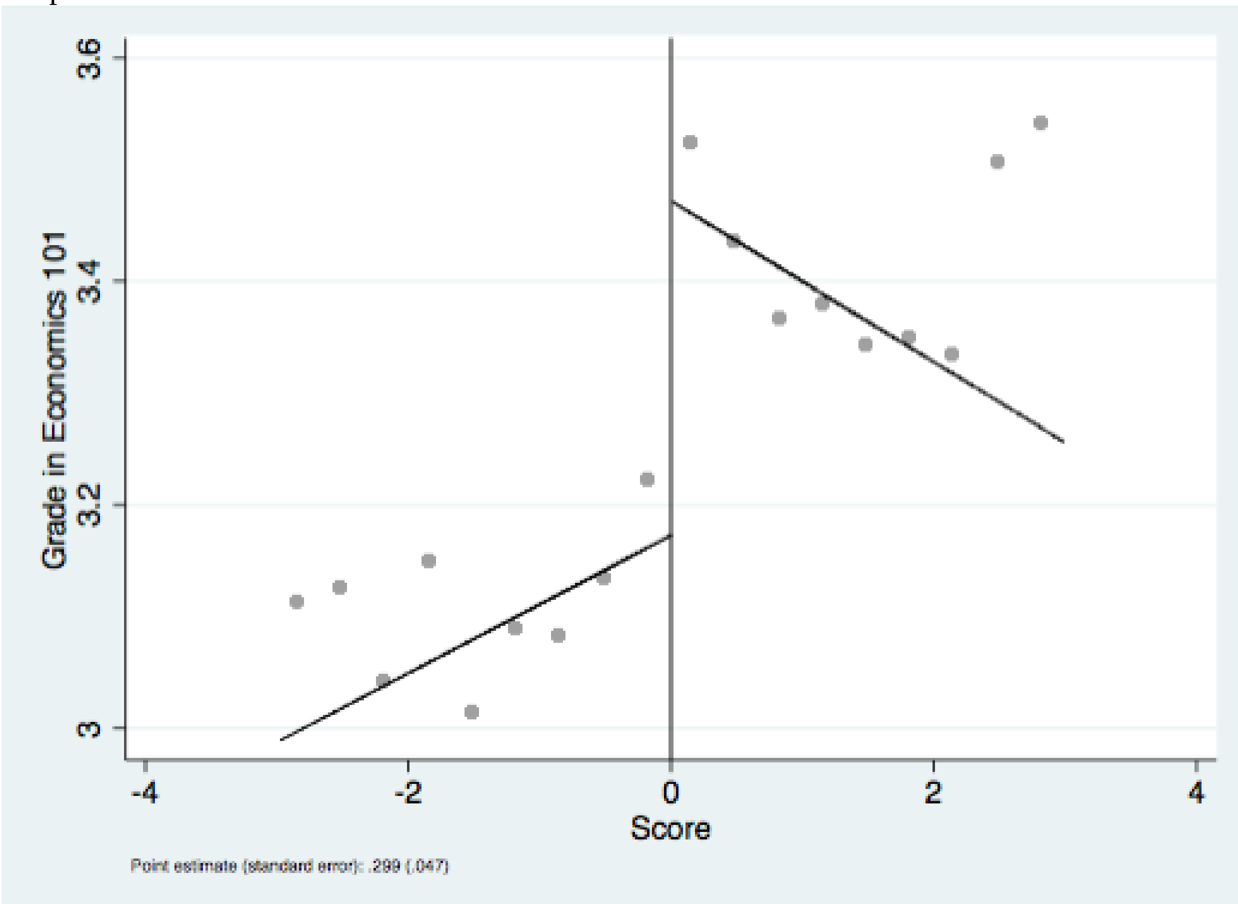
*Note: Point estimates and standard errors are saved from regression specification (1) with the enumerated letter grade as the dependent variable. There is a triangular kernel and 15 bins on each side.

Graph 1B: Bandwidth of 4



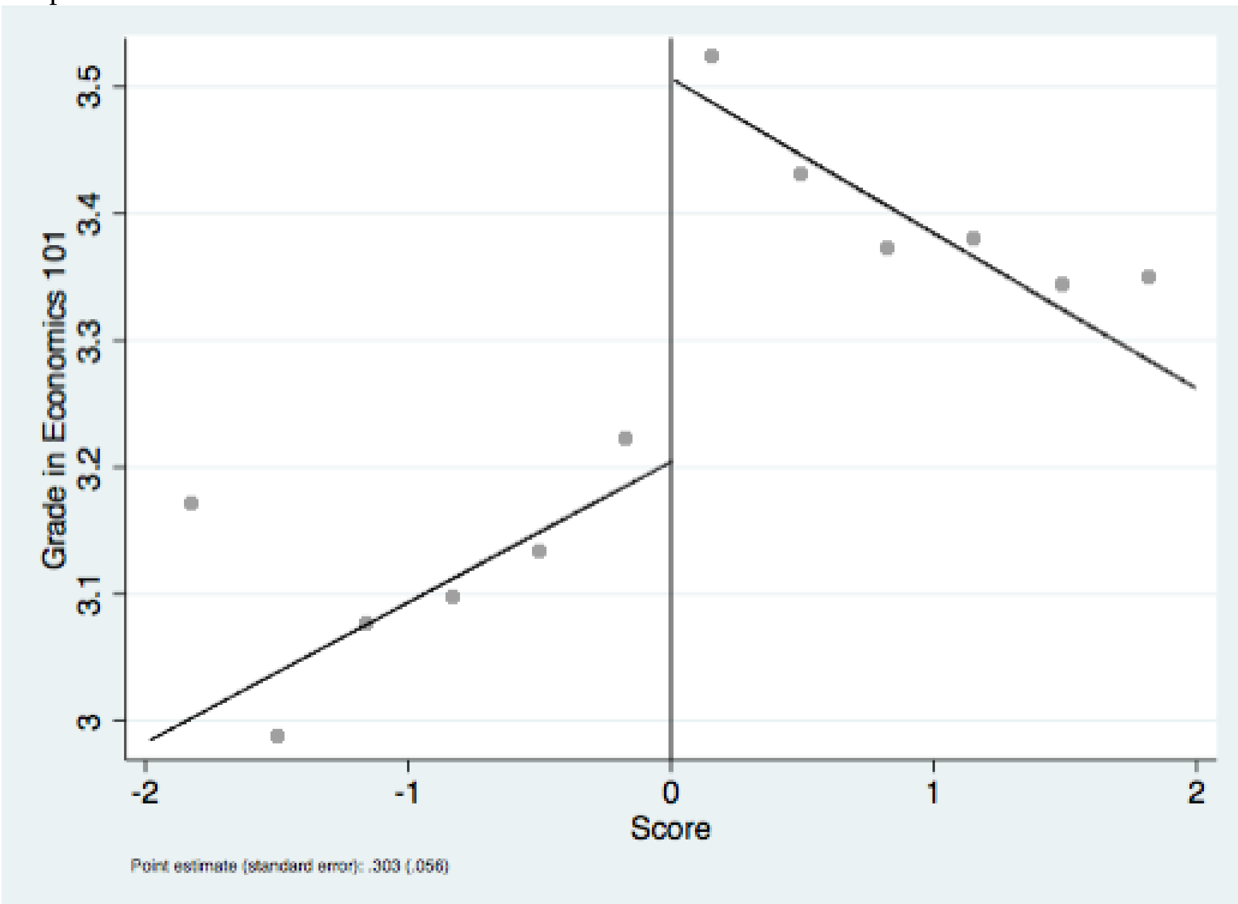
*Note: Point estimates and standard errors are saved from regression specification (1) with the enumerated letter grade as the dependent variable. There is a triangular kernel and 12 bins on each side.

Graph 1C: Bandwidth of 3



*Note: Point estimates and standard errors are saved from regression specification (1) with the enumerated letter grade as the dependent variable. There is a triangular kernel and 9 bins on each side.

