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DISSERTATION

High School Graduation Rates in the United States and the Impact of Adolescent Romance

Chung Pham

This document was submitted as a dissertation in December 2010 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Nelson Lim (Chair), Bing Han, and Richard Buddin.

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I thank you all.

CHAPTER 1: INTRODUCTION

High school is an important milestone in life. People with high school diplomas earn significantly more than those without, and there are many more opportunities for social advancement, such as higher education, for high school graduates than for dropouts. There have been many controversies over the true high school graduation rate in the United States. Some researchers argue that the United States is under a high school graduation crisis, with graduation rates as low as 65 percent. Others are certain that almost 90 percent of American students graduate from high school. For that reason, the second chapter of this dissertation will provide a comprehensive review of the debate, discuss shortcomings of current methods, and propose new methods that address the shortcomings. The essay concludes that current methods that are widely used are flawed. High school graduation rates in the United States are well above 80 percent, with high racial disparity. The graduation rates for white and Asian students are around 85 percent, and the rates for Hispanic and African American students are around 70-80 percent.

High school graduation rate is also an important indicator of the quality of American future labor force. The labor force is the driving force for the rapid growth of American economy. Studying the past trend and forecasting the future movements of the graduation rate will help inform decision makers of the shape of future American labor force. The third chapter investigates the movements of the high school graduation rate in the United States over the last 20 years, and provides projection for year 2015. The Current Population Survey data were used to describe the trend in high school graduation rate. The National Longitudinal Survey of Youth 1997 data were used to model the

associations between high school graduation and individual and family characteristics. Two different approaches: a logistic regression and Generalized Boosted Modeling were used to perform out-of-sample projections with American Community Survey data. The chapter concludes that the overall high school graduation rate has been increasing slightly and will likely remain stable above 80 percent by 2015.

Finally, one important factor, although appears to be non-educational, that could play a role in one's high school academic performance is early romantic relationship. Indeed, "romantic relationship is central in adolescent life. It is the most common topic in adolescents' conversations and is the common cause of strong positive or negative emotions, more than friendship, relationship with parents or school" (Furman & Shaffer, 2003). Understanding the impact of such activities will help school and parents develop policies and partnerships that potentially could improve student achievement. The fourth chapter uses the propensity score method to investigate the impact of early adolescent romance on academic performance in terms of high school graduation, college preparation, and college enrollment, controlling for gender, race, mother education, family income, student ability, indicator of intact family, age at the start of 9th grade, indicator of neighborhood gang-related activities, school type, and urbanicity. Main findings of this chapter highlight mixed effects of early adolescent romance. Moderate dating shows a positive impact on college readiness and college enrollment. Serious dating and early sex show significant negative impact on graduation and college enrollment.

CHAPTER 2: A REVIEW OF THE HIGH SCHOOL GRADUATION RATE DEBATE IN THE UNITED STATES

INTRODUCTION

High school is an important milestone in life. People with high school diplomas earn significantly more than those without (Peng, 1985), and there are many more opportunities for social advancement, such as higher education, for high school graduates than for dropouts. Since 2002, the No Child Left Behind Act holds schools, districts, and states accountable for their academic assessment and high school graduation rates. As a result, these rates are an important indicator of academic performance.

However, there have been many controversies as to what the true high school graduation rate in the United States is. As of 2003, 70 percent of students nationwide earned diplomas in four years, but most local departments of education reported much higher rates (De Vise, 2007). This has led to a debate, in which the national education leaders have accused state and local education officials of masking the problem by publishing inflated graduation rates (Hall, 2005). This argument continues among educational researchers as well. According to Swanson (2004a & 2004b), the national graduation rate in the United States is 68 percent. Similarly, Greene and Forster (2003) found a graduation rate of 70 percent. Hirschman, Ciurej, and Willhoft (2006) strongly disagree with Swanson and Greene by claiming that the rate is actually between 80-90 percent.

Clearly, not all of the current methods can be right; 70 percent-90 percent is a wide range. This study contributes to the literature with an objective analysis on current

methods of calculating the graduation rate and provides more reliable estimates of the rate.

In this study, I summarize the most widely used methods using the National Longitudinal Survey of Youth 1997 (NLSY97), the Current Population Survey (CPS), and the Common Core of Data (CCD), and analyze the disadvantages of each method. I then recommend alternative methods that have corrected for these disadvantages.

HIGH SCHOOL GRADUATION RATES- REVIEW OF MOST INFLUENTIAL METHODS

Greene's Method

The method is based on raw baseline enrollment with some additional adjustments for population changes. Greene (2003) claims that the method can be used to "estimate public high school graduation rates nationwide and in each region and state" (p. 5). During the course of his research, Greene has developed 3 different versions of this method:

Version 1: Using 9th Grade Enrollment

$$GreeneRate = \frac{R_{2003}}{G^{9}_{99-00} + \left[G^{9}_{99-00} * \frac{G^{9-12}_{02-03} - G^{9-12}_{99-00}}{G^{9-12}_{99-00}} \right]} \qquad \text{(Formula 2.1)}$$

R_{2003} is the number of regular high school diploma recipients for the school year 2002-2003 counted in 2003. G^{i}_{j} is the enrollment of i^{th} grade(s) in academic year j. Greene counts the number of diploma recipients in 2003 and then divides by the adjusted 9th grade enrollment four years earlier (as cited in Swanson & Chaplin, 2003, p. 18). Greene also adjusts for population growth by inflating the 9^{th} grade enrollment in 1999-2000 to take into account the growth in total enrollment of grades 9^{th} to 12^{th} between 1999-2000 and 2002-2003. If I use Formula 2.1 with the Common Core of Data (CCD) (Appendix 2.1, table 2.1.1), the graduation rate is only 65 percent. [1]

Version 2: Using 8th Grade enrollment

[1] It is important to note that Greene's formula (without the population adjustment) will measure the 4 year on-time graduation rate if R_{2003} is the number of diploma recipients among the first time 9^{th} graders in 1999-2000.

Greene's method generally relies on administrative data. Therefore, Greene encounters a countrywide issue called "the ninth grade bulge". This issue results from a strikingly high left-back rate in 9^{th} grade (Haney et al., 2004), which in turn inflates enrollment in 9th grade to a level significantly higher than that in all other grades (Figure 2.1). The high left back rate stems from students' inability to adapt to the more difficult high school environment as compared to the relatively laid-back one in middle school (Black, 2004).

Being aware of this phenomenon, Greene changed to using 8^{th} grade enrollment five years earlier instead of 9^{th} grade enrollment four years earlier. It is essentially a similar approach, using a different grade enrollment, and the adjustment is not for changes in enrollment data of grades 9^{th} to 12^{th}, but instead for enrollment changes in the entire jurisdiction (grades 1^{st} to 12^{th}).

$$GreeneRate = \frac{R_{2003}}{G^{8}_{98-99} + \left[G^{8}_{98-99} * \frac{G^{1-12}_{02-03} - G^{1-12}_{98-99}}{G^{1-12}_{98-99}} \right]} \qquad \text{(Formula 2.2)}$$

According to Formula 2.2, the graduation rate is 75 percent with the CCD data (Appendix 2.1, table 2.1.1).

Greene and Forster (2003) acknowledge that the 8^{th} grade enrollment data might not be very close to the true number of first time 9^{th} graders since a large number of students attend private school in 8^{th} grade but enter public school in 9^{th} grade. In addition, the number of 8^{th} grade dropouts might be another source of bias. I do not know yet if this part of 8^{th} grade population and private-public transfer tend to offset each other or one is significantly higher than the other.

Version 3: Using 8th, 9th, and 10th Grades Enrollments

Concerned with the unreliability of 8th grade enrollment as a substitute for ninth grade enrollment due to the private-public transfer discussed above, Greene decided to use the average of 8th, 9th, and 10th grade enrollments instead of just one of them in order to "smooth out" the denominator (Greene & Forster, 2003). This version also adjusts for growth in the population of grades 9th to 12th.[2]

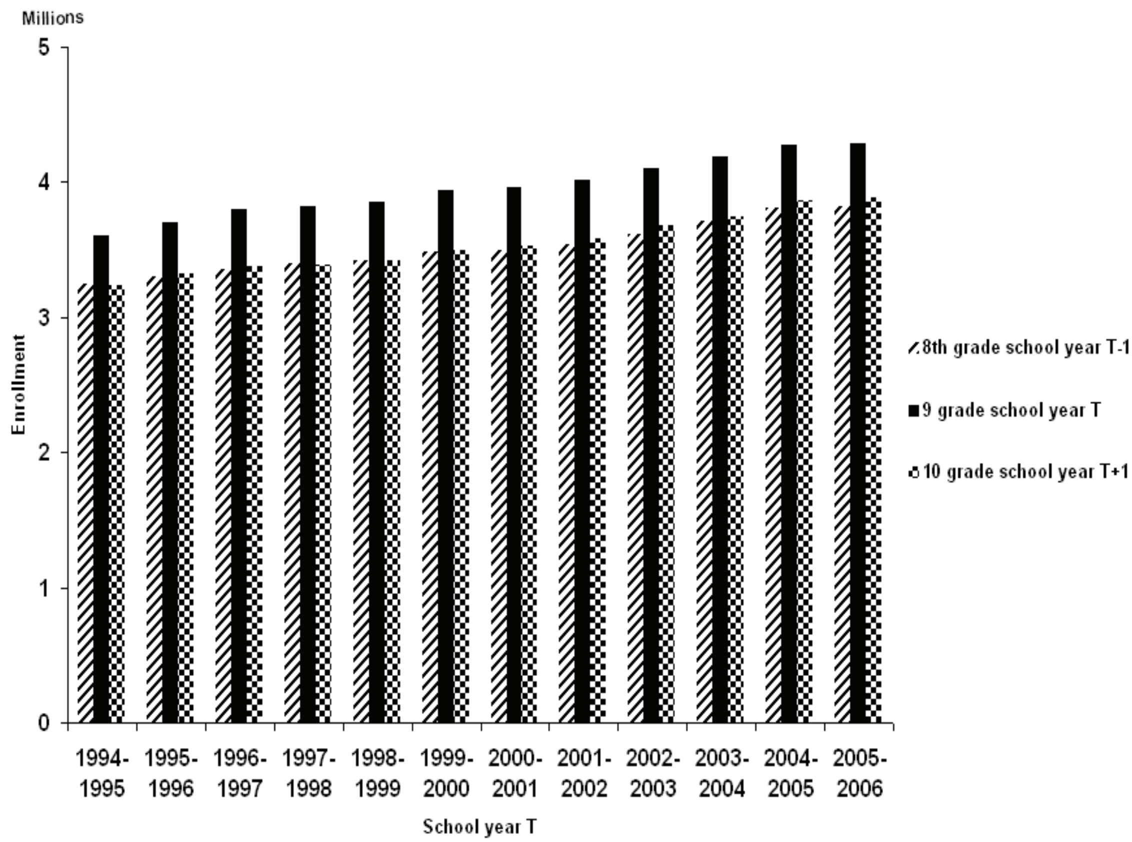
$$Greene's Rate = \frac{R_{2003}}{G^{s}_{98-99-00} + (G^{s}_{98-99-00} * \frac{G^{9-12}_{02-03} - G^{9-12}_{98-99}}{G^{9-12}_{98-99}})} \quad \text{(Formula 2.3)}$$

$G^{s}_{98-99-00} = \frac{1}{3}(G^{98-99}_{8} + G^{99-00}_{9} + G^{00-01}_{10})$ is the average of the 8th grade enrollment in 1998-1999, the 9th grade enrollment in 1999-2000, and the 10th grade enrollment in 2000-2001. G^{i}_{j} is the enrollment of ith grade(s) in academic year j. Under Formula 2.3, this version yields a graduation rate of 71 percent (Appendix 2.1, table 2.1.1).

Figure 2.1 shows that 8th grade and 10th grade enrollments are about the same, while 9th grade has around 20 percent more students than both 8th grade and 10th grade. This implies that the approach of smoothing out 8th, 9th, and 10th grade is less biased than using 9th grade alone, but is still questionable because the "9th grade bulge" remains, which is significant.

[2] Later, the population adjustment uses population estimates by age, race, and gender reported by United States Census. (Greene& Winter, 2005; Greene& Winter, 2006).

Figure 2.1. The Ninth Grade Bulge



Source. Author's calculations using CCD.

Greene's rate is still biased downward due to one significant source of error--adjustment for population changes, despite the fact that using 8th grade enrollment should theoretically bring the graduation rate closer to the "true" rate because it bypasses the "9th grade bulge." Greene argues that student population will grow over time, so we need to adjust for this change. In other words, the number of diploma recipients in 2003 tends to over estimate the true number of diploma recipients among the 9th grade cohort of 1999-2000. However, this adjustment is illogical because students receiving diplomas in 2003

are already born, hence this population cannot grow. In addition, when we calculate graduation rate for the United States as a whole, the effect of transfers from one school to another is eliminated, hence there would be no new students receiving high school diplomas in 2003 to adjust for, unless they, as migrants, entered the United States after baseline and graduated in 2003. Using the CPS, I was able to track the ratio of senior students in 2002-2003 who entered the United States after baseline. It is estimated that this population accounts for only 1.6 percent of the cohort that graduated in 2003 [3]. The adjustment, if any, should only be for this change in population. To correct for this change, the adjusted number of high school diplomas awarded (the corrected adjustment in Figure 2.2) should be: $R_{2003}^{Adjusted} = R_{2003}(1-M)$, where M is the ratio of senior students in academic year 2002-2003 who migrated into the United States after baseline (see Figure 2.2 for a comparison of corrected adjustment versus Greene's adjustment). The population adjustment is also strongly opposed by Phelps (2005). Phelps' example using a hypothetical school district reveals fully the flaws of the population adjustment rationale. This example is described in details in Appendix 2.4.

National Center for Education Statistics (NCES) 's Methods

The Dropout-Based Method

The dropout-based method, as applied in Winglee, Marker, Henderson, Young, and Hoffman (2000), relies on the number of students known to have dropped out. Its definition of the dropout rate is the proportion of students who leave school each year without completing a high school program, which means GED holders are also counted as dropouts. There are two variants of this method: longitudinal and synthetic.

[3] We might need a larger sample to have a more reliable estimate. The CPS does not allow for the estimation of the "outflow" of U.S. students who moved to other countries after entering 9th grade in 1999.

NCES's longitudinal graduation rate

$$NCESRate = \frac{C_{2003}}{C_{2003} + D^{12}_{02-03} + D^{11}_{01-02} + D^{10}_{00-01} + D^{9}_{99-00}} \quad \text{(Formula 2.4)}$$

C_{2003} is the total number of high school diplomas awarded (not including GEDs) in 2003.

D^{i}_{j} is the total number of students who dropped out of grade *i* during the academic year *j*.