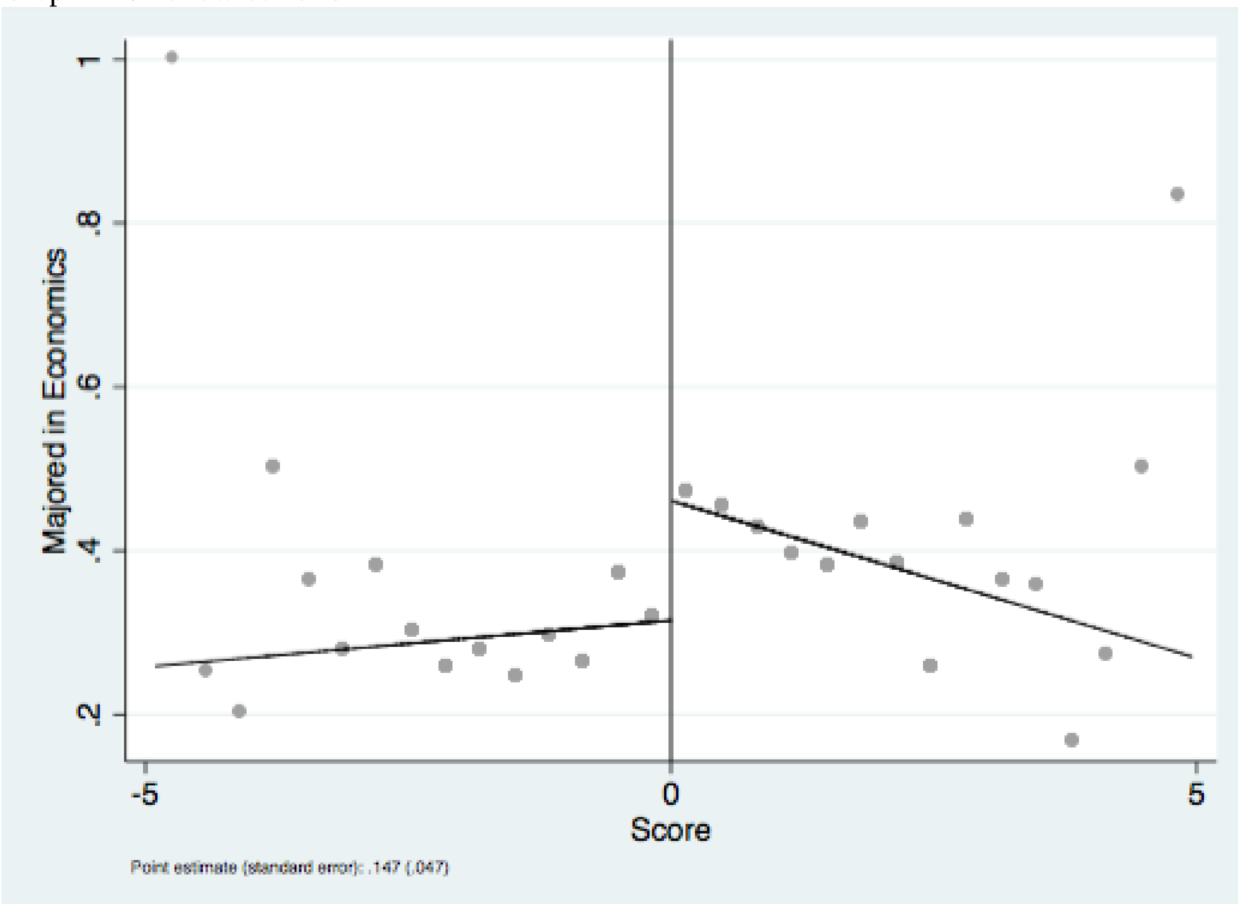
Graph 1D: Bandwidth of 2



*Note: Point estimates and standard errors are saved from regression specification (1) with the enumerated letter grade as the dependent variable. There is a triangular kernel and 6 bins on each side.

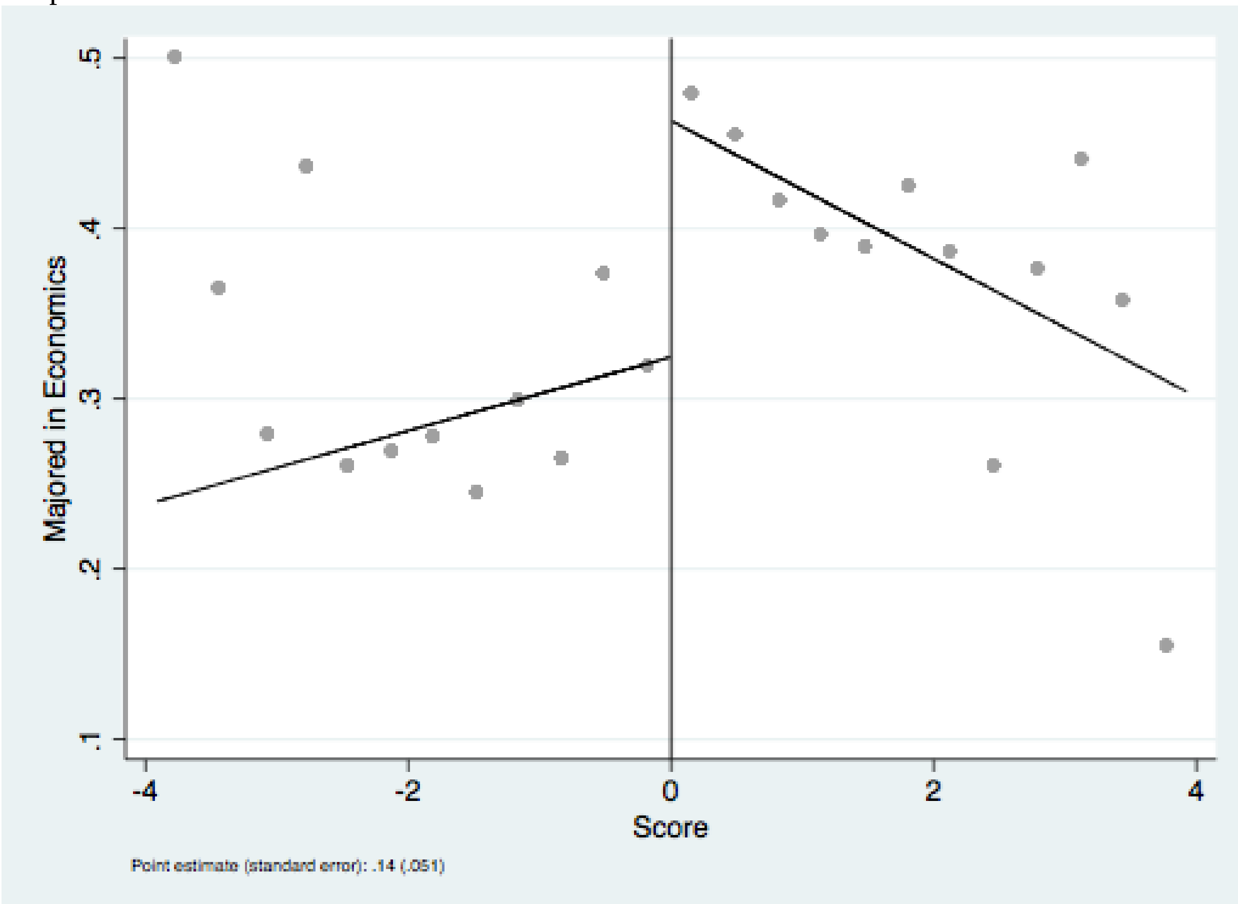
<u>Graph 2: Economics Major with Pooled Sample</u>

Graph 2A: Bandwidth of 5



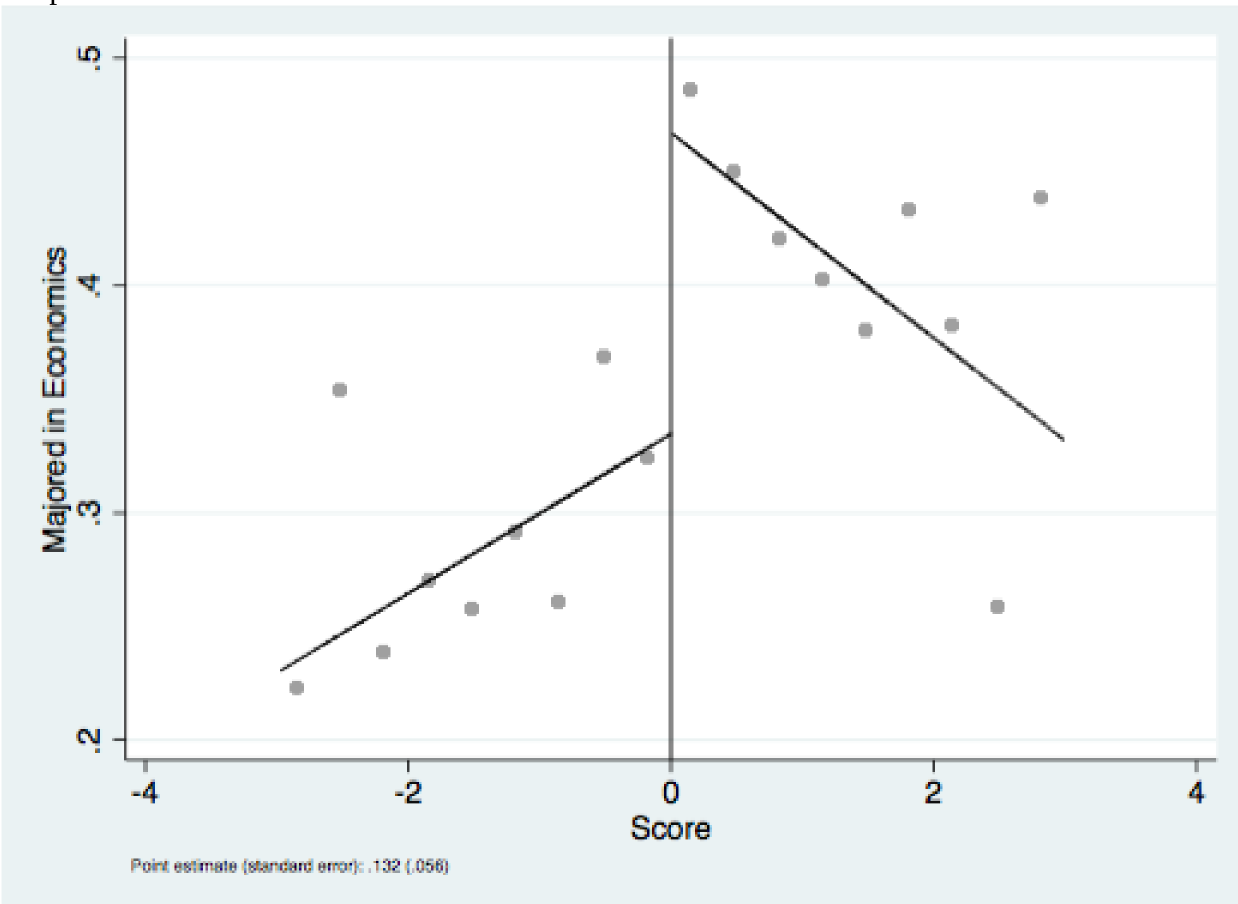
*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student majored in economics as the dependent variable. There is a triangular kernel and 15 bins specified.

Graph 2B: Bandwidth of 4



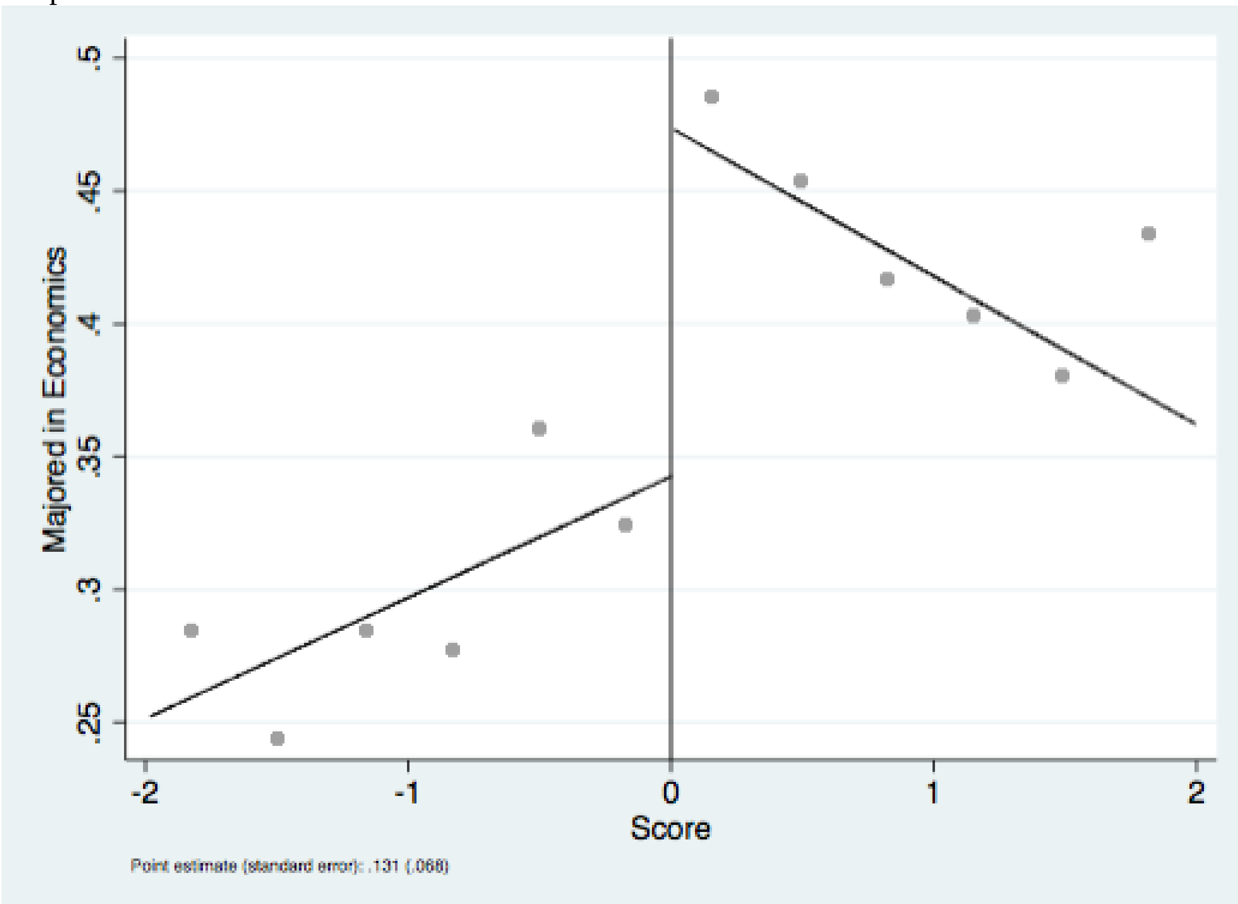
*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student majored in economics as the dependent variable. There is a triangular kernel and 12 bins specified.

Graph 2C: Bandwidth of 3



*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student majored in economics as the dependent variable. There is a triangular kernel and 9 bins specified.

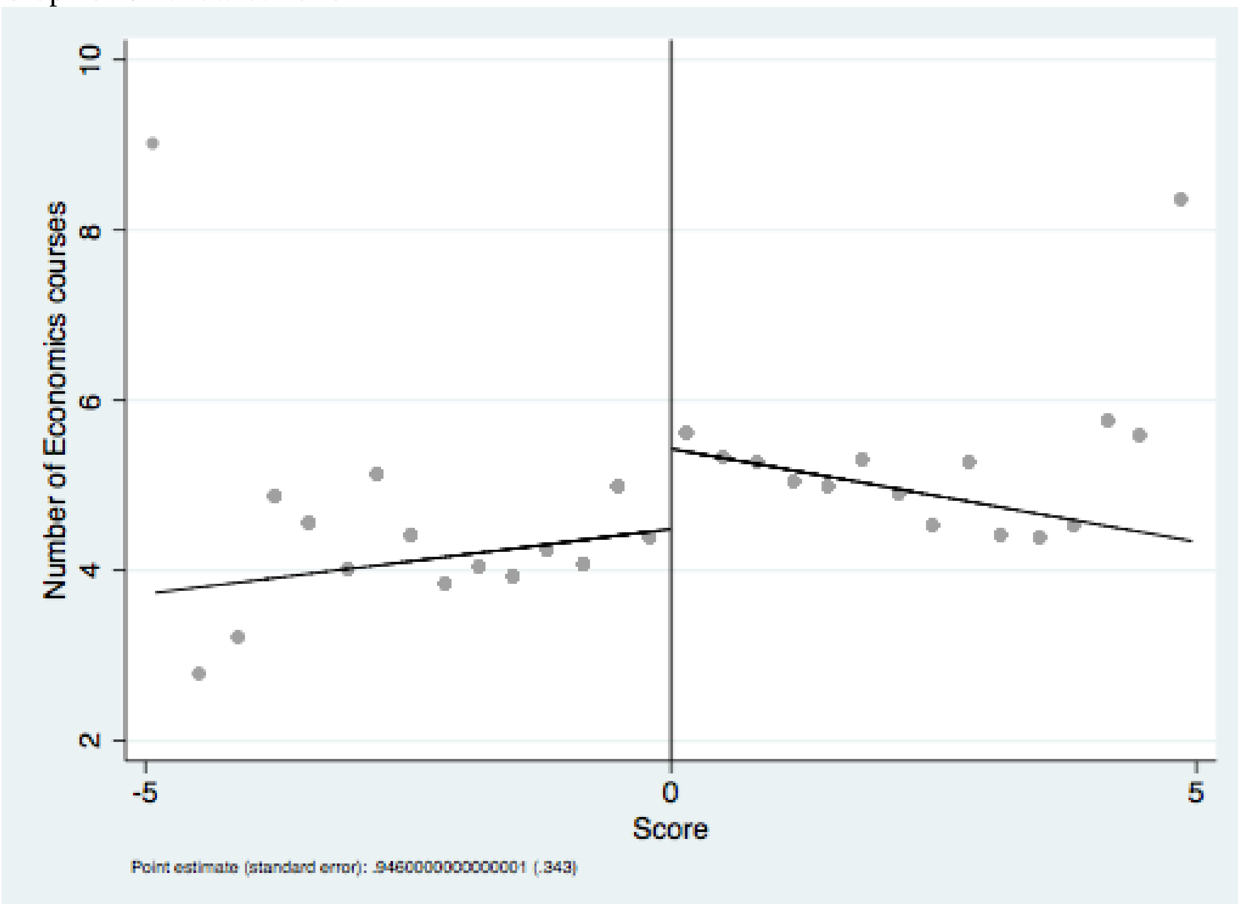
Graph 2D: Bandwidth of 2



*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student majored in economics as the dependent variable. There is a triangular kernel and 6 bins specified.