NCES's synthetic (or reconstructive) graduation rate

One problem with the above mentioned longitudinal method is that the number of dropouts is hard to track. Therefore, this alternative method deals with this problem by assuming that dropout rates are stable over time.

$$NCESRate = \frac{C_{2003}}{C_{2003} + D^{12}_{02-03} + D^{11}_{02-03} + D^{10}_{02-03} + D^{9}_{02-03}} \quad \text{(Formula 2.5)}$$

Note that neither of these methods relies on enrollments but dropouts. Therefore, theoretically, they should give more accurate estimates of the graduation rate, but one major weakness is that they are both based on the number of students known to have dropped out. Tracking this dropout rate is not simple, and in many places, one student is counted as a dropout only when he/she officially is registered as a dropout, which is unlikely (De Vise, 2007). According to Winglee et al. (2000), the NCES also acknowledges the extent of nonconformance in the CCD's dropout data and suggests an adjustment to deal with this issue. If this adjustment works, it will drive the graduation rate down by 2 percentage points compared to the CCD's raw graduation rate. [4]

Due to the nonconformance issue, I was only able to use a sample of schools that reported both the number of diploma recipients and the number of dropouts. These

[4] Presenting the adjustment is beyond the scope of this paper. For more information on the adjustment, please refer to Winglee et al.(2000), pages 13-28.

schools and districts might conform in some years but might not in others. Therefore, in this study, I analyze only the synthetic graduation rate using the academic year 2001-2002 data[5]. Using this rate, the CCD dropout data (Appendix 2.1, Table 2.1.2) yields a graduation rate of 81 percent.

Averaged Freshman Graduation Rate (AFGR)

According to the NCES (Seastrom, Hoffman, & Chapman, 2006):

> The Averaged Freshman Graduation Rate provides an estimate of the percentage of high school students who graduate on time by dividing the number of graduates with regular diplomas by the size of the incoming freshman class 4 years earlier… The size of the incoming freshman class is estimated by summing the enrollment in eighth grade in one year, ninth grade for the next year, and tenth grade for the year after and then dividing by three. The averaging is intended to account for prior year retentions in the ninth grade (p. 1).

$$AFGR = \frac{R_{2003}}{\frac{1}{3}(G^{8}_{98-99} + G^{9}_{99-00} + G^{10}_{00-01})} \qquad \text{(Formula 2.6)}$$

In this case, the AFGR method is essentially the same as Greene's, using 8th, 9th and 10th grades enrollments, but without the population adjustment. As a result, it is also subject to the bias resulting from the aforementioned "Ninth Grade Bulge". According to the AFGR method, the CCD data (Appendix 2.1, Table 2.1.1) yields a graduation rate of 75 percent (note that it produces exactly the same result as Greene's method using 8th , 9th, and 10th grades enrollment without the population adjustment (Figure 2.2)).

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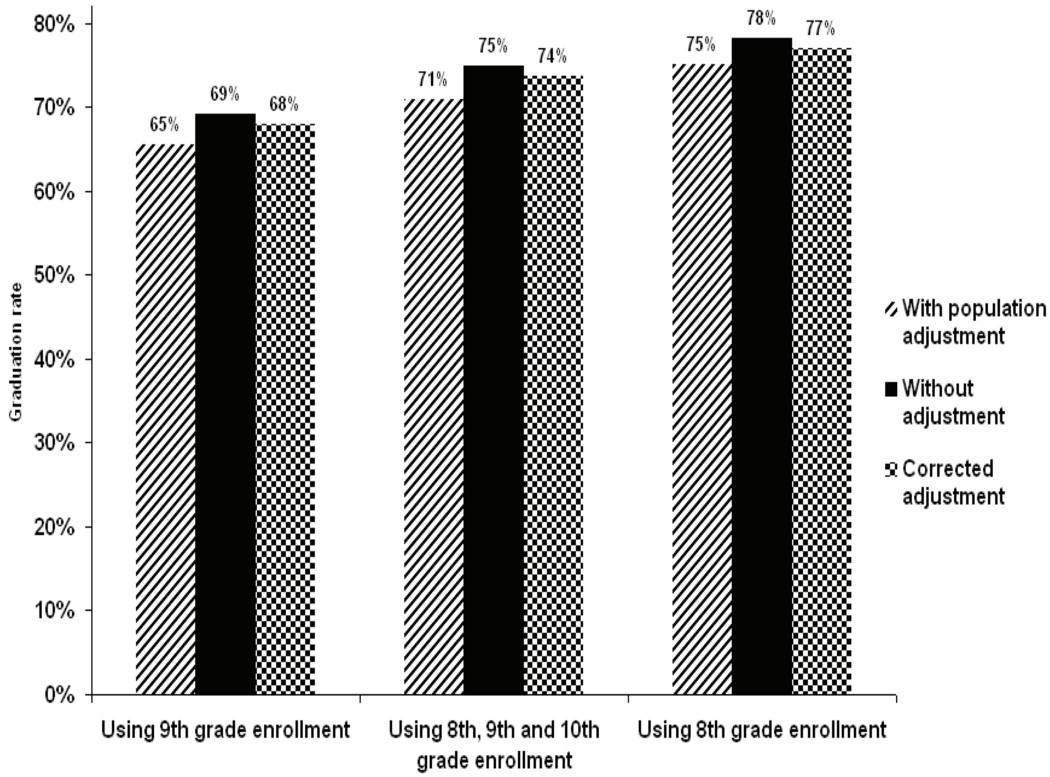
[5] At the time this study is written, the author couldn't obtain dropout data for school year 2002-2003, so data for school year 2001-2002 was used instead.

Figure 2.2. Greene's Graduation Rates



Swanson's Cumulative Promotion Index (CPI) Method

According to Swanson and Chaplin (2003) and Swanson (2004b), the Cumulative Promotion Index reflects "the probability that a student entering 9th grade will complete high school on time with a regular diploma".

$$CPI\_Rate = \left[\frac{G^{10}_{03-04}}{G^{9}_{02-03}}\right]\left[\frac{G^{11}_{03-04}}{G^{10}_{02-03}}\right]\left[\frac{G^{12}_{03-04}}{G^{11}_{02-03}}\right]\left[\frac{R_{2003}}{G^{12}_{02-03}}\right] \qquad \text{(Formula 2.7)}$$

It is important to note that if we use this method in a system that has stable dropout and retention rates in each grade, it is expected to produce the same rates as Greene's method (9th grade enrollment, no population adjustment). This holds true

because in a steady state, the enrollments in each grade tends to be stable over time and will cancel each other out. For example, Formula 2.7 shows that if $G^{10}_{03-04} \approx G^{10}_{02-03}$;

$G^{11}_{03-04} \approx G^{11}_{02-03}$; and $G^{12}_{03-04} \approx G^{12}_{02-03}$ then the formula has become: $CPI\_Rate \approx \left[\frac{R_{2003}}{G^{9}_{02-03}}\right]$

The CCD data (Appendix 2.1, table 2.1.1) yields a graduation rate of 70 percent. This is exactly what was expected: the CPI method produces a graduation rate close to Greene's (9th grade enrollment, no population adjustment, which was 69 percent, as shown in Figure 2.2). Because this method is similar to Greene's, it is also subject to the "ninth grade bulge" as discussed earlier.

Moreover, following the logic of the CPI is also paradoxical. If the method truly estimates "the probability that a student entering 9th grade will complete high school *on time* with a regular diploma", then counting 8th grade as part of high school, instead of starting with 9th grade, should logically result in a lower "on time" graduation rate. However, Swanson's formula will likely lead to the opposite. In fact, Swanson's "on time" graduation rate starting from 9th grade is only 70 percent (as calculated above), while his "on time" graduation rate starting from 8th grade is as high as 79 percent (as shown in Formula 2.8). The reason Formula 2.8 yields a higher rate is due to the "ninth grade bulge".

$$CPI\_Rate = \left[\frac{G^{9}_{03-04}}{G^{8}_{02-03}}\right]\left[\frac{G^{10}_{03-04}}{G^{9}_{02-03}}\right]\left[\frac{G^{11}_{03-04}}{G^{10}_{02-03}}\right]\left[\frac{G^{12}_{03-04}}{G^{11}_{02-03}}\right]\left[\frac{R_{2003}}{G^{12}_{02-03}}\right] \qquad \text{(Formula 2.8)}$$

In fact, the CPI method cannot tell who graduates on time and who does not. First, Formula 2.7, by starting with a raw 9th grade enrollment in 2002-2003 does not exclude retained students. They, by definition, are already at least 1 year late. Second, it counts all diplomas awarded in 2003, which, by the same token, also includes all the retained

students from previous years who happen to have graduated in 2003. A detailed analysis of how Swanson misestimated the on time graduation rate is presented in Appendix 2.5.

HIGH SCHOOL GRADUATION RATES- AUTHOR'S RECOMMENDED METHODS

Population-Based Method

The population-based method (as demonstrated in Formula 2.9) takes a snapshot of students within a certain age range and derives the proportion with high school diplomas. This method requires that the population of interest be old enough that only a negligible number are still in high school. The minimum age that satisfies this requirement, according to the CPS, is 22. At this age, almost every individual either has had a diploma, GED, or has dropped out. [6]

$$\text{Graduation rate} = \frac{\text{Total high school graduates, no college} + \text{College graduates and college students}}{\text{Total population of the age group that have attended high school}} \qquad \text{(Formula 2.9)}$$

In the numerator of the formula, most college students and college graduates have a high school diploma, but some might have gotten into college with a GED. These high ability GED holders (though small in number) are counted toward high school graduates. It is important to note that the population-based method excludes most of the GED holders and only counts those with GED that have attended college (using the CPS, I

[6] Mishel&Roy (2006) calculates completion rates for those ages 25-29 by gender/race from 1994-2004. The major difference between Mishel's method and our Population-Based method is the exclusion of GED in our method. Mishel's calculation using CPS in Mishel&Roy (2006) did not exclude GED.

estimated this proportion to be about 20 percent of total GED holders). The reason to exclude GEDs from high school diplomas stems from the fact that later outcomes such as job performance and earnings of GEDs are much more like high school dropouts than that of high school graduates (Cameron & Heckman, 1993; Heckman & LaFontaine, 2006).

Formula 2.9 yields graduation rates of 83-85 percent for the population aged 22-24. These rates are highest for Whites and Asians (90 percent), followed by African Americans (80 percent), and Hispanics (70 percent). Graduation rates by race for the period 2000-2006 are reported in Table 2.1.

Table 2.1. Graduation Rates, 2000-2006, Population-Based Method

	Final Graduation Rates (22-24 year-old youth) (%).						
Race/Ethnicity	2000	2001	2002	2003	2004	2005	2006
White	88	86	87	89	88	87	89
African American	81	78	80	78	79	81	80
Hispanic	68	68	70	70	73	72	72
Other races	90	92	89	88	88	90	89
All races combined	85	83	84	84	84	84	85

Source. Author's calculations using CPS.
NOTE. Most of students in the "Other races" group are Asian.

Longitudinal Method

The longitudinal method follows a cohort of representative youth over time as illustrated in Formula 2.10. For the students in the 1997 9^{th} grade cohort, I allowed 3 more years for them to graduate after the expected graduation point before tallying the number with diplomas. Similarly, for the students in the 1997 8^{th} grade cohort, I allow 2 years beyond the expected graduation point.

$$\text{Graduation rate} = \frac{\text{Number of regular diplomas by 2004 of the 8th + 9th grade cohorts in 1997}}{\text{Total number of 8th +9th graders enrolled in 1997}} \qquad \text{(Formula 2.10)}$$

In the National Longitudinal Survey of Youth 1997 (NLSY97) data, there are "right-censored" observations (people in that cohort who are still struggling in school after 2004), but this group is relatively small (less than 1 percent of the cohort), and therefore has an insignificant effect on the estimated graduation rate. Using the NLSY97 data, the longitudinal method yields a graduation rate of 81 percent by 2004. This graduation rate is somewhat lower than the one obtained with the CPS data (84 percent for 2004), probably because we are looking at a younger population (19-24 year olds in the NLSY97 as compared to 22-24 year olds in the CPS [7]). Mishel and Roy (2006) also used the National Education Longitudinal Study of 1988 (NELS 88) and the NLSY97 to calculate longitudinal graduation rates by race and gender. Full results are reported in Table 2.2. Differences between results reported here and those found by Mishel and Roy (2006) are largely due to differences in cohorts. The longitudinal method can also be used to calculate the on time graduation rate, presented in Appendix 2.5. Appendix 2.6 presents a case study, a simulation using Texas Education Agency's data.

[7] When I apply the Population-Based formula for the age range of 19-24 using CPS, October 2004, I got 83%, marginally higher than the estimate using NLSY97.

Table 2.2. Graduation Rates, Longitudinal Method

Race/Ethnicity	Graduation rates (%)		
	NLSY97 (Author's calculation)	NLSY97 (Mishel&Roy. 2006)	NELS88 (Mishel&Roy. 2006)
White	83	85	85
African American	74	75	74
Hispanic	79	76	74
Other	86	-------	95
All races combined	81	82	83

NOTE. Most of students in the "Other" group are Asian.

CONCLUSIONS

America was shock at the news that only 65-70 percent of American high school students graduate as a result of Greene and Swanson's calculations. The Bush Administration and national education leaders endorsed the results, called it a "dropout crisis", and all 50 governors were ready to build their education policies based on these percentages (De Vise, 2007). The National Center for Education Statistics (NCES) also has its own estimates of the graduation rate, but the NCES's methods are either incorrect or require data that are currently very difficult to obtain.

Although some researchers have questioned Greene's methods (Phelps, 2005; Mishel & Roy, 2006), there has been little corroboration of their criticism. My research puts all critics together to form a comprehensive review of Greene's methods. In addition, I have also analyzed the pitfalls in Swanson's CPI method. My research indicates that Greene and Swanson's calculations, which are based on administrative enrollment data, are methodologically biased, and my calculations raises questions regarding whether a dropout crisis exists in the United States. The overall graduation rate is above 80 percent. The graduation rates for Whites and Asians are around 85 percent, and the rates for Hispanics and African Americans are around 70-80 percent.

My analyses also prove that the NCES's Average Freshman Graduation Rate method and Swanson's CPI method do not estimate on time graduation rates. Neither the NCES nor Swanson could bypass the "ninth grade bulge" and avoid counting students who graduate late as on time.

To estimate graduation rates, like Mishel & Roy, (2006), I recommend using the Longitudinal and Population-Based methods (but separate most of GED holders from

high school graduates). The Population-Based method is the simplest way since it just requires a representative cross-sectional data. The Longitudinal method needs an acceptable attrition rate and a follow-up period long enough to capture most of the late graduations.

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APPENDIX 2.1
COMMON CORE OF DATA (CCD)

The Common Core of Data (CCD) is a program of the U.S. Department of Education's National Center for Education Statistics (NCES) that annually collects fiscal and non-fiscal data about all public schools, public school districts and state education agencies in the United States (NCES website).

Table 2.1.1. Enrollment Data

Cohort	Year / School year	Count
8th grade	1998-1999	3,480,371
Grades 1-12	1998-1999	41,704,530
9th grade	1999-2000	3,934,876
Grades 9-12	1999-2000	13,165,830
10th grade	2000-2001	3,491,013
8^{th} grade	2002-2003	3,709,195
9^{th} grade	2002-2003	4,104,719
10^{th} grade	2002-2003	3,584,412
11^{th} grade	2002-2003	3,228,867
12^{th} grade	2002-2003	2,989,509
Grades 9-12	2002-2003	13,907,507
Grades 1-12	2002-2003	43,387,553
9^{th} grade	2003-3004	4,190,636
10^{th} grade	2003-2004	3,675,312
11^{th} grade	2003-2004	3,277,253
12^{th} grade	2003-2004	3,046,516
Total regular diplomas awarded	2003	2,719,947

Source. Author’s calculations using the CCD data.

Table 2.1.2. Dropout Data

Cohort	School year	Dropout Counts
12th grade	2001-2002	118,864
11th grade	2001-2002	117,177
10th grade	2001-2002	133,335
9th grade	2001-2002	120,111
Total regular diplomas awarded	2001-2002	2,084,682

Source. Author's calculations using the CCD data.
NOTE. Table 2.1.2 only includes schools and districts that reported both number of dropouts and number of diploma recipients in academic year 2001-2002.

APPENDIX 2.2
CURRENT POPULATION SURVEY (CPS)

The CPS has been the main source of information on the labor force characteristics of the U.S. population. The CPS is a nationally representative data for non-institutional population from a monthly survey conducted by the Bureau of the Census since late 1960s, with a sample of around 50,000 households. The CPS conducted in October focuses primarily on Education and School enrollment.

Table 2.2.1. CPS Data for Graduation Rates from 2000 to 2006

Number of people	Year						
	2000	2001	2002	2003	2004	2005	2006
22-24 years old	10,739,727	10,749,115	11,281,151	11,853,048	11,852,868	11,581,081	11,814,022
HS diplomas	2,999,680	2,986,351	3,060,433	3,290,108	3,288,112	3,206,477	3,120,700
College	6,276,587	6,208,263	6,573,814	6,914,692	6,893,668	6,732,788	7,165,000
College with GED	189,079	311,291	178,799	215,491	195,747	197,517	233,280
Graduation rate (%)	85	83	84	84	84	84	85

APPENDIX 2.3
NATIONAL LONGITUDINAL SURVEY OF YOUTH 1997 (NLSY97)

The NLSY97 is a longitudinal study following up a sample of approximately 9,000 youth who were 12 to 16 years old as of December 31, 1996. Youth are interviewed annually. This data set consists of extensive information about youth's educational experiences over time.

Table 2.3.1. Final Graduation rates using NLSY97.

	8^{th} and 9^{th} graders in 1997	Regular diplomas by 2004	Graduation rate (%)
Total	7,983,923	6,471,213	81
White	5,221,968	4,350,421	83
African American	1,310,523	965,986	74
Hispanic	1,033,773	816,577	79
Other	475,547	411,205	86

NOTE. Most of students in the “Other” group are Asian.

Table 2.3.2. On time Graduation rates using NLSY97.

	First time 9^{th} graders in 1997, 1998, 1999	Regular diplomas on time	On time graduation rate (%)
Total	9,601,234	7,030,983	73
White	6,404,004	4,929,161	77
African American	1,527,793	952,732	62
Hispanic	1,231,916	821,318	67
Other	506,765	393,756	78

NOTE. Most of students in the “Other” group are Asian.

APPENDIX 2.4
SUNBELTURBIA SCHOOL DISTRICT EXAMPLE (PHELPS, 2005, P. 8).

Sunbelturbia is a hypothetical school district that has positive population growth due to both migration and fertility, and hence it has the enrollment data described in Table 2.4.1. *Sunbelturbia*'s students are excellent. Nobody will be either left back or drop out of high school before graduation. Therefore, the graduation rate is 100 percent.

Employing Greene's method using 8th grade enrollment for instance, the population adjustment would be $\frac{162{,}500\text{-}130{,}000}{130{,}000} = 25\%$

Given that all 11,000 students in senior year will graduate, Greene's graduation rate would be: $Greene\_rate = \frac{11,000}{10,000 + (10,000 * 25\%)} = \frac{11,000}{12,500} = 0.88$

Due to his flawed population adjustment, Greene would have calculated an 88 percent graduation rate for *Sunbelturbia* while it is truly 100 percent.

Table 2.4.1. Sunbelturbia School District's Enrollment

Grade level	Year 0 enrollment	Year 4 enrollment
K	10,000	14,000
1	10,000	13,750
2	10,000	13,500
3	10,000	13,250
4	10,000	13,000
5	10,000	12,750
6	10,000	12,500
7	10,000	12,250
8	10,000	12,000
9	10,000	11,750
10	10,000	11,500
11	10,000	11,250
12	10,000	11,000
Total	130,000	162,500

Source. Phelps (2005)

APPENDIX 2.5
DETAILED ANALYSIS OF ON TIME GRADUATION RATE BY SWANSON

My analysis in Figure 2.5.1 shows how Swanson misestimates the on time graduation rate. To do this, I have to separate the student population into 5 different cohorts. The students who entered 8th grade for the first time in the 1998-1999 school year are called NEW students. After 8th grade, only the portion of them who continue on to 9th grade are referred to as NEW. In 1999-2000, I refer to the students who have to repeat 9th grade as "OLD1" students. Similarly, 10th graders in 2000-2001 who have to repeat the grade are referred to as OLD2; 11th graders in 2001-2002 who repeat the grade are OLD3; and 12th graders left back in 2002-2003 are OLD4.

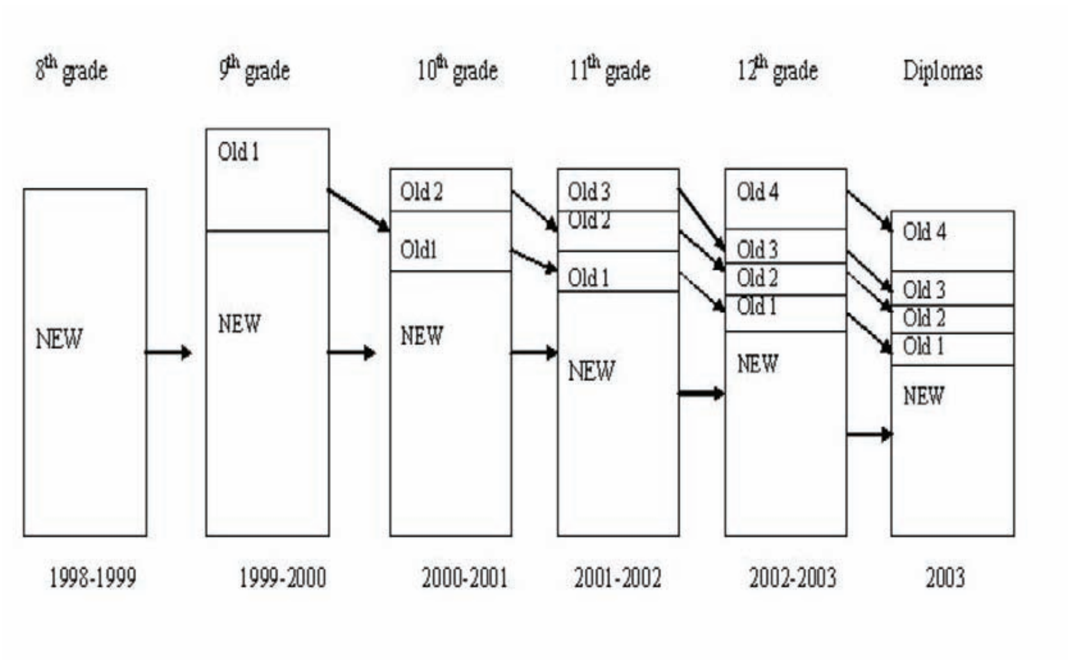
The correct on time graduation rate would be: $\frac{NEW_{2003}}{NEW_{1999-2000}}$ (9)

By counting all diplomas awarded in 2003 and dividing them by the raw 9th grade enrollment in 1999-2000, Swanson essentially applies the incorrect formula:

$$\frac{NEW_{2003} + OLD1_{2003} + OLD2_{2003} + OLD3_{2003} + OLD4_{2003}}{NEW_{1999-2000} + OLD1_{1999-2000}} \qquad (10)$$

We can see that (9) does not necessarily equal (10), and the comparison may vary depending on the tendency to graduate of the retained students.

Figure 2.5.1. On time Graduation Vs Graduation in Swanson's CPI Method.



NOTE. "New" are students who have never been left back. "Old1", "Old2", "Old3", and "Old4" are students who were left back in 9th,10th,11th, and 12th grade respectively.

APPENDIX 2.6
ON TIME GRADUATION RATES

I look at the cohort of first time 9th graders in 1997, first time 9th graders in 1998, and first time 9th graders in 1999 . I define on time graduation for the cohort 9th grade in 1997 as having a regular high school diploma by Fall 2001, on time graduation for cohort 9th grade in 1998 as having a regular diploma by Fall 2002, and on time graduation for cohort 9th grade in 1999 as having a regular diploma by Fall 2003.

Students who do not show up in the sample at the time of on time graduation are excluded from my calculation. I acknowledge that attrition might affect the results in the sense that people who dropped out of the sample might have a different tendency to graduate than the people who stayed in the sample. Nevertheless, sample weights provided by NLSY97 are expected to correct at least part of the problem.

$$\text{On-time rate} = \frac{D_j^i}{E_j} \qquad (13)$$

D_j^i is the total diplomas awarded by year i (on time) for the 9th grade cohort in year j. E_j is the total number of first time 9th graders in year j. Since the sample for a single year is rather small, I combine all 3 years and calculate a combined on time graduation rate.

$$\text{Combined on-time rate} = \frac{D_{97}^{01} + D_{98}^{02} + D_{99}^{03}}{E_{97} + E_{98} + E_{99}} \qquad (14)$$

Table 2.6.1 presents on time graduation rates by cohort, and table 2.6.2 presents on time graduation rate by race/ethnicity.

Table 2.6.1. On time Graduation Rates by Cohort

Cohort	On time graduation rates (%)
First time 9th graders in 1997	74
First time 9th graders in 1998	74
First time 9th graders in 1999	70
Combined	73

Source. Author's calculations using NLSY97.

Table 2.6.2. On time Graduation Rates by Race/Ethnicity

Race/Ethnicity	On time graduation rates, NLSY97 (%)	On time graduation rates, NELS 88 (Mishel&Roy. 2006) (%)
White	77	82
African American	62	63
Hispanic	67	66
Other	78	93
All races combined	73	78

NOTE. Most of students in the "Other" group are Asian.

APPENDIX 2.7
UNDERSTANDING HIGH SCHOOL GRADUATION RATES, A SIMULATION

To better understand the differences between methods, I have developed a simple model of a hypothetical high school system. In this model, the student population has a constant number of first-time 9^{th} graders entering each year. The total enrollment in a given grade is the sum of first time accession and the number of left back students from the same grade the year before. Each year, some students drop out and some are left back. The non-dropout, non-left-back students will continue to the next grade or graduate depending on their current grade.

This model also assumes that dropouts are permanent (no dropouts will return to the system), there are no migrations, and the left back and dropout rates in a given grade remain stable over time. In a given year, the model's inflow is the number of students entering the system for the first time, and the outflow is the number of students receiving high school diplomas. The high school final graduation rate in the steady state is simply the $\frac{\text{outflow}}{\text{inflow}}$ ratio. The follow up of the first cohort to graduation gives us an estimate of the on time graduation rate. Figure 2.7.1 illustrates how this hypothetical high school system works. Note that the number of years it takes the model to reach its steady state depends on the retention rates in each grade. The higher the retention rate, the longer it takes to reach the steady state. Once it reaches its steady state, the high school system's graduation rate no longer depends on the retention rate in any grade. Indeed, it is the number of diplomas awarded divided by the total population of first time 9^{th} graders. It is also important to note that only dropouts matter because as long as a student persists, he/she will finally graduate one day.

To estimate model parameters for the national level, cross sectional data like the CPS cannot be used while current longitudinal data such as the NELS and NLSY have selection biases in later grades (only those who were not retained in 9^{th} grade are passed on to 10^{th} grade, and in the following year, the retention rate in 10^{th} grade will be biased because the 10^{th} grade we are observing has no retained students to start with).

While obtaining a national level of dropout rates and retention rates by grade is difficult, one state that tracks these statistics very well is Texas. In the last few years Texas has come under fire for its supposed graduation rate crisis. Swanson (2006) has criticized Texas educators for distorting the numbers to inflate the graduation rate to 84 percent while according to his model, it is only 67 percent.

In my simulation, I assume that the Texas High School system always has 1000 new students each year coming to 9^{th} grade from 8^{th} grade (implying that the population is stable). At the end of each academic year, some of these students will pass on to 10^{th} grade, some will be retained, and others will drop out of high school. Table 2.7.1 lists Texas' dropout and retention rates, and Figure 2.7.2 illustrates my simulation in detail.

In Figure 2.7.2, in Year 1, 1000 first time 9^{th} graders enter the high school system. (In Year 1, the system only has 9^{th} grade). The retention rate for 9th grade is 16.9 percent, and the dropout rate is 3.1 percent. Therefore, the number of left back students is 169 (1000*16.9%), and the number of dropouts in 9^{th} grade is 31 (1000*3.1%). We are left with 800 students (1000-169-31) who will continue to 10^{th} grade. A similar line of reasoning can be applied to following years when the system starts to include higher grades.

With the information provided in Table 2.7.1, it takes around 10-12 years for the system to reach its steady state, which in a given year sees 1000 new students enter, 160 drop out in the entire system from all grades (37 from 9th grade, 42 from 10th grade, 35 from 11th grade, and 45 from 12th grade), and 840 graduate (1000-160). The correct high school graduation rate is therefore 84 percent (which exactly matches the number reported by Texas Education Agency for the 2002-2003 school year (Swanson. 2006)).

With Swanson's method (Formula 2.8), however, the steady state's graduation rate is only 70 percent:

$$CPI\_Rate = \left[\frac{963+86}{1000+203}\right]\left[\frac{921+57}{963+86}\right]\left[\frac{884+42}{921+57}\right]\left[\frac{840}{884+42}\right] = \frac{840}{1000+203} = 0.70$$

Note that in the steady state, enrollment in each grade remains stable over time (9th grade enrolment in year 12 is exactly the same as 9th grade enrolment in year 11), so they cancel each other out, and we are left with the final number of diplomas as the numerator and the 9th grade enrollment as the denominator. Swanson's estimate is much lower than the correct graduation rate.