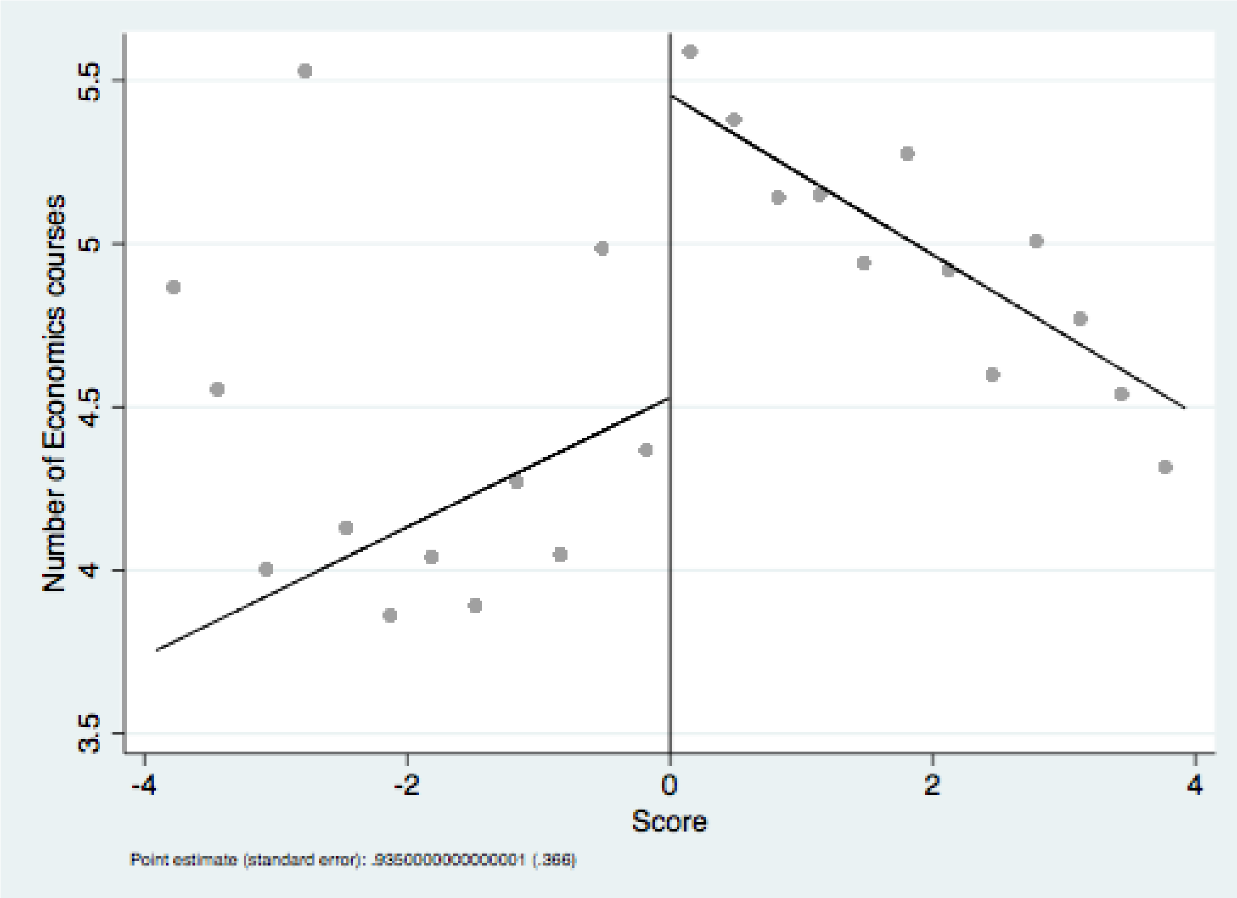
<u>Graph 3: Number of Economics Classes with Pooled Sample</u>

Graph 3A: Bandwidth of 5



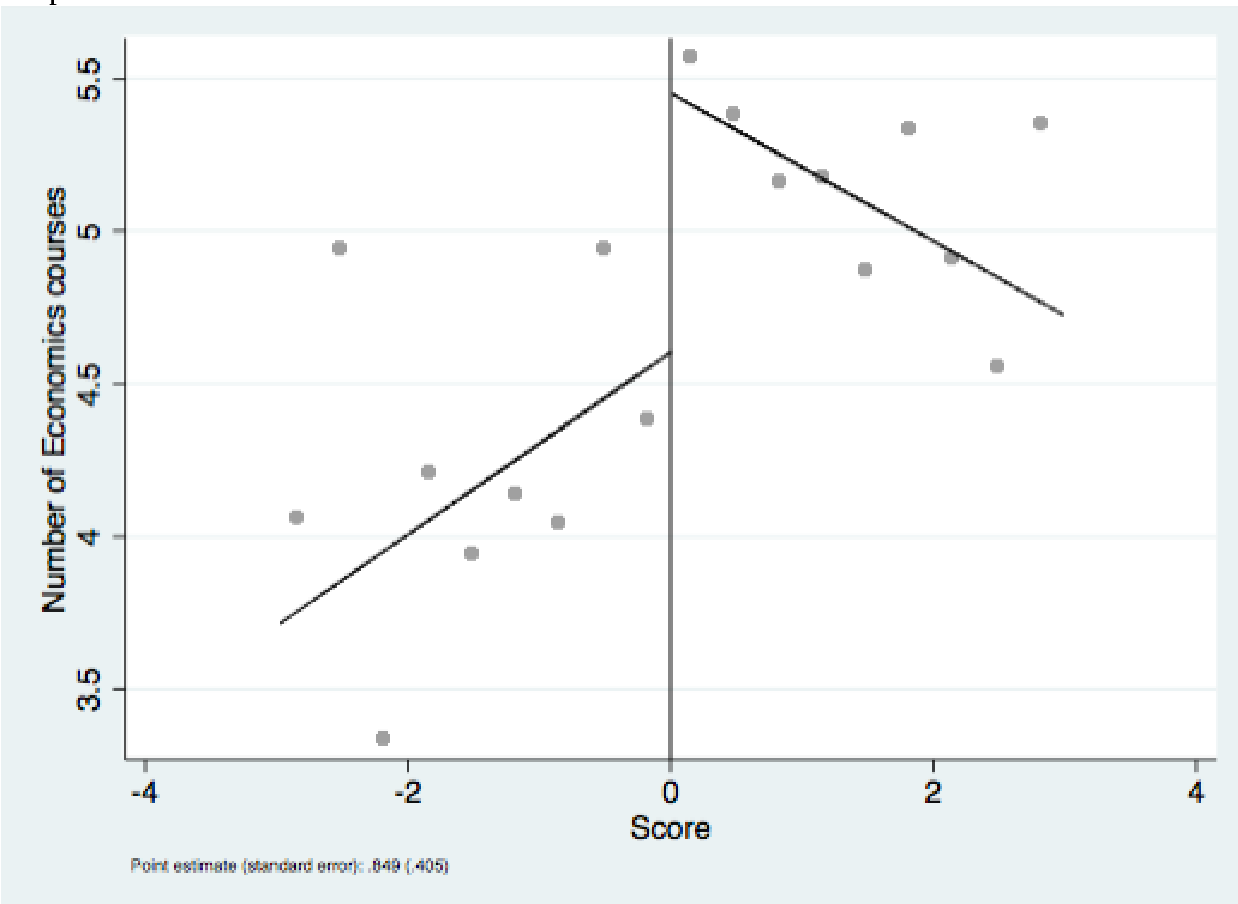
*Note: Point estimates and standard errors are saved from regression specification (1) with the number of economics courses as the dependent variable. There is a triangular kernel and 15 bins specified.