Not surprisingly, Greene's method using 9th grade enrollment (denoted Greene (9) in Figure 2.7.2) also yields a graduation rate of 70 percent:

$$Greene\ Rate = \frac{840}{(1000+203)+\left[(1000+203)*\frac{4158-4158}{4158}\right]} = \frac{840}{(1000+203)} = 0.70$$

Assuming that 8th grade enrollment is always 1000 students and all of them pass on to 9th grade, Greene's method using 8th, 9th, and 10th grade enrollments (denoted as Greene(S) in Figure 2.7.2) yields a graduation rate of 77 percent:

$$Greene's\ Rate = \frac{840}{((1000+1203+1049)/3) + \left[((1000+1203+1049)/3) * \frac{4158-4158}{4158}\right]}$$

$$= \frac{840}{((1000+1203+1049)/3)} = 0.77$$

Clearly, the effect of the population adjustment in my simulation disappears because there is no population growth to adjust for.

As discussed above, the source of bias in Greene and Swanson's methods is the fact that they are dependent on retention rates. For on time graduation rate, retention matter, but for final graduation rate, they do not. This is a serious issue since the retention rates in 9^{th} grade are significantly higher than in other grades. The higher the ninth grade bulge, the greater Greene and Swanson's understatement of the true high school graduation rate is.

Estimates from my simulation correspond to independent calculations performed by the Texas Education Agency and Swanson, as demonstrated in Table 2.7.2. This suggests that the differences in Swanson's and the Texas Education Agency's numbers stem from the differences in methodology, not from the fact that Texas has been reporting inflated graduation rates.

Note that in this case, Greene's method using 8^{th} grade enrollment would provide the correct estimate of final high school graduation rate. However, in reality, if Greene were to estimate the high school graduation rate for Texas, he might not be able to do it accurately because he would need a good estimate of the total number of first time 9^{th} graders. Unfortunately, there is not an easy way to do so. My simulation only relies on grade dropout and retention rates (available from the Texas Education Agency), so it does not require as much information as Greene's does.

Table 2.7.1. Texas's Grade Dropout and Retention Rates in 2001-2002

	Grade 9	Grade 10	Grade 11	Grade 12
Retention / enrollment rate (%)	16.9	8.2	5.8	4.6
Dropout / enrollment rate (%)	3.1	4.0	3.6	4.9

Source. Texas Education Agency. (2006a) & (2006b).

Table 2.7.2. Texas's Graduation Rates by Different Methods

	Estimates from my simulation	Texas official release, 2002-2003	Swanson's CPI method for Texas, 2002-2003
Graduation rate (%)	84	84*	---
CPI rate (%)	70	---	67*

NOTE. * Cited from Swanson (2006).

Figure 2.7.1: The Simulation using Texas's Parameters

Year		Grade	Grade	Grade	Grade
		9	10	11	12
1	First time enter	1000	NA	NA	NA
	Left back from last year	0	NA	NA	NA
	Passed	800	NA	NA	NA
	Held back but did not drop out	169	NA	NA	NA
	Dropout	31	NA	NA	NA
2	First time enter	1000	800		
	Left back from last year	169	0		
	Passed	935	702		
	Held back but did not drop out	198	66		
	Dropout	36	32		
3	First time enter	1000	935	702	
	Left back from last year	198	66	0	
	Passed	958	879	636	
	Held back but did not drop out	202	82	41	
	Dropout	37	40	25	
4	First time enter	1000	958	879	636
	Left back from last year	202	82	41	0
	Passed	962	913	833	576
	Held back but did not drop out	203	85	53	29
	Dropout	37	42	33	31

Figure 2.7.1: The Simulation using Texas's Parameters (continue)

Year		Grade	Grade	Grade	Grade							
		9	**10**	**11**	**12**							
5	First time enter	1000	962	913	833		**On-time**					
	Left back from last year	203	85	53	29	Diploma	**graduation rate**					
	Passed	963	919	876	780	576	**0.58**					
	Held back but did not drop out	203	86	56	40							
	Dropout	37	42	35	42							
						Diploma						
							Grad rate	Dropout	Green (9)	Greene (S)	Swanson CPI	
6	First time enter	1000	963	919	876	780	0.78	159	0.67	0.74	0.70	
	Left back from last year	203	86	56	40							
	Passed	963	921	884	828							
	Held back but did not drop out	203	86	57	42							
	Dropout	37	42	35	45							
						Diploma		Dropout				
							Grad rate		Green (9)	Greene (S)	Swanson CPI	
7	First time enter	1000	963	921	884	828	0.83	160	0.69	0.77	0.70	
	Left back from last year	203	86	57	42							
	Passed	963	921	885	838							
	Held back but did not drop out	203	86	57	43							
	Dropout	37	42	35	45							
						Diploma		Dropout				
							Grad rate		Green (9)	Greene (S)	Swanson CPI	
8	First time enter	1000	963	921	885	838	0.84	160	0.70	0.77	0.70	
	Left back from last year	203	86	57	43							
	Passed	963	921	886	840							
	Held back but did not drop out	203	86	57	43							
	Dropout	37	42	35	45							

Figure 2.7.1: The Simulation using Texas's Parameters (continue)

Year		Grade	Grade	Grade	Grade	Diploma					
		9	10	11	12		Grad rate	Dropout	Green (9)	Greene (S)	Swanson CPI
9	First time enter	1000	963	921	886	840	0.84	160	0.70	0.77	0.70
	Left back from last year	203	86	57	43						
	Passed	963	921	886	840						
	Held back but did not drop out	203	86	57	43						
	Dropout	37	42	35	45						
	Steady State										
Year						Diploma	**Grad rate**	Dropouts	Green (9)	Greene (S)	Swanson CPI
10	First time enter	1000	963	921	886	840	**0.84**	160	**0.70**	**0.77**	**0.70**
	Left back from last year	203	86	57	43						
	Passed	963	921	886	840						
	Held back but did not drop out	203	86	57	43						
	Dropout	37	42	35	45						
									Green (9)	Greene (S)	Swanson CPI
11	First time enter	1000	963	921	886	840	**0.84**	160	**0.70**	**0.77**	**0.70**
	Left back from last year	203	86	57	43						
	Passed	963	921	886	840						
	Held back but did not drop out	203	86	57	43						
	Dropout	37	42	35	45						
									Green (9)	Greene (S)	Swanson CPI
12	First time enter	1000	963	921	886	840	**0.84**	160	**0.70**	**0.77**	**0.70**
	Left back from last year	203	86	57	43						
	Passed	963	921	886	840						
	Held back but did not drop out	203	86	57	43						
	Dropout	37	42	35	45						

CHAPTER 3: TRENDS AND PROJECTIONS OF HIGH SCHOOL GRADUATION RATES IN THE UNITED STATES BY 2015

INTRODUCTION

The labor force has been contributing to the rapid growth of American economy. The past has witnessed economic growths went hand in hand with the replacement of retiring cohorts with increasingly well-educated cohorts. For that reason, the high school graduation rate is an important indicator of the quality of American labor force, and studying the trend of the rate will help inform decision makers of the shape of future American labor force.

The current literature contains conflicting conclusions about this trend. On the one hand, for instance, Day and Bauman (2009) report that the population's middle aged group and young group share the same rate of high school completion. Some other recent studies also inform us of a worsening situation in high school graduation rate (Chaplin, 2002; Heckman & LaFontaine, 2007; Haney et al, 2004; Warren, 2005). These conclusions, if correct, alarm us of a decreasing quality of the future US labor force. On the other hand, other studies, such as Mishel & Roy (2006), Fox, Connolly & Snyder (2005) find a remarkable increase in graduation rate over the last 50 years.

This study contributes to the literature by investigating the high school graduation rate historical trend[8], using an alternative method that has corrected for some of the shortcomings of others. It also informs policy makers of the status of the future

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[8] But including only people with a regular diploma. Most GEDs are separated from regular diplomas for people with GEDs tend to have future outcomes such as job performance and earnings closer to that of high school dropouts (Cameron &Heckman, 1993; Heckman &LaFontaine, 2006, 2008). However, in this study, I count people with GEDs who went to college as high school graduates because they in fact have demonstrated their ability equal to that of high school graduates

workforce by offering three different forecasts of the graduation rate by year 2015. Unlike forecasting approaches in the literature, which ignore most of the important factors that affect high school graduation rates, two out of three approaches in this study utilize information from the individuals such as family income percentile and mother's education, and perform projections based on regression models. One important finding of this study is the overall high school graduation rate in the United States has been increasing slightly in the last 20 years and will likely remain stable above 80 percent by 2015.

The rest of the study is organized as follows. The second section contains literature review on the high school graduation rate and trend. The third section describes the data used in the study. The fourth section documents the method of calculating the high school graduation rate and three approaches of projecting the rate for 2015. The fifth section summarizes the regression results, the historical trend, and projected values of the graduation rate. The last section summarizes and discusses the study's findings.

LITERATURE REVIEW

Over the last seven years, researchers have developed different approaches to estimating the high school graduation rate and investigating its trend, but their conclusions conflict greatly with one another.

Firstly, the literature on graduation rate shows both high (80-90 percent) (Mishel & Roy, 2006; Adelman, 2006; Hill & Holzer, 2006) and low (65-70 percent) (Greene & Foster, 2003; Swanson, 2004) estimates. Studies that reported low graduation rates usually use the National Center for Education Statistics' Common Core of Data (CCD). These studies divided the number of graduates by the number of 9th grade cohort four

year earlier (Greene and Foster, 2003) or multiply accumulatively (Swanson, 2004) the promotion rate of each grade (i.e. the percentage of 9th grade students promoted to 10th grade, 10th grade students promoted to 11th grade, and so forth). However, these methods systematically underestimate the graduation rates because the size of a 9th grade cohort tends to be inflated by the high percentage of left-back students (a phenomenon called "ninth grade bulge"[9]). Greene and Foster (2003) yield national graduation rates of 65 percent, and that of Swanson (2004) is 70 percent.

Studies that yield high rates are usually ones that use survey data. Mishel and Roy (2006) use the Integrated Public Use Microdata Series (IPUMS), a cross-sectional survey data of year 2000. This study reports a graduation rate of 84 percent among people aged 25-29 in year 2000, but the calculation was unable to separate General Educational Development (GED) holders from graduates. In fact, it is important to count only regular diplomas because GED holders are more similar to high school dropouts than high school graduates in terms of future earning and job performance (Cameron & Heckman, 1993; Heckman & LaFontaine, 2006). Addressing this GED issue, Adelman (2006) uses the National Education Longitudinal Study of 1988 (NELS88), the longitudinal data that tracks the cohort of students who were in their eighth grade in the spring of 1988, to estimate the percentage of youth who have graduated from high school. The study reports that by 2000, 83 percent of the original 8th grade cohort of 1988 has earned a regular diploma. Similarly, Hill and Holzer (2006) use the National Longitudinal Study of Youth

[9] The 9th grade bulge is a countrywide phenomenon, resulted mainly from a strikingly high left-back rate in 9th grade (Haney et al., 2004), which in turn inflates enrollment in 9th grade to a level significantly higher than that in all other grades. The high left back rate seems to stem from students' inability to adapt to the more difficult high school environment as compared to the relatively laid-back one in middle schol (Black, 2004). The transfers from private schools, including home schooled students, also contribute to the 9th grade bulge (Hirschman, Ciurej, & Willhoft, 2006).

1997 (NLSY1997), a longitudinal survey data that tracks students aged 12-16 by the end of 1996. The study reports that by 2002, 82 percent has earned a regular high school diploma. While these longitudinal methods are more accurate, they use dated data sets and are unable to describe trends.

Secondly, the literature on trends of high school graduation rates also shows both upward and downward trends. Studies that report upward trends usually use survey data (Mishel & Roy, 2006); Fox, Connolly & Snyder, 2005). Mishel and Roy (2006), and Fox, Connolly and Snyder (2005) use the Current Population Survey (CPS) to look at the historical trend of the high school graduation rate in the US. Their studies find a remarkable increase in graduation rate over the period of 1950-2004. However, each point estimate reported in the study counts GEDs as high school graduates. [10]

Studies that report downward trends usually use administrative data (i.e. CCD data) (Warren, 2005; Heckman & LaFontaine, 2007). Warren (2005) reports a consistently declining trend over the 1975-2002 period. However, Warren's formula of calculating high school graduation rate is essentially Greene's formula, which has been shown above as unreliable[11]. Heckman and LaFontaine (2007) use various sources of data, including the NCES data and the Census, to show a worsening situation in graduation rates over a

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10 Mishel and Roy (2006) made an attempt to separate the GEDs from each point estimate by obtaining the share of the population with GEDs from the American Council on Education (which administered the test), but this method is rather ad hoc.

11 Instead of dividing the number of diplomas by the total number 9th graders, the author uses the number of 8th graders as a proxy for the number of first time 9th graders. He also applies migration adjustment to the results by comparing the size of 17-year olds population to the size of 13-year olds four years earlier. Besides failing to account for the "ninth grade bulge", Warren's method has a number of other flaws. First of all, the use of the number of 8th graders as a proxy for the number of first time 9th graders might not be justifiable because not all public school 8th graders will go to high school, and among those who do go to high school, some of them might choose to attend private schools (which is not reported in the CCD data). There are also a number of 8th graders from private and parochial middle schools attending 9th grade in public schools. Second, the adjustment for migration counts 17 year old migrants who never went to public schools in the US as dropouts.

long period of time since 1940s. However, on the one hand, the NCES data is an administrative database and is not a good fit for this purpose due to difficulties in estimating the size of the incoming 9th grade cohort (i.e. excluding the left back students in 9th grade). The Census data, on the other hand, does not separate GED recipients from the graduates [12].

Finally, the literature on projection of high school graduation rates is relatively thin. Hussar and Bailey (2009) use a time series model with exponential smoothing constant to project the number of high school graduates to 2018. More specifically, the authors model the number of future graduates as a function of past observations. These past observations are weighted by some exponential smoothing constant in such a way that more recent observations have higher influences on the projected values. The study projects an increase in the number of graduates by over 3 million, but this projected increase reflects changes in the 18-year-old population rather than changes in the graduation rates of 12th graders (Hussar & Bailey, 2009). A regression-based method was introduced by Day and Bauman (2000). The authors use the CPS to model the probability of completing an additional level of education as a function of cohort indicators, gender, ethnicity, and immigration status. These probabilities are then applied to the projected population to produce estimates of the educational levels. The study concludes that high school completion rates will increase by 4 to 7 percentage points by 2028. This model was designed to project education attainment for all groups conditional on current education level. However, the current methods seem inadequate for the

12 Like Mishel and Roy (2006), Heckman and LaFontaine (2007) employ estimates of GED population from GED Testing Service in their calculation in order to separate the GEDs from the graduates. However, this approach is rather ad hoc, and Heckman and LaFontaine did not mention how reliable these estimates are.

purpose of projecting the trend of high school graduation rate, because they simply "fit" a line through observed data points (Hussar and Bailey, 2009) and omit important factors that are associated with education attainment such as family income and parent education (Day and Bauman, 2000).