Graph 3B: Bandwidth of 4



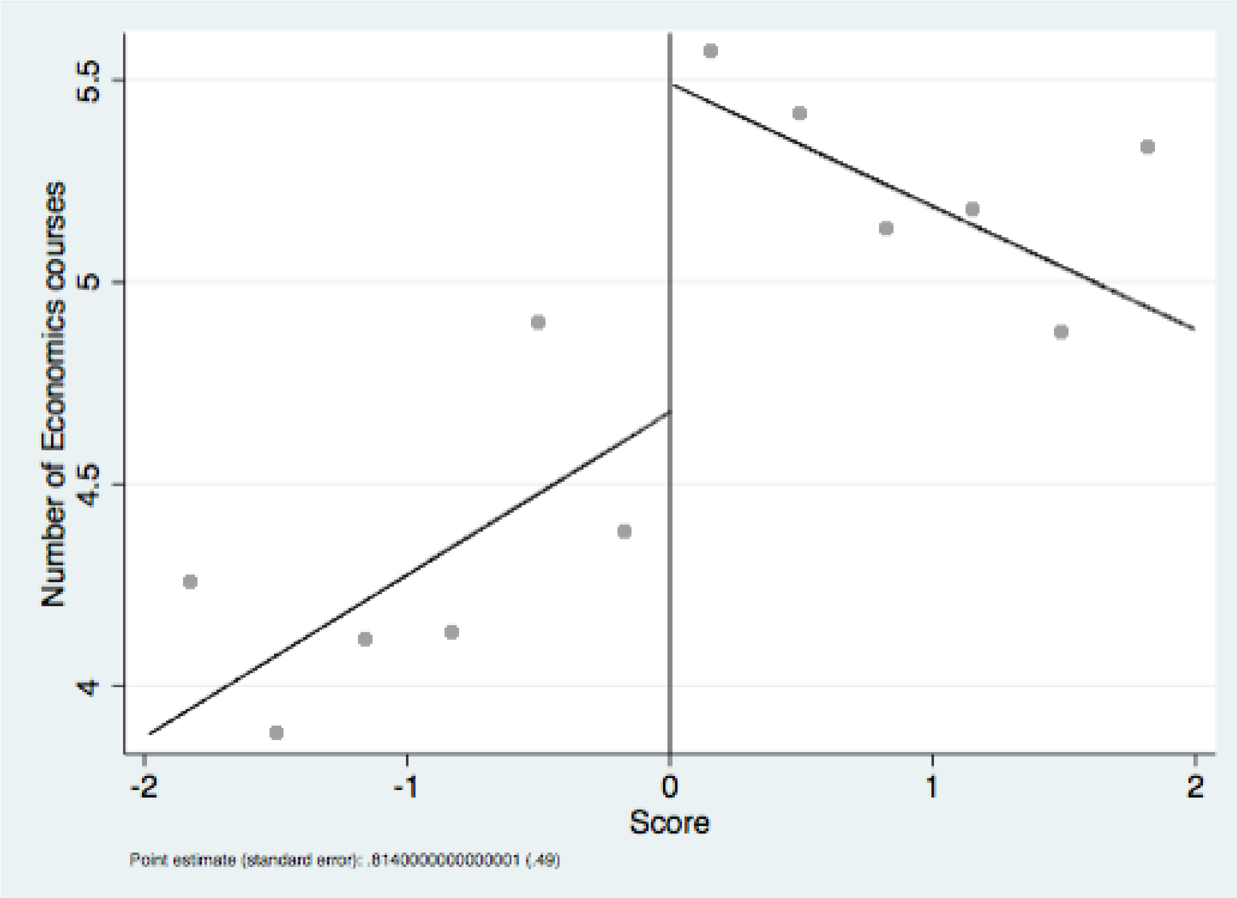
*Note: Point estimates and standard errors are saved from regression specification (1) with the number of economics courses as the dependent variable. There is a triangular kernel and 12 bins specified.

Graph 3C: Bandwidth of 3



*Note: Point estimates and standard errors are saved from regression specification (1) with the number of economics courses as the dependent variable. There is a triangular kernel and 9 bins specified.

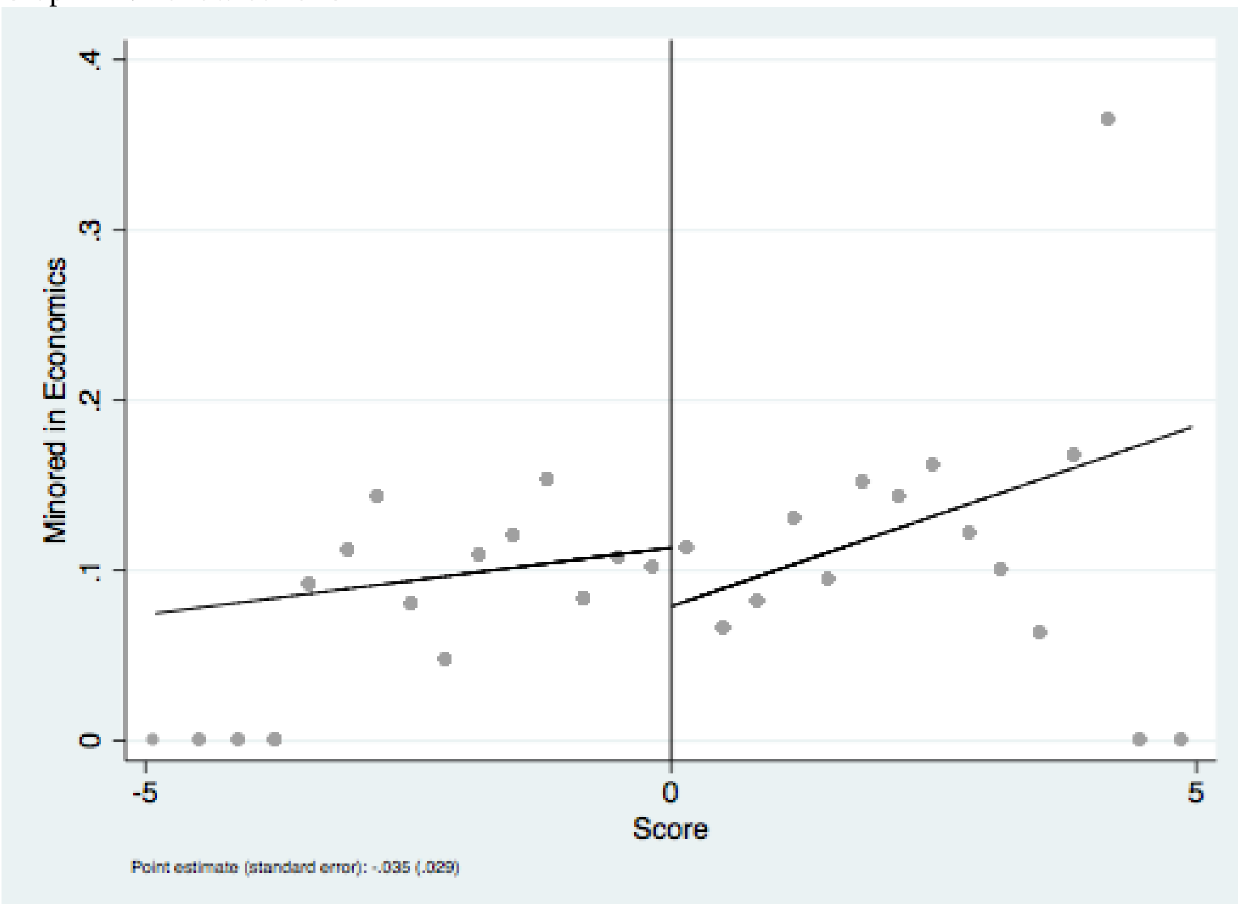
Graph 3D: Bandwidth of 2



*Note: Point estimates and standard errors are saved from regression specification (1) with the number of economics courses as the dependent variable. There is a triangular kernel and 6 bins specified.