In this study, I will investigate the historical trend of high school graduation rate using the Current Population Survey (CPS) and propose 3 different approaches to projecting the trend into year 2015. I use the definition of a high school graduate as a person who has completed high school with a regular diploma, or a GED holder that attended college. The reason that most (about 80%) GEDs are separated from regular diplomas for people with GEDs tend to have future outcomes such as job performance and earnings closer to that of high school dropouts (Cameron &Heckman, 1993; Heckman &LaFontaine, 2006, 2008). People with GEDs who went to college are counted as high school graduates because they in fact have demonstrated their ability equal to that of high school graduates.

DATA

The first data source is the Current Population Survey (CPS). The CPS contains nationally representative data for the non-institutional population (i.e., exclusive of individuals in prison or in the military). These data have been collected in monthly surveys conducted by the U.S. Census Bureau since the late 1960s. The average sample size is approximately 50,000 households, although the sample size has been increasing, from 60,000 households each month in 1990 to 72,000 in 2001. The study uses data on household members collected from interviews conducted annually in October from 1992-

2007. The population that the study focuses on is youth between the age of 21 and 23, who are US citizens. I assume that by the age of 21-23, most youth would have either graduated from high school or dropped out. Because the CPS includes recent non-citizen immigrants, who generally have lower education level and were most likely never enrolled in US schools, estimates of high school graduation rates without taking out immigrants will be understated. Therefore, in this study, I exclude non-citizens from the analyses. I use the highest educational level attained to generate an indicator of whether the individual has graduated from high school. The CPS also has a question indicating whether the individual graduated from high school by means of a GED or not. This variable is used to separate GED holders from high school graduates.

Another data source is the National Longitudinal Study of Youth 1997 (NLSY97). The NLSY97 is a longitudinal study following up a nationally representative sample of approximately 9,000 youth who were 12 to 16 years old as of December 31, 1996. Those youth are interviewed annually. The data set provides extensive information about youth background, educational experiences over time, and parent socioeconomic background. My study focuses on individuals who were 14-16 years old when the first wave of data was collected. I dropped 12-13 year olds from my sample because their cohorts are unusually small compared to that of 14-16 year olds, which makes the age-specific estimates unreliable when compared with the CPS estimates. Variables used in the study include a dichotomous variable of whether the youth has earned a regular high school diploma by 2004, a gender indicator, race/ethnicity indicators, a dichotomous variable of whether the youth's mother has finished high school, an indicator of whether the youth's parents live together, family income percentile, and region indicators.

The last data source is the American Community Survey (ACS). The ACS is a nationwide survey conducted by the Census Bureau. The information collected in the data includes children, parents, and family socioeconomic characteristics. My study uses individual and family level data of 14-16 year old individuals in the surveys of years 1980, 1990, and each year from 2000 to 2008. The sample sizes of the data are approximately 1% of American population. I identify the parents of the 14-16 year old youth through a "relation" variable. I, therefore, was able to include in my analysis parent information such as a variable indicating whether the mother has completed high school and another indicator variable of whether both parents are living together. Other variables used in the study are a gender indicator, race/ethnicity indicators, family income percentile, and region indicators.

METHODS

To calculate the high school graduation rates in the past, I use a “population-based” method. This method (as demonstrated in Formula 2.9, from Chapter 2) takes a snapshot of students within a certain age range and derives the proportion of those with high school diplomas. This method requires that the population of interest be old enough that only a negligible number are still in high school. For that purpose, I choose the 21-23 age range in the CPS. At this age range, almost every individual either has had a diploma, GED, or has dropped out.

$$\text{Graduation rate} = \frac{\text{Total high school graduates did not go to college} + \text{College graduates or college students}}{\text{Total population of the age group that attended high school}} \quad \text{(Formula 2.9)}$$

In the numerator of the formula, most college students and college graduates have a high school diploma, but some might have gotten into college with a GED. These high ability GED holders (though small in number) are counted toward high school graduates.

Projection of high school graduation rates

I approach the projection of high school graduation rates in three ways: a simple weighted least squares regression, a logistic regression, and a “machine-learning technique” named Generalized Boosted Modeling (GBM).

Weighted Least Squares

The first approach is the simplest one. I first apply the population-based method to the CPS (1992-2007) to estimate the percentage of 21-23 year old youth who are high school graduates. I then project the high school graduation rate from 2008 to 2015 based

on a simple linear regression that uses the historical point estimates from the CPS and time as the only explanatory variable. Because this regression uses historical points that are independently measured, they are uncorrelated. However, the fact that the sample size varies each year leads to non-constant variances. Therefore, I use the Weighted Least Squares approach which makes use of the reciprocal of the variances as the analytic weight. The regression is described as follows:

$$Y_i = \beta_0 + \beta_1 * time_i + \varepsilon_i$$

i=1,2,3,…with $time_i$ =1 for the year 1992; $time_i$=2 for 1993;…; and $time_i$=16 for 2007;

Y_i is the high school graduation rate for year i; β_o is the intercept and β_1 is the estimated slope; ε_i is the normally distributed error term.

And $Weight = \frac{1}{\delta_i^2}$

Because "graduation" is a dummy variable, each observed graduation rate is the mean of the sample, thus $\delta_i^2 = \frac{VarY}{n_i}$

This method assumes that there is a constant slope, and the trend will continue in the future. For instance, provided that the slope is positive, and hence we have an increasing trend, if we look far enough into the future, the projection line will eventually hit the "ceiling" (i.e. a 100% graduation rate), which is clearly unrealistic. In addition, this approach does not cover key factors that affect high school graduation such as parent education and family socioeconomic status. However, in short run, this approach could be used for exploratory purposes.

Structure Model Based Methods: Logistic Regression and GBM

Both logistic regression and GBM can address some shortcomings of the WLS model by predicting the probability of high school graduation based on observed

characteristics of the individuals in the sample. The main idea of these two approaches is to apply the existing deterministic relationship between individual characteristics and high school graduation (obtained from the "structure" model) to a cohort that will graduate from high school in the future to predict the probability that the individuals will be high school graduates. The structure model is obtained from individuals in the NLSY97. It models the relationship between characteristics of 14-16 year olds in 1997 (such as mother education, race, gender, family characteristics etc. at the time they are 14-16 years old) and the event of high school graduation when they are 21-23 in 2004. I will then apply the coefficients of the structure model to 14-16 year-old individuals in the ACS data sets. Based on observed characteristics associated with these 14-16 year olds (such as mother education, race, gender, family characteristics) in the ACS, I conduct the out-of-sample projections. Because the characteristics of 14-16 year olds in 1997 predicts the high school graduation outcomes in 2004 (in the structure model), the same characteristics of 14-16 year olds observed in the ACS in 1980, 1990, and 2000 - 2008 will predict high school graduation outcomes in 1987, 1997, and 2007-2015 respectively.

Logistic Regression

The logistic regression approach performs an out-of-sample projection using ACS data sets based on a logistic structure model from the NLSY97 data set. This structure model is described as follows:

$$P(Y=1)=\frac{1}{1+e^{-Z}}$$

Where P(Y =1) is the probability of an individual, who is 14-16 years old by 1997, graduating from high school in 2004 (by the age of 21-23).

$Z = \beta X$

X is a vector of explanatory variables which consists of a gender indicator; a race variable categorized into White, African American, Hispanic, and Other races; an indicator variable of whether the individual's mother has high school education; interaction variables of mother education indicator and race indicators; an indicator of whether the individual's parents live together; family income percentile; and a region variable categorized into North East, North Central, South, and West. β is the coefficient vector.

I then apply the structure model's estimates to the ACS samples to get the projection of 7 years in the future. For example, applying these coefficient estimates to an ACS sample of 14-16 year old youth in 2008 can provide projection of high school graduation rate by the age of 21-23 for year 2015. Since the predicted series overlaps with the series that I estimated from the CPS, some of the projections could be compared with the estimates from the CPS (such as ones in 1997 and 2007) to see how well the model predicts the past. For example, if the predicted values for years 1987, 1997, and 2007 are close to what we observed from the CPS, it is a good indication that the model is likely to produce good projections about the future.

Projection based on this approach assumes that the impact of explanatory variables on high school graduation are unchanged over time. This assumption can be somewhat restrictive because due to changes in other socioeconomic conditions, the impact could have changed.

Generalized Boosted Modeling (GBM)

The GBM approach differs from the Logistic approach only in the structure model. To create this structure model, the GBM technique finds an optimal function $F^*(x)$ $(x \in X)$ that maps "input variables" vector X to the "output" variable y in a way that minimizes some specified loss function (Friedman, 1999). In this context, the "output" variable is the probability of an individual, who is 14-16 years old by 1997, graduating from high school in 2004 (by the age of 21-23). The "input variables" include gender, race, whether the mother has high school education, whether the parents live together, family income percentile, and region. Essentially, the GBM approach lets the machine "learn" the data and try out different models with different possible interactions between explanatory variables. The $F^*(x)$ that minimizes the specified loss function will be selected as the structure model, and the relative influences of different covariates will be calculated. The algorithm of finding $F^*(x)$ is described in details in Ridgeway (2007). This algorithm is also summarized in Appendix 3.1.

After estimating the structure model, similar to the Logistic Regression approach, the GBM approach also performs an out-of-sample projection using ACS data. The projection procedure will apply the relative influences to ACS data and derive the predicted graduation rates for years 1987, 1997, and 2007-2015.

Like the Logistic Regression approach, projections using the GBM approach also assume that the relative influences of explanatory variables on high school graduation are unchanged, which could be restrictive. Another disadvantage of this approach is we do not really see the functional form of $F^*(x)$ even though we know that it fits the data well.

RESULTS

This section presents the historical estimates from the CPS between 1992 and 2007, the linear projections of the WLS approach, the result summary of the Logistic regression, the relative influence of covariates in the GBM approach, and the comparison of projections by these approaches. I will also present past projections of the GBM and Logistic approaches in order to assess these method's validity.

The historical estimates and projections using the WLS approach are presented in Figure 3.1. The points from 1992 to 2007 in the graph are historical data estimated from the CPS. Those beyond 2007 are projections from the regression that uses these historical point estimates as the outcome variable and year as the only predictor. The coefficient of this regression is 0.003, which means each year the graduation rate is expected to increase by 0.3 percent.

The CPS historical data show a slight decrease in high school graduation rate from 84 percent in 1993 to 82 percent in 1998, before continuing to increase. The WLS fitted line indicates an overall upward trend of high school graduation rate. By 2015, the high school graduation rate would be about 90 percent (standard errors of the estimates are presented in Appendix 3.2, Table 3.2.1), and will continue to increase.

Table 3.1 presents a summary of the Logistic regression, performed on NLSY97 data. The results indicate that among statistically significant coefficients, being female, mother has high school diploma, parents living together, and family income are positively associated with the probability of graduating. At the same time, students from the North East and the South are less likely to graduate than students from the West. The interaction terms indicates that compared to White students, mother education has a larger impact on

African American students, and a smaller impact on Hispanic students and students of "Other" races (mostly Asian). However, the differences in impact size are not statistically significant.

Figure 3.1: Historical data and WLS fitted line

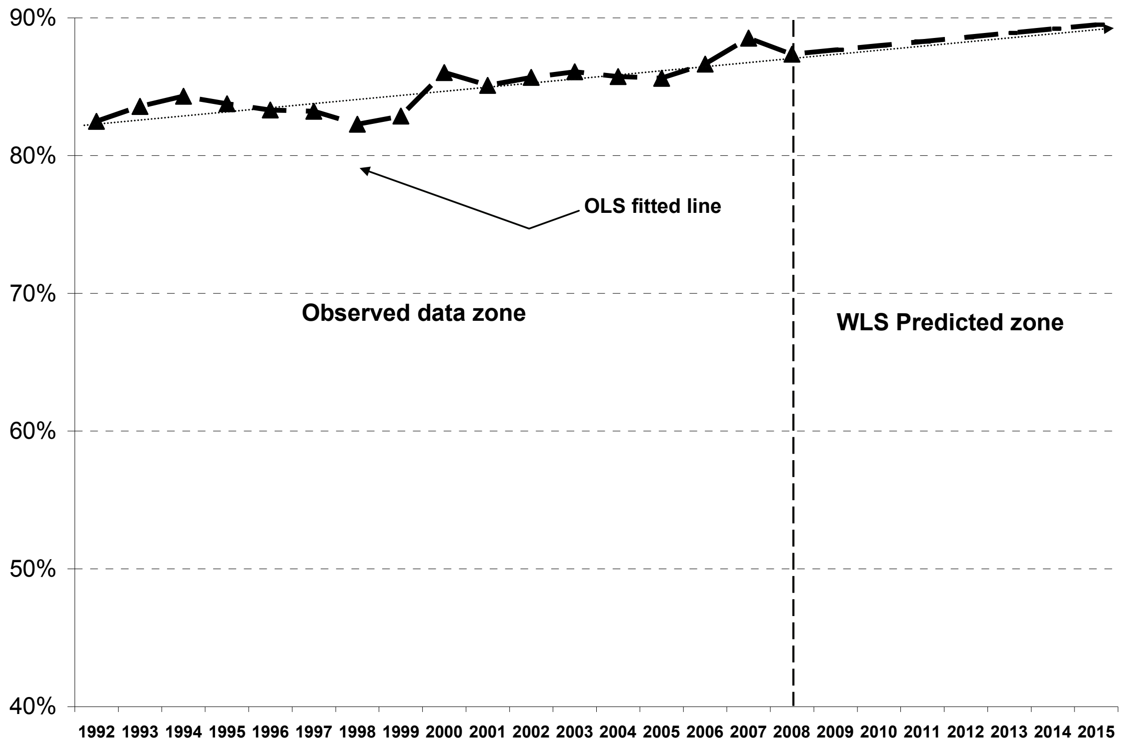


Table 3.1: Summary of the logistic regression

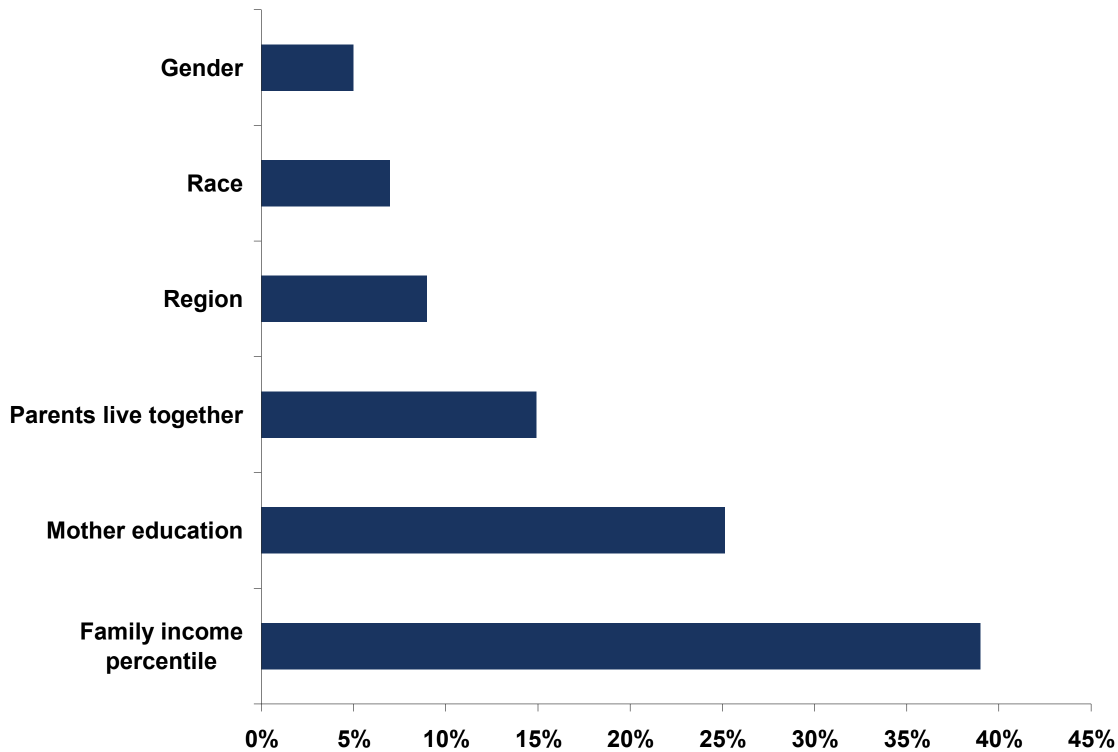
Dependent variable is a dummy indicating whether the individual graduated from high school. N= 4593

	Coefficient	Standard Error
Female	0.44**	0.09
Race		
Hispanic	0.26	0.20
African American	-0.04	0.22
Other races	0.59	0.54
Mother Education	0.94**	0.16
Interactions		
Mother Education* Hispanic	-0.15	0.26
Mother Education * African American	0.12	0.25
Mother Education * Other races	-0.05	0.66
Parents live together	0.84**	0.10
Family income percentile	0.15**	0.02
Region		
North East	-0.25*	0.15
North Central	-0.13	0.14
South	-0.27**	0.13

NOTE
Data: NLSY97
Outcome variable: Graduating from high school by 2004.
White, Mother Education * White, West are reference groups for race, interactions, and region.
* denotes statistical significant at 0.1; ** denotes statistical significant at 0.05.

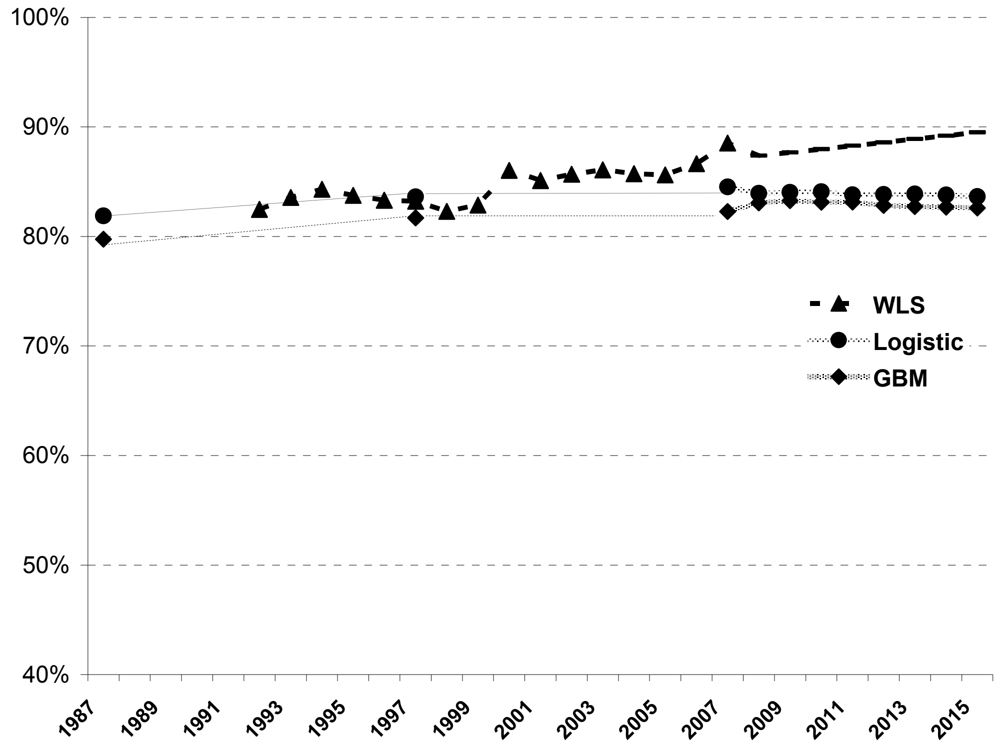
Figure 3.2 describes the relative influences of different covariates on high school graduation. Unlike the Logistic regression approach, the GBM package (also performed on NLSY97 data) lets the computer decide between different models featuring different sets of interactions to find the model that best fits the data. We can see from Figure 3.2 that the GBM approach highlights basically the same set of factors that are influential on the probability of graduating from high school.

Figure 3.2: GBM relative influence of covariates
Dependent variable is a dummy indicating whether the individual graduated from high school. N= 4593



Both GBM and Logistic approaches underline the importance of family income, mother's education, and a solid nuclear family environment on the chance of a student graduating from high school. Therefore, changes in our social structure (such as percentage of mothers who have high school diplomas) will be likely associated with changes the high school graduation rate. The projections of high school graduation rates by Logistic and GBM approaches presented in Figure 3.3 are based on such associations.

Figure 3.3: Comparing projections between approaches



NOTE. WLS uses CPS data. Logistic and GBM use NLSY97 data for structure model and extrapolate using ACS data.

In Figure 3.3, the WLS estimates are the same as in Figure 3.1. Both GBM and Logistic approaches indicate a slight increase in high school graduation rate through the 1990s, but the projected rate remains stable during the 2000s. These estimates fluctuate around 83 percent (GBM) and 84 percent (Logistic) during the period between 2008 and 2015 (standard errors of the estimates are presented in Appendix 3.2, Table 3.2.1). During this period, the WLS projections are increasing from 87 to 90 percent.

The reliability of results produced by GBM and Logistic approaches can be assessed by comparing the past projections of these approaches against observed graduation rates. Figure 3.3 shows that the GBM and Logistic projection points are about in the same range with the observed CPS graduation rates before year 2000. For instance,

the GBM and Logistic projections for 1997 are 82 percent and 84 percent respectively. These projections are close to the CPS point estimate for 1997, which is 83 percent. Similarly, the GBM and Logistic projections for 1987 are 80 percent and 82 percent respectively. These are also close to the first available CPS point estimate (1992), which is 82 percent. From 2000 to 2007, the CPS estimates are about 3 percentage points higher than the GBM line, and 2 percentage points higher than the Logistic Regression line. The lines in Figure 3.3 show that when compared against estimates from the CPS between 1992 and 2007, the Logistic Regression approach seems to produce projections closer to the observed CPS points. Analyses by race and gender are presented in Appendix 3.3

DISCUSSION AND SUMMARY

Past attempts to estimate the trend of high school graduation rate have encountered difficulties in methodology and data. In this study, I exclude the GEDs and recent immigrants in the CPS data to document the past movements of the high school graduation rate from 1992 to 2007. I apply three different approaches to project the trend of the graduation rate to 2015. All three approaches conclude that the high school graduation rate in the United States in the last 20 years has been increasing slightly and will likely remain above 80 percent by 2015.

Projection approaches used in previous studies are somewhat inadequate. The time series method in Hussar and Bailey (2009) projects new points only based on previous points, even thought it has attempted to be realistic by weighting recent observations more heavily than earlier data. However, the weight selection is somewhat arbitrary and the additional complication in the model (such as including a quadratic term) may not yield any more accuracy. Therefore, it should only be used for exploratory purpose in short terms. The regression based method in Day and Bauman (2000) does make use of some student characteristics such as gender, ethnicity, and immigration status. However, Day and Bauman (2000) did not include other key variables that are shown to affect education attainment such as parent education and family income.

The WLS approach in this study is an alternative to the time series method, for short terms exploratory purposes. It generates new points through 2015 using a constant slope. This process of extrapolation in longer term might not be very meaningful and subject to significant uncertainty. Moreover, even though the CPS data contains other meaningful variables such as family income and parent education level, the WLS

approach cannot extrapolate with more complicated models because we do not have information such as family income and parent education in the future.

The logistic regression and GBM approaches utilize information on factors associated with the chance of graduating from high school. Therefore, these two approaches produce more reliable projections. In addition, the GBM and logistic regression approaches do not capture the trend in graduation rate directly like the WLS approach, but rather the trend in factors associated with high school graduation rate. These factors, altogether, tend to be more stable than the graduation rate itself, which is subject to greater fluctuation. Therefore, predictions based on GBM and logistic regressions are more stable than that of the WLS approach. However, the relative importance of factors in the logistic regression and GBM models might have changed since 1997 (for example the current effect of mother education on children might not be as strong compared to what it was in 1997). This could lead to biases in projection results. A more recent data set that supports the modeling of such relationship will produce better projections. Data sets that include other important factors that affect education attainment such as teacher quality and school funding will help improve the accuracy of the projections.

Although nationally representative surveys like the CPS are established, well-reputed, and large-scale, skeptics are concerned about the potential for misrepresentation, willful or other, in such surveys. The fact that one person answers all questions, including those on educational attainment of others, might cause some measurement errors. In addition, these variables are self-reported and not independently verified by comparing to school transcripts.

Another factor that may affect the accuracy of the results reported in this study is different states may have different graduation requirements (such as having to pass exit exam, or obtain more course credits). These requirements may also change over time during the projected period. This study is based on data at national level, not state level. Therefore it could not take into account variation in graduation requirements across state, nor could it document how these requirements have changed over time.

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APPENDIX 3.1
SUMMARY OF THE TECHNICAL DETAILS OF THE GBM APPROACH

Before running the procedure, we need to specify a loss function $\Psi(y, F(x))$, the number of iterations T, the depth of interaction K (K=1 being an additive model, K=2 being a two-way interactions model, etc), the learning rate λ, and the sub-sampling rate p. Then choose an initial constant value $\hat{f}(x) = \arg\min_{\rho} \sum_{i=1}^{N} \Psi(y, \rho)$

For each t in 1,…, T do the following steps

1) compute the negative gradient as the working response

   $$z_i = -\frac{\partial}{\partial f(x_i)} \Psi(y, f(x_i)) |_{f(x_i)=\hat{f}(x_i)}$$

2) Randomly select $p \times N$ cases from the dataset

3) Fit a regression tree with K terminal nodes, $g(X) = E(z \mid X)$ using the selected sub-sample.

4) Compute the optimal terminal node projections, $\rho_1, ..., \rho_K$, as

   $$\rho_k = \arg\min_{\rho} \sum_{x_i \in S_k} \Psi(y, \hat{f}(x_i) + \rho)$$

   Where S_k is the set of x variables that define terminal node k.

5) update $\hat{f}(x)$ as

   $$\hat{f}(x) \leftarrow \hat{f}(x) + \lambda \rho_{k(x)}$$

   Where $k(x)$ indicates the index of the terminal node into which an observation with feature X would fall.

APPENDIX 3.2
STANDARD ERRORS OF ESTIMATES

Table 3.2.1. Standard errors of estimates

	WLS		Logistic Regression		GBM	
Year	Estimates	SE	Estimates	SE	Estimates	SE
1987*	82.5%	0.50%	81.9%	0.04%	79.8%	0.04%
1997	83.2%	0.59%	83.6%	0.05%	81.7%	0.04%
2007	88.5%	0.48%	84.5%	0.04%	82.3%	0.04%
2008	87.4%	1.15%	83.9%	0.06%	83.1%	0.06%
2009	87.7%	1.17%	84.0%	0.06%	83.3%	0.06%
2010	88.0%	1.20%	84.1%	0.06%	83.1%	0.05%
2011	88.3%	1.23%	83.8%	0.06%	83.1%	0.05%
2012	88.6%	1.25%	83.8%	0.04%	82.8%	0.04%
2013	88.9%	1.29%	83.9%	0.04%	82.7%	0.04%
2014	89.2%	1.32%	83.8%	0.04%	82.7%	0.04%
2015	89.5%	1.35%	83.6%	0.04%	82.6%	0.04%

NOTE. The WLS approach started with year 1992, instead of 1987.