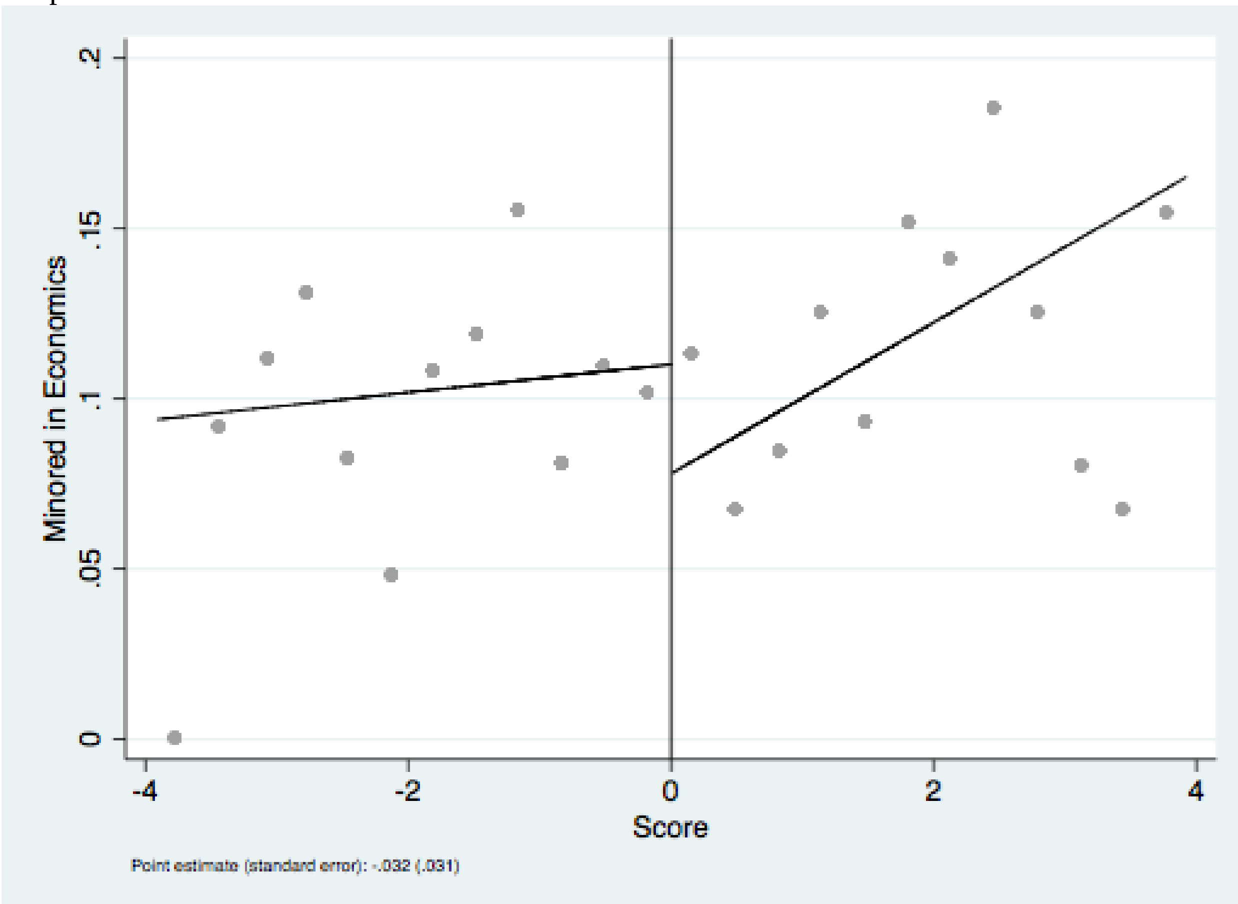
Graph 4: Economics Minor with Pooled Sample

Graph 4A: Bandwidth of 5



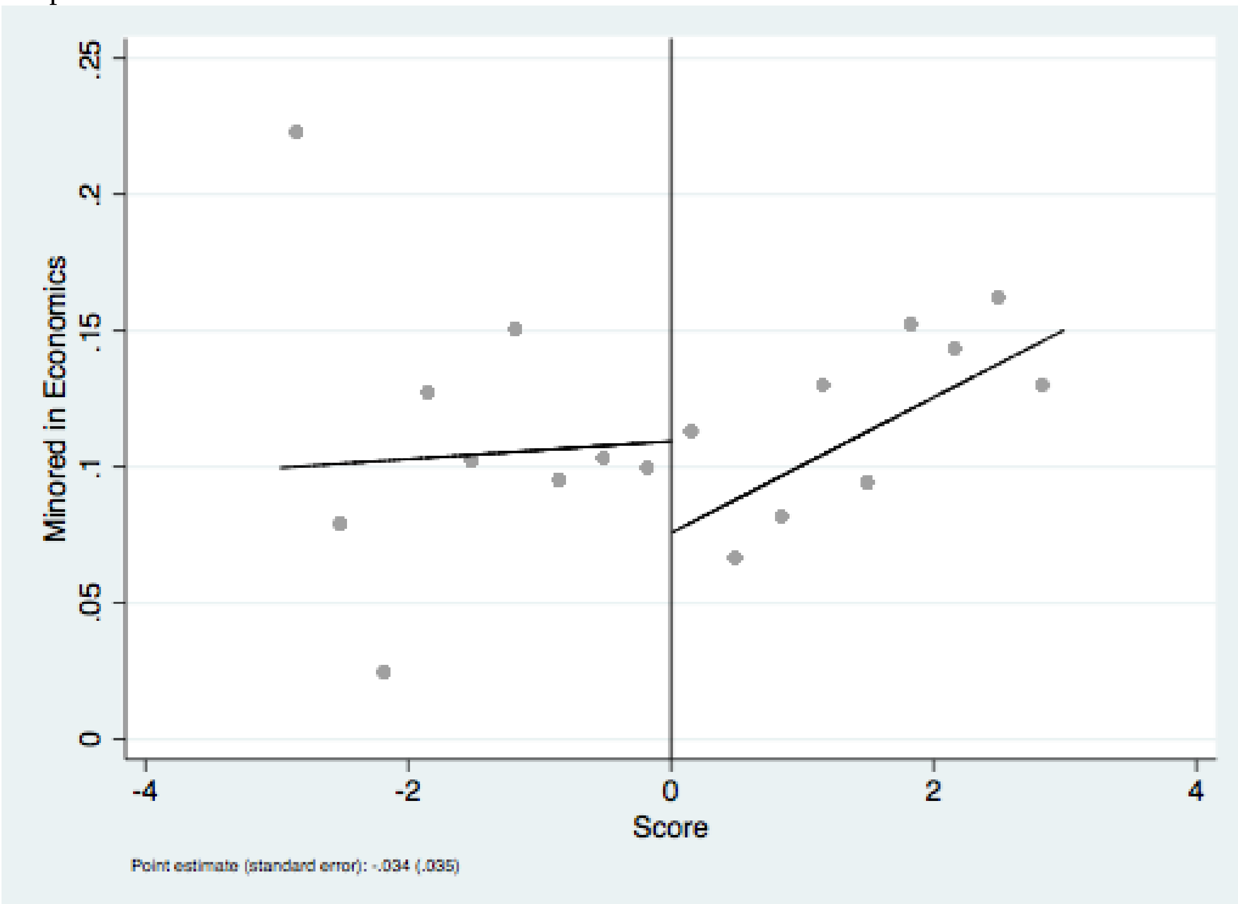
*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student minored in economics as the dependent variable. There is a triangular kernel and 15 bins specified.

Graph 4B: Bandwidth of 4



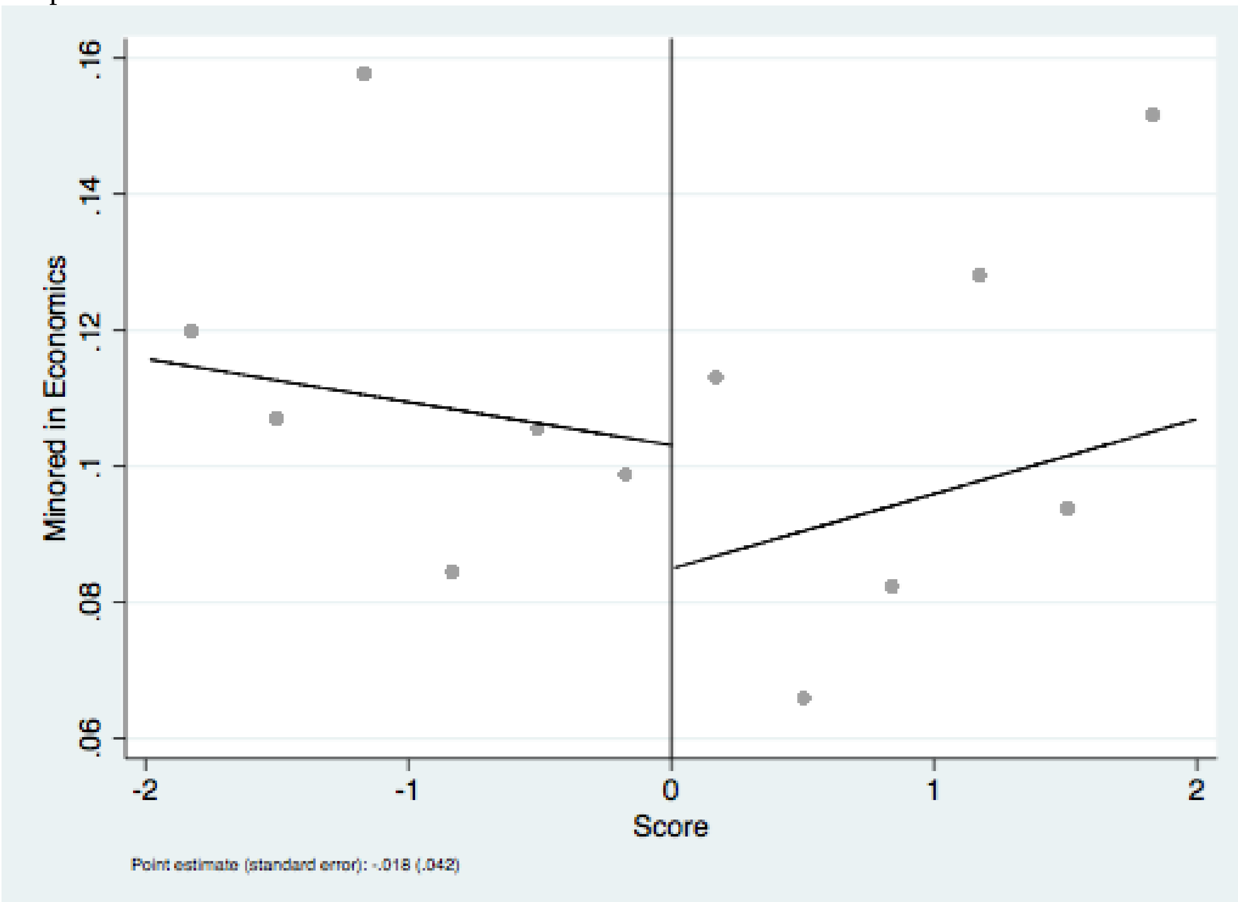
*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student minored in economics as the dependent variable. There is a triangular kernel and 12 bins specified.