APPENDIX 3.3
PROJECTION BY RACE AND GENDER

Figure 3.3.1: Comparing projections between approaches. White females

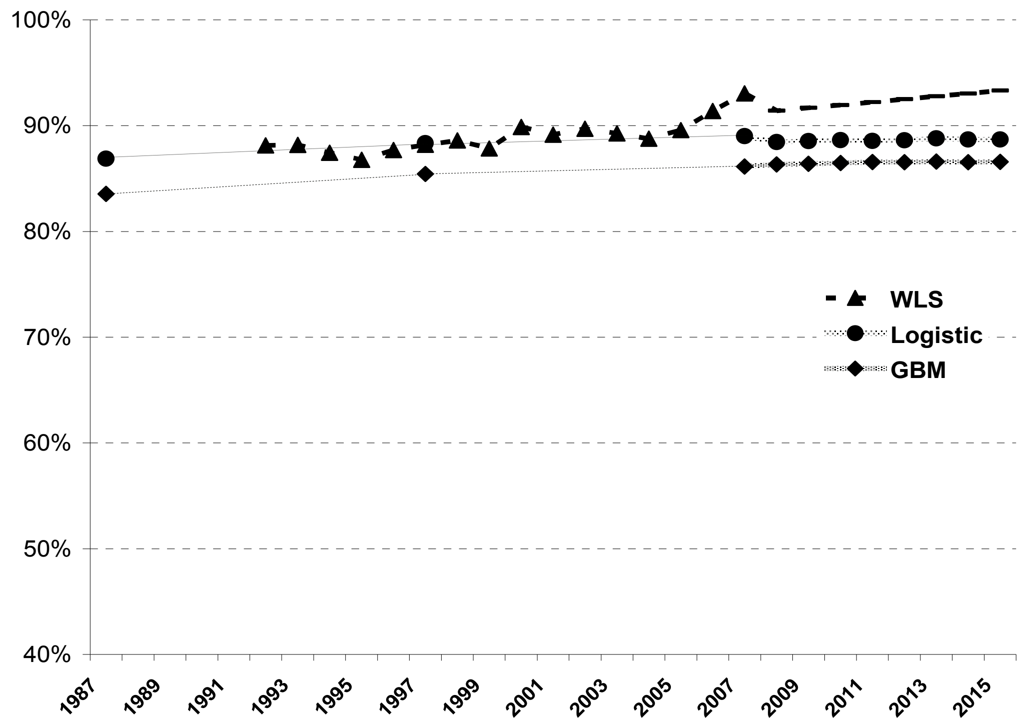


Figure 3.3.2: Comparing projections between approaches. White males

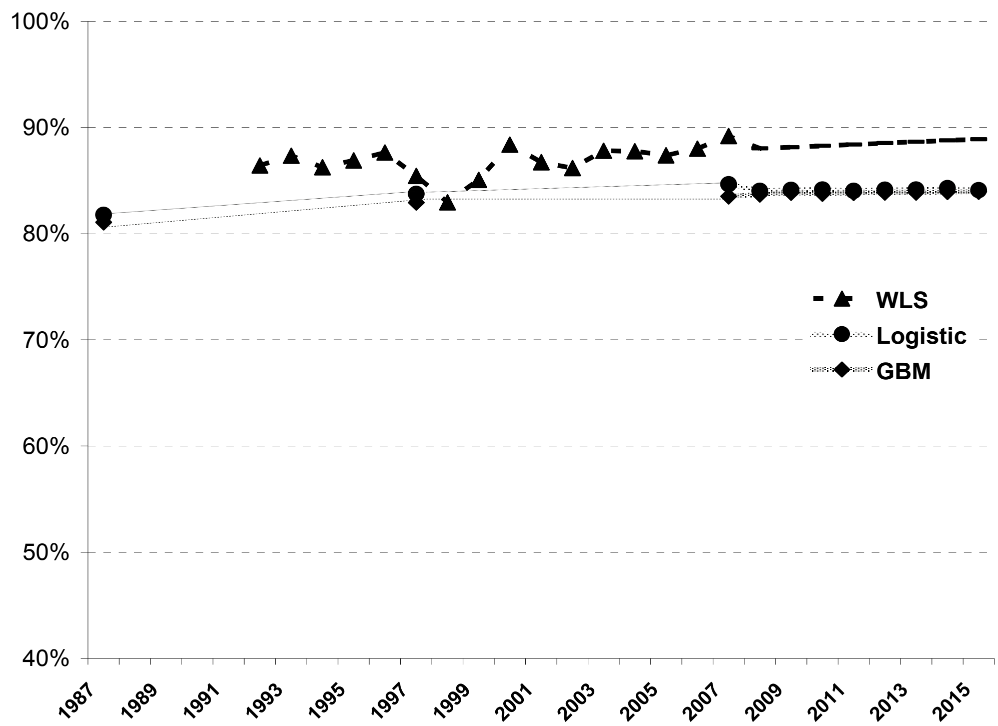


Figure 3.3.3: Comparing projections between approaches. African American females

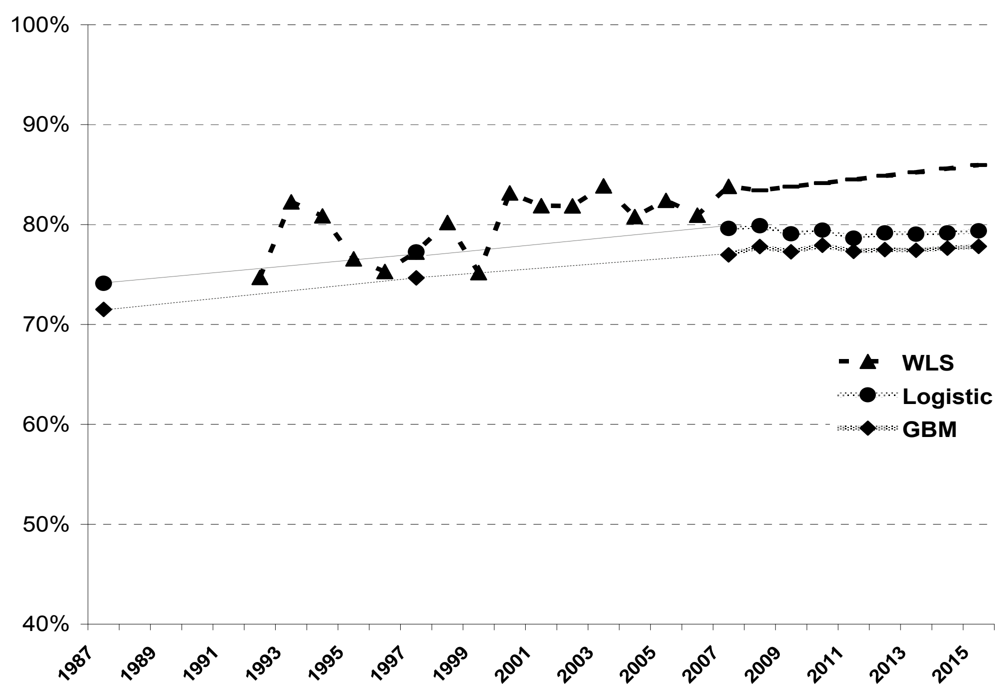


Figure 3.3.4: Comparing projections between approaches. African American males

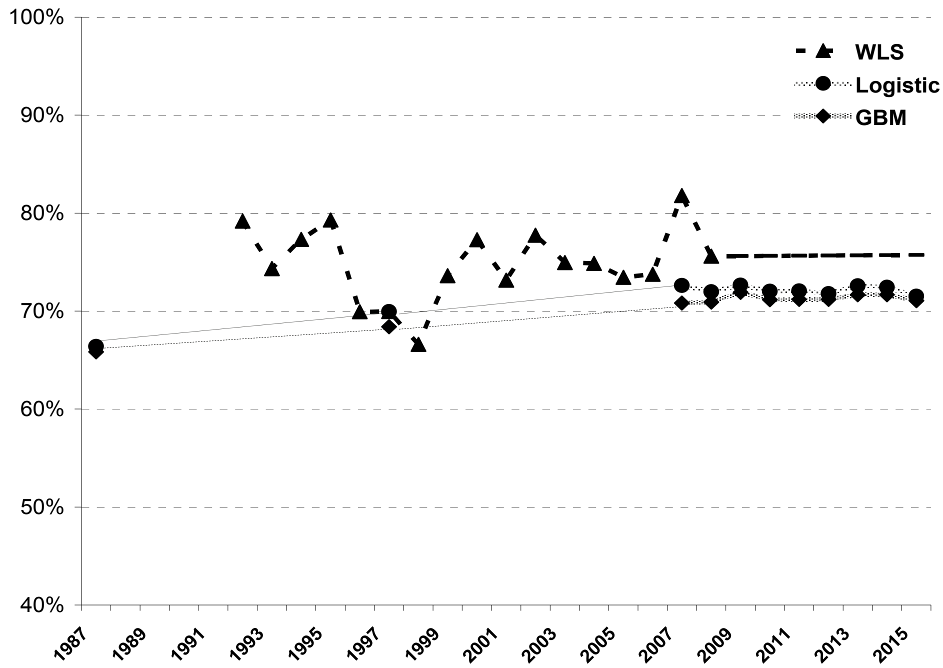


Figure 3.3.5: Comparing projections between approaches. Hispanic females

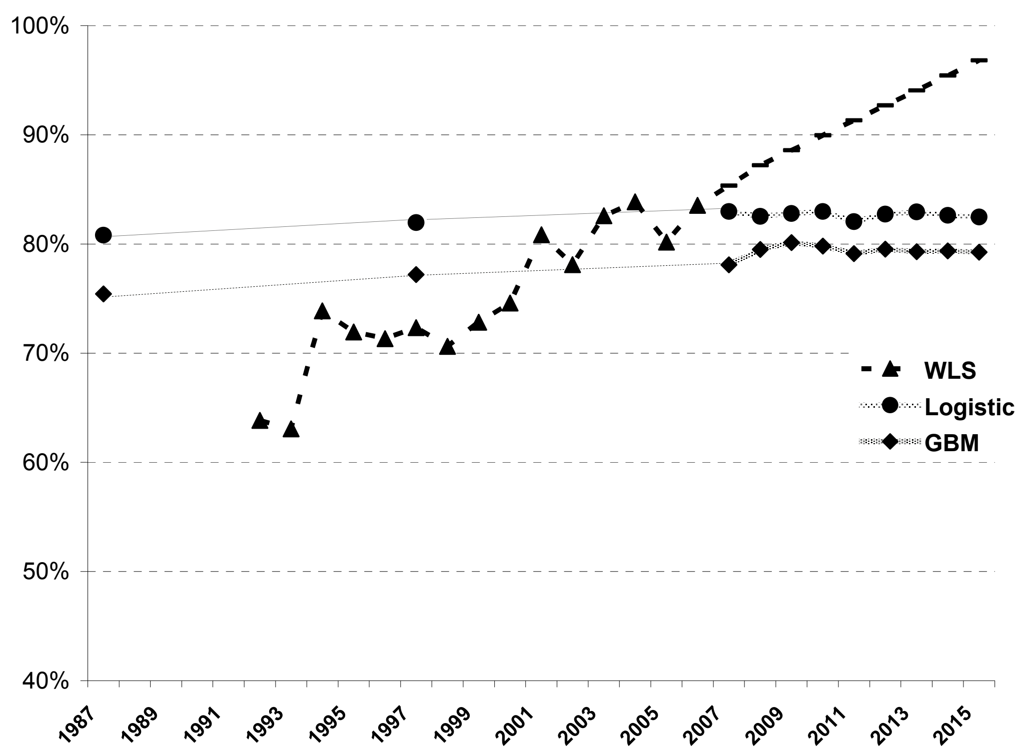


Figure 3.3.6: Comparing projections between approaches. Hispanic males

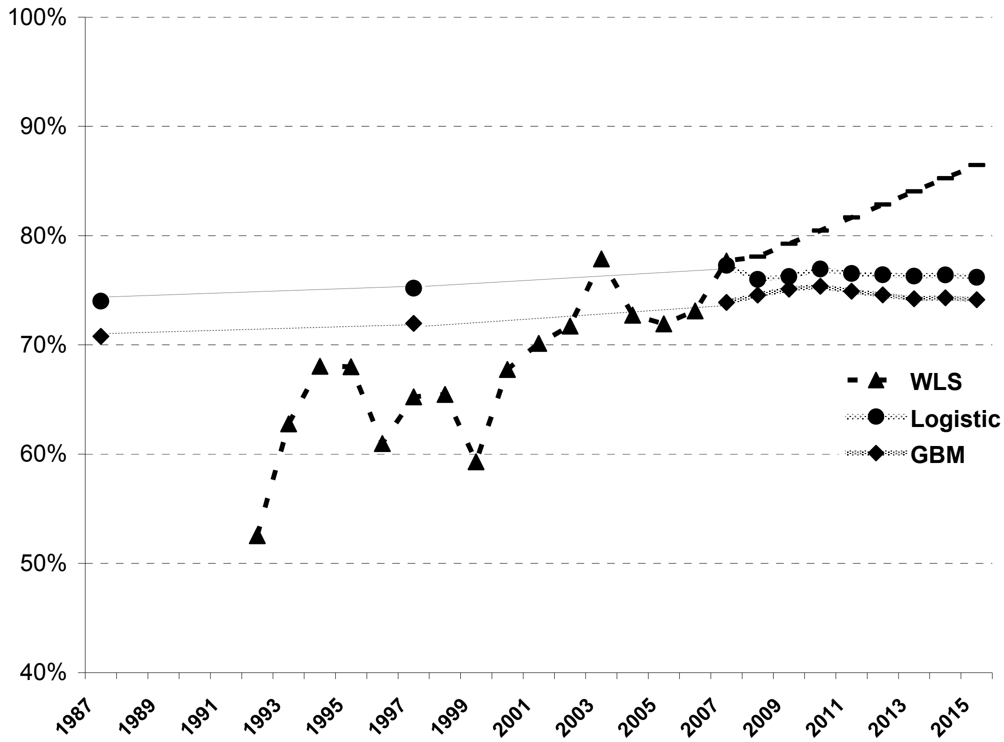


Figure 3.3.7: Comparing projections between approaches. Other races, females

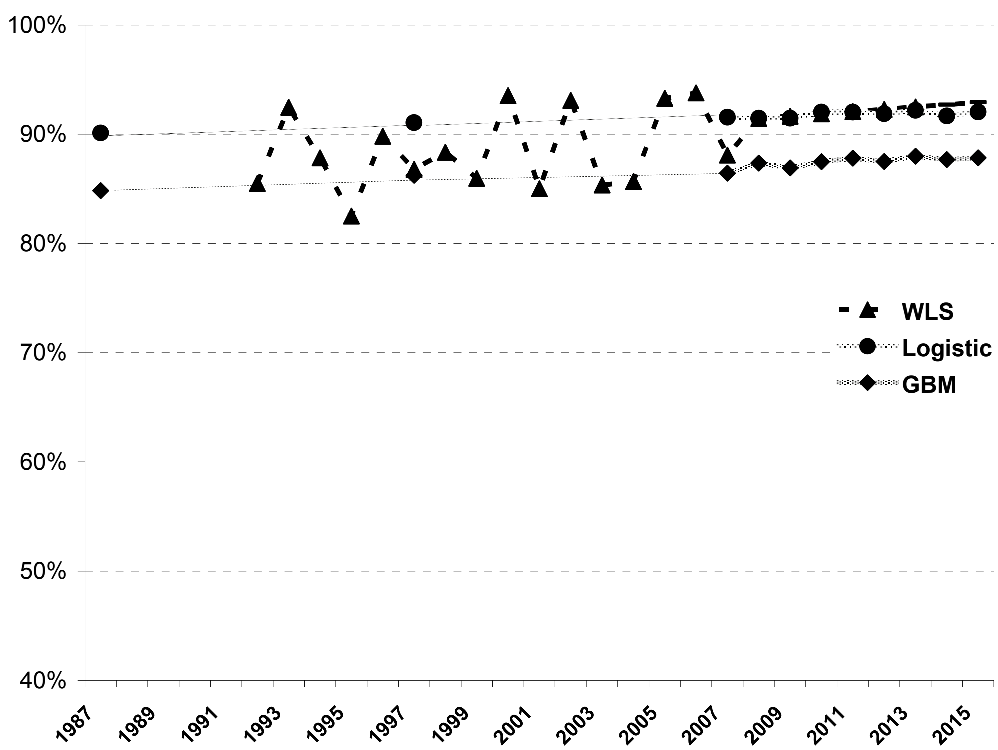
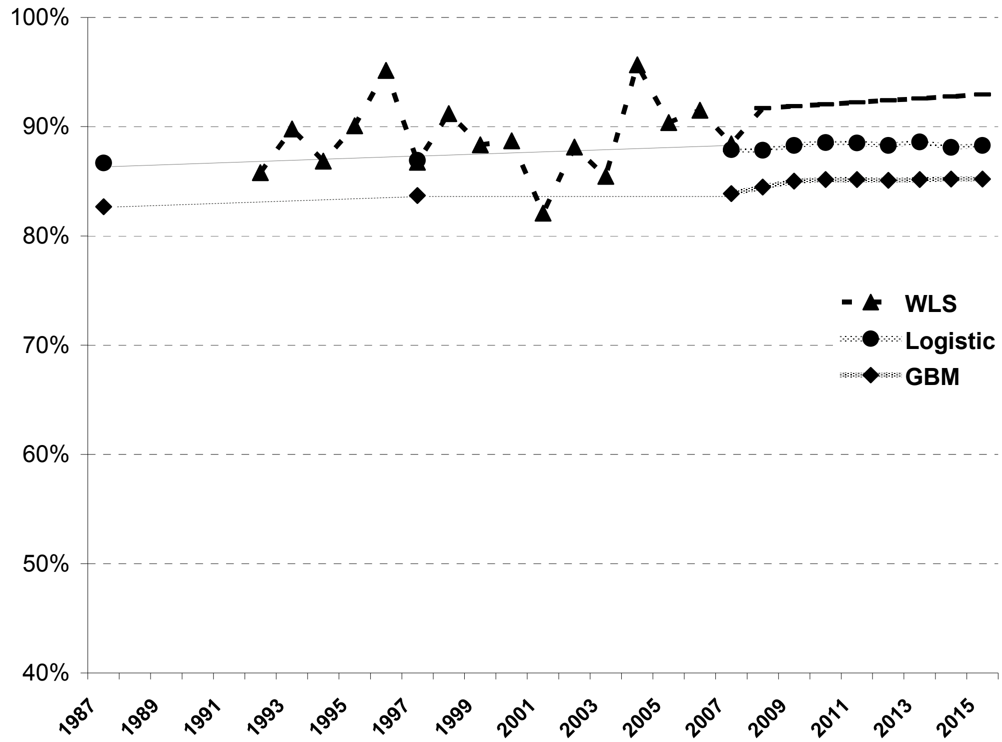