Graph 4C: Bandwidth of 3



*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student minored in economics as the dependent variable. There is a triangular kernel and 9 bins specified.

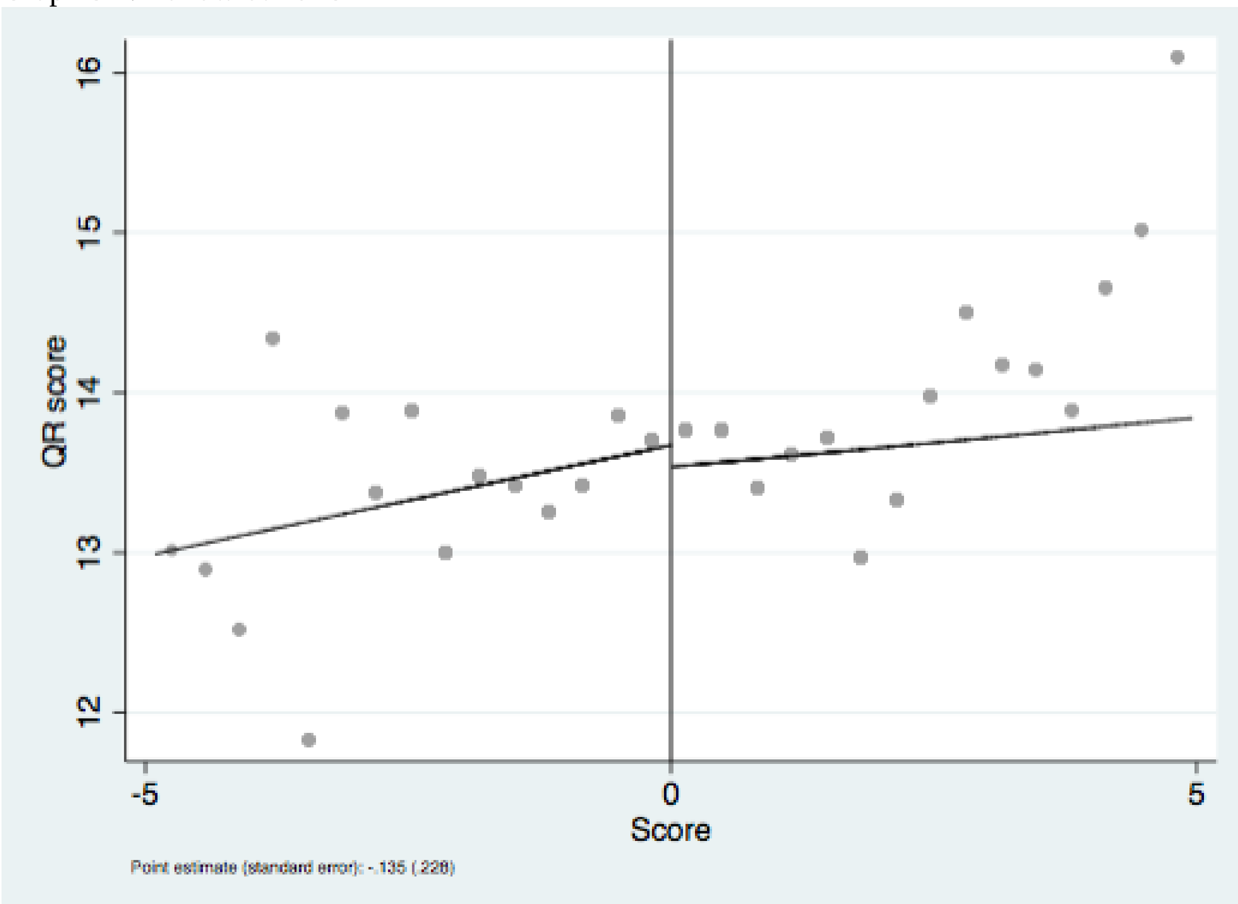
Graph 4D: Bandwidth of 2



*Note: Point estimates and standard errors are saved from regression specification (1) with a dummy variable if the student minored in economics as the dependent variable. There is a triangular kernel and 6 bins specified.

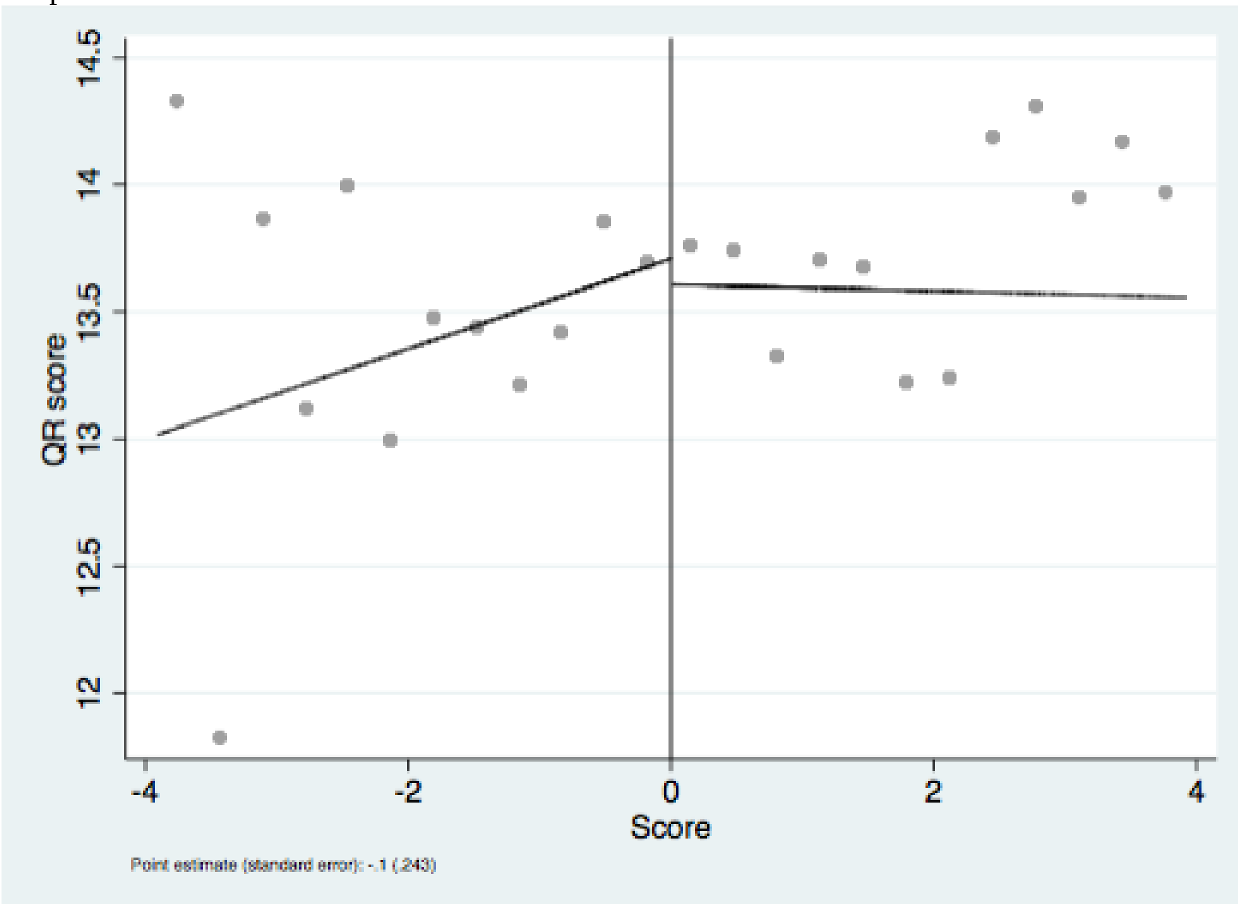
Graph 5: QR Score Balance with Pooled Sample