Figure 3.3.8: Comparing projections between approaches. Other races, females



CHAPTER 4: EVALUATING IMPACT OF EARLY ADOLESCENT ROMANCE USING PROPENSITY SCORE STRATIFICATION

INTRODUCTION

Romantic relationship is central in adolescent life. Youth spend a significant amount of time thinking about, talking about and being in romantic relationships. Romantic relationships are also the common cause of strong positive or negative emotions among youth, more so than other kinds of relationship (such as with friends, parents, or school) (Furman & Shaffer, 2003). We tend to hypothesize that romantic relationships will negatively affect youth's academic outcomes because the time spent with a romantic partner might distract the student from schoolwork. However, such effect might be highly dependent on the nature of the relationship. Those with supportive relationships could be more involved in school whereas those with more conflictual relationships could be more disruptive (Furman & Shaffer, 2003).

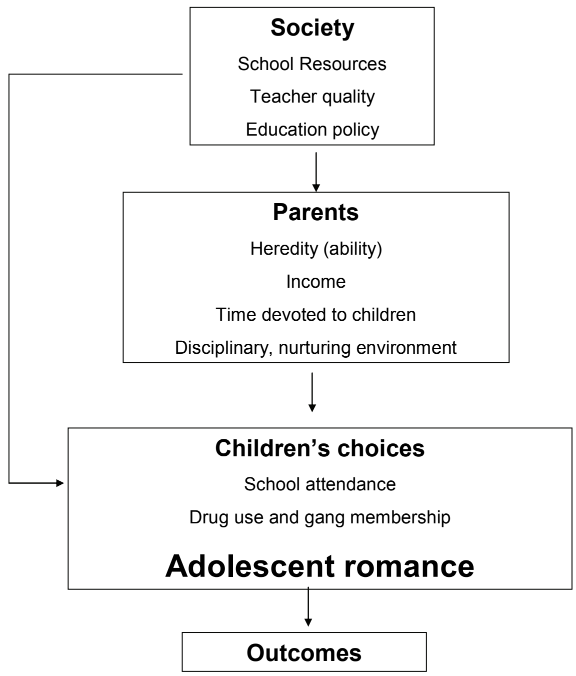
While the findings about whether romantic relationship can negatively (or positively) affect academic outcomes are inconclusive, the theoretical framework developed by Haveman & Wolfe (1995) shows that romantic relationship, as a student choice, do play a role in determining education outcomes. However, so far, the relation between early adolescent romance and youth's educational attainments is still very under-researched. Most previous studies are dated, and the rest might not be methodological sound.

First of all, studies on this topic are dated. Studies such as Grinder (1966), Larson et al. (1976) and Simmons et al. (1979) all find that romantic relationships during high

school are linked with lower GPAs or standardized test scores. But findings from these studies might not be applicable to today's conditions.

Second, all studies, including more recent ones, face selection issues. I.e. students who choose to date may be predisposed to poor academic outcomes. This happens because important factors affecting both the likelihood to be involved in early romance and academic outcomes (such as student intelligence, parent education, income, neighborhood effect, etc.) are not controlled for. For instance, Rector, Johnson, Noyes & Martin (2003), finds that early sexual activities initiation among young girls are related to negative health outcomes (such as increased rate of STD, increased abortion, increased depression, and decreased happiness) which are likely to foster negative academic outcomes. However, this study is a descriptive report where none of the demographic and social economic status variables are controlled for.

Figure 4.1. Determinants of children's attainments



NOTE: Adapted from Haveman & Wolfe (1995) [13]

Similarly, Quatman et al. (2001) find that students who date frequently (more than twice per month) exhibited consistently lower academic achievement and motivation. However, the dating frequency could be influenced by other factors correlated with education outcomes that the study did not control for. In other words, frequent daters might already be low performing students before they dated, thus the low performance might have little to do with dating. Research have shown that students from a non-intact families might be more likely to date (Wood, Avellar, & Goesling, 2008) and perform

[13] "Society" acts first to prepare the environment for "parents" and "children" to make their decisions. "Society" can influence "children's decisions" both directly and indirectly. Given the environment set by "society", "parents" decide their level of investment on children. Finally, given the resources provided by "parents" and "society", "children" make their own choices of time spent on studying and on other activities including dating.

poorly in school at the same time (Astone & McLanahan, 1991; Ekstrom et al., 1986; Goldschmidt & Wang, 1999; McNeal, 1999; Rumberger, 1995; Rumberger & Larson, 1998; Swanson & Schneider, 1999; Teachman, Paasch, & Carver,1996).

Other recent studies such as Halpern et al. (2000) and Neemann et al. (1995) also find negative associations between academic achievement and romantic relationship in early adolescence, but they are unsure if the relationship itself has any negative impact on academic achievement. In fact, Halpern et al. (2000) find that those who are less academically motivated are more likely to initiate sexual activities early, and those who score higher in intelligence measures are much less likely to be involved in sexual activities during high school. According to Halpern et al. (2000), a possible reason for this might be that high-intelligence students tend to actively postpone romantic activities as a demonstration of their desire to safeguard their future educational plans and avoid risks associated with sexual intercourse (e.g. pregnancy and STDs).

In this study, I investigate the impact of early adolescent romance on student performance in terms of: High school graduation, college preparation, and college enrollment. In addition, because current literature on teenage romance and its consequences tends to pay more attention to girls than boys (Simmons et al., 1979; Rector, Johnson, Noyes & Martin, 2003), to critique this belief, I will also investigate the effects of early adolescent romance by gender. I focus on early dating and sexual behaviors among 9th graders. These students are the youngest cohort in high school, thus

policy intervention should be placed here, if not earlier. If we wait until later, consequences might become permanent.[14]

The rest of the study is organized as follows. The second section describes the data used in the study. The third section documents the propensity score method. The fourth section summarizes the estimated effects of early adolescent romance on three outcomes. The last section summarizes and discusses the study's findings.

[14] It has been shown that the impact of dating, if any, become less clear in late adolescence. Kopfler (2009) tries to test the hypothesis that college students who were involved in romantic relationships would not perform as well academically in undergraduate coursework. However, the difference was not statistically significant in his 75-student sample. Neemann et al. (1995) also find that later in adolescence, romantic relationship involvement loses its negative significance, perhaps as it becomes a normative developmental task.

DATA

I use the National Longitudinal Study of Youth 1997 (NLSY97). The NLSY97 is a longitudinal study following up a nationally representative sample of approximately 9,000 youth who were 12 to 16 years old as of December 31, 1996. Those youth are interviewed annually. The last wave of data is in 2005. The data set provides extensive information about youth background, educational experiences over time, parent socioeconomic background, and dating experience. My study focuses on 2,895 individuals who have attended 9th grade in the survey, and whose outcomes could be observed by the end of the last wave.[15]

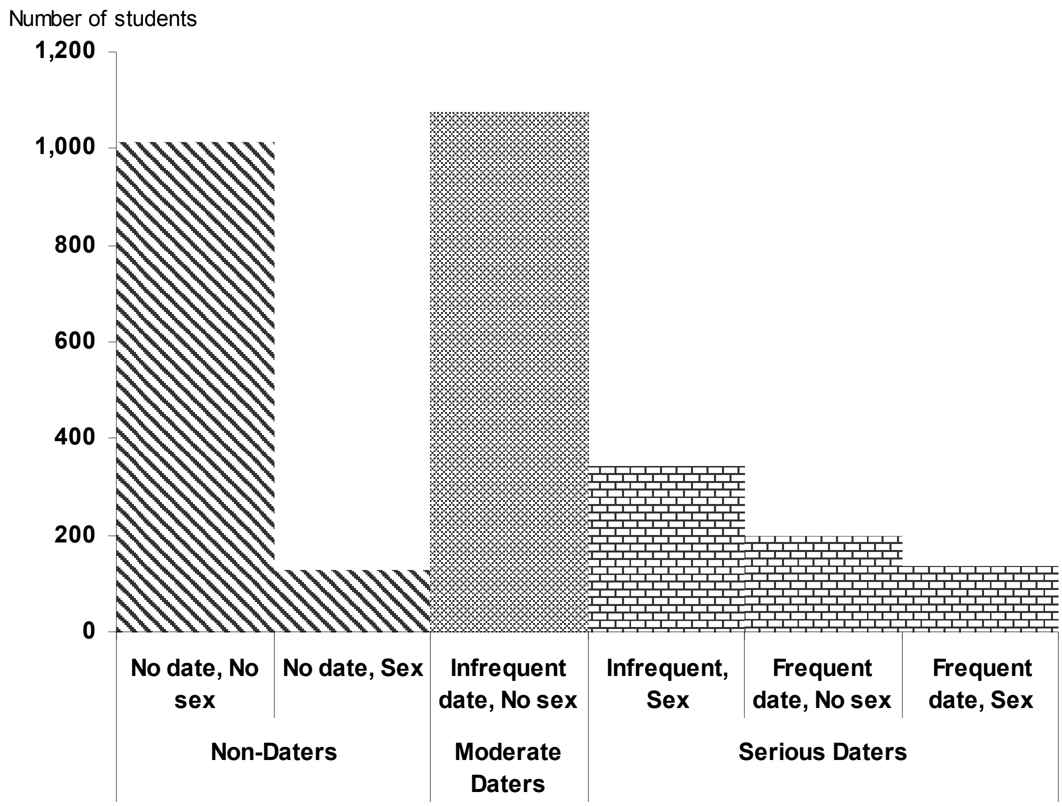
In this study, I construct three outcome variables: An indicator of whether the individual has graduated from high school by the age of 20; an indicator of whether he/she has taken advanced math courses during high school (proxied for college preparation); and an indicator of whether the student has finally enrolled in college by the last wave of data.

There are also three treatment variables. The first treatment variable is a combination of dating frequency and sexual activities of the individual in 9th grade. I group these behaviors into 3 categories: 1) non-daters- students who did not date in 9th grade; 2) moderate daters- students who dated less often than once per week, and never had sex; and 3) serious daters- students who dated less often than once per week but have had sex by 9th grade, or students who dated once per week or more. The grouping of this variable is described in Figure 4.2. The second treatment variable is a binary variable

[15] These students could be from different cohorts. Due to limited sample size, I was unable to target just one cohort. Instead, I included all individuals attended 9th grade, whose outcomes can be observed. For example, a 9th grader in 2003 would not be included in our analysis due to truncation. Similarly, a 10th grader in 1997 would not be included because his/her dating behavior in 9th grade is not observed.

indicating whether the student dated in 9th grade. The analysis with this treatment variable is intended to separate the "pure" effects of dating from effects of sex. Similarly, the third treatment variable is another binary variable indicating whether the student had sex in 9th grade. Because the population of students who had sex before 9th grade is small and the characteristics of students in this population look closer to those who had sex in 9th grade than those who never had sex, I group them in the 9th grade sex group. The analysis with this treatment variable is intended to separate the effects of sexual activities from effects of dating.

Figure 4.2. Grouping of the multiple-dose treatment variable



Other covariates controlled for in the analysis include gender; race/ethnicity (dummied out); age at beginning of 9th grade; mother education in years; student AFQT score percentile[16]; a continuous variable ranging from 1 to 8 indicating 8th grade performance (Mostly below Ds, mostly Ds, about half Cs and half Ds, mostly Cs, about half Cs and half Bs, mostly Bs, about half Bs and half As, and mostly As)[17]; an indicator of both parents living together; family income deciles; school type (public or non public); indicator of gang-related activities in the neighborhood or school; and student

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[16] Armed Force Qualification Test (AFQT) is a composite of four core tests that measure knowledge in a group of typical high school level academic disciplines. AFQT in this study is used as a proxy of student ability.

[17] Because this study investigates the impact of dating in 9th grade, controlling for 8th grade school performance is important to make sure that we are comparing students with similar "ability" but differ in "romance".

urbanicity.[18] These variables are selected based on current literature and their potential correlation with both treatment and outcomes. Detailed descriptions of these variables are presented in Appendix 4.1.

METHODS

In this study, I utilize a parametric propensity score model. The propensity score method was first introduced in Rosenbaum and Rubin (1983) and has been widely used since then. In this method, the propensity score is used to balance control and treatment groups in terms of characteristics (covariates) that affect the probability of receiving treatment. In the context of this study, the analytic strategy is to obtain predicted probabilities of entering "romance" based on observed characteristics of the students. Then, the differences in academic outcomes will be measured as a function of these predicted probabilities (propensity scores).

To obtain the propensity scores, I run a logistic regression model and obtain a linear prediction.

The Logistic model takes the following form:

$$Log\left(\frac{P(Y_i = 1)}{1 - P(Y_i = 1)}\right) = \alpha + \beta X_i$$

Where $P(Y_i = 1)$ is the probability of individual *i* receiving the treatment (early sex or dating), X_i is a vector of covariates that affect the probability of receiving the treatment, and β is the coefficient vector.

[18] The analysis using the dating binary treatment also controls for sexual activity, and the analysis using sex binary treatment also controls for dating behavior.

This propensity score method can also be used in cases of multiple dose-treatments (e.g. high, medium, and low), as first introduced in Lu, Zanutto, Hornik & Rosenbaum (2001). Accordingly, to get the propensity scores, researchers