Graph 5A: Bandwidth of 5



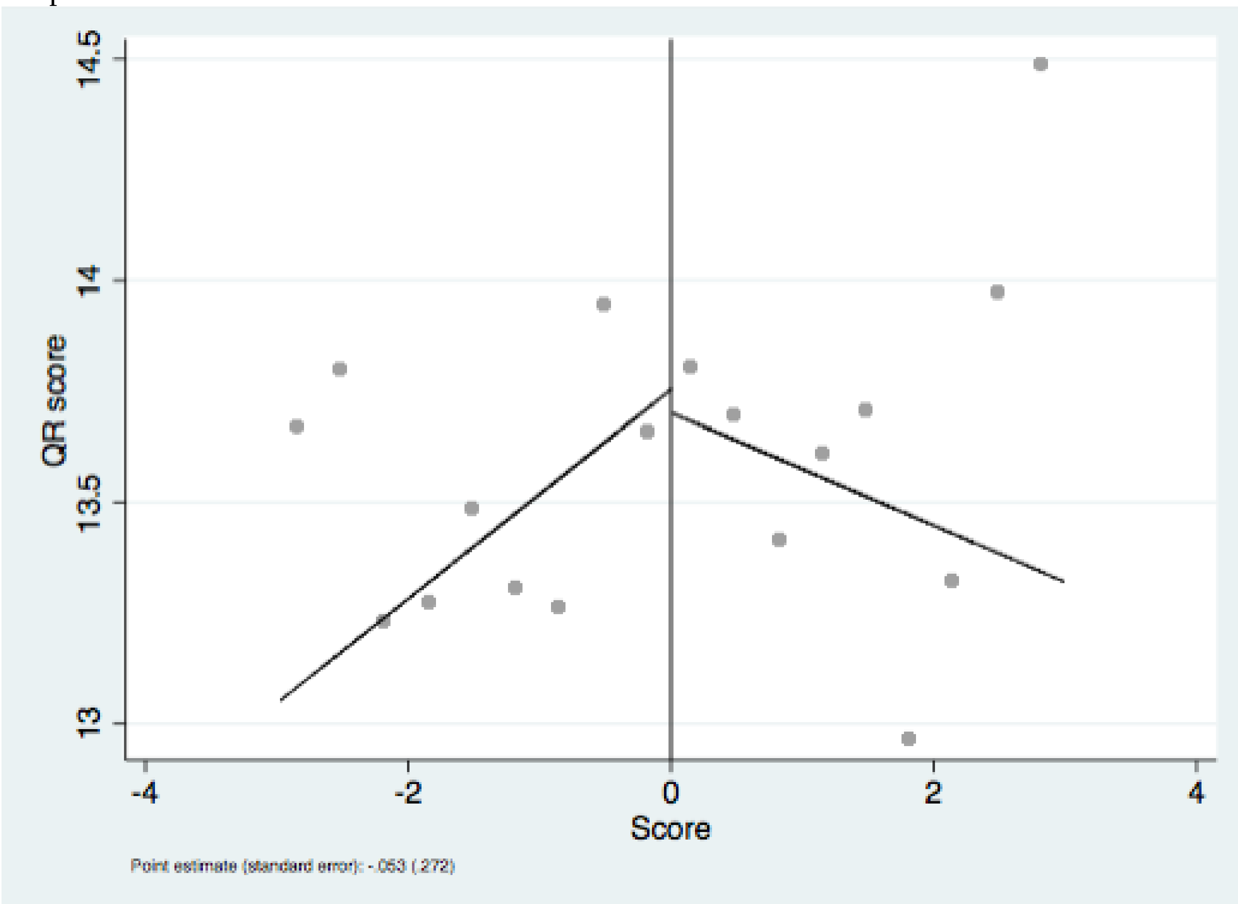
*Note: Point estimates and standard errors are saved from regression specification (1) with the QR score as the dependent variable. There is a triangular kernel and 15 bins specified.

Graph 4B: Bandwidth of 4



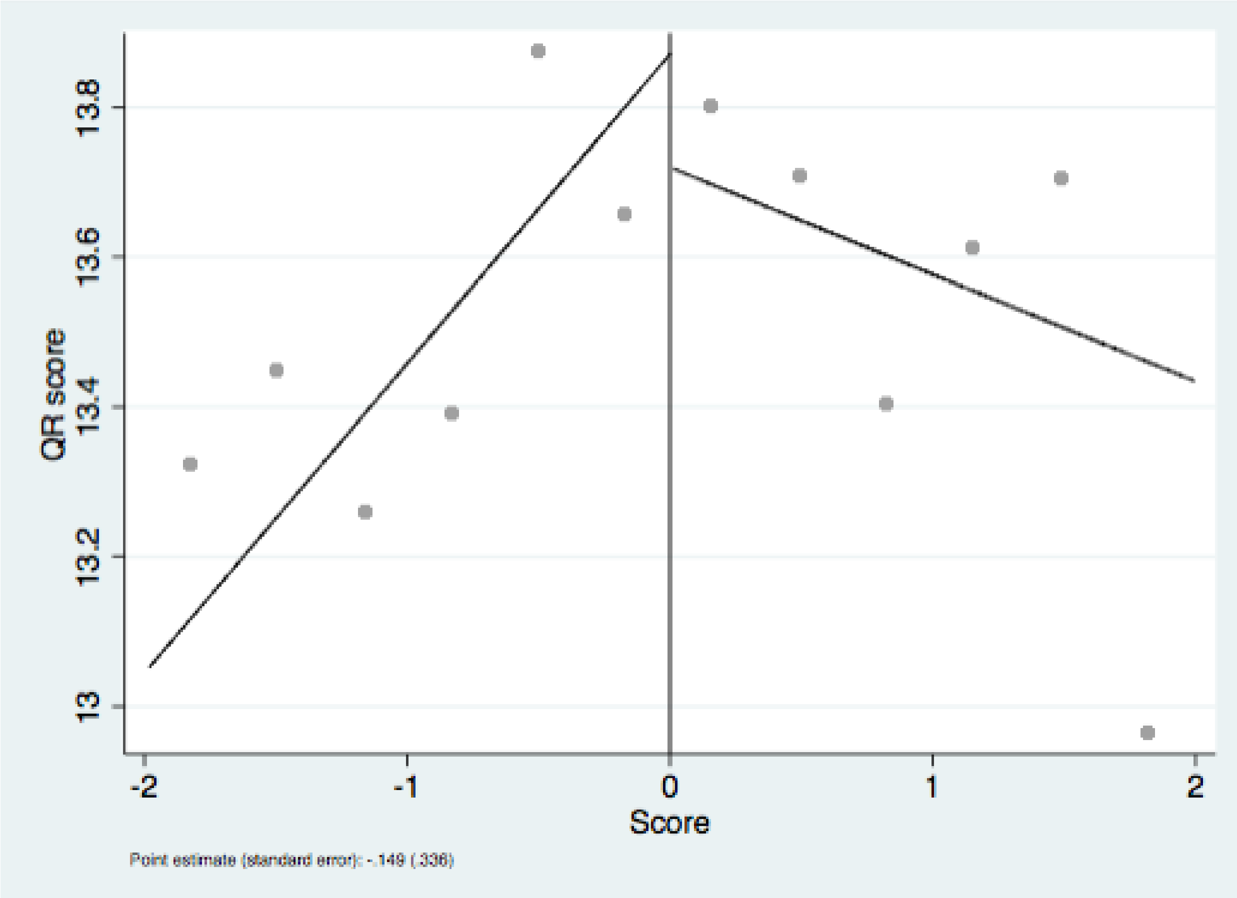
*Note: Point estimates and standard errors are saved from regression specification (1) with the QR score as the dependent variable. There is a triangular kernel and 12 bins specified.

Graph 4C: Bandwidth of 3



*Note: Point estimates and standard errors are saved from regression specification (1) with the QR score as the dependent variable. There is a triangular kernel and 9 bins specified.

Graph 4D: Bandwidth of 2



*Note: Point estimates and standard errors are saved from regression specification (1) with the QR score as the dependent variable. There is a triangular kernel and 6 bins specified.

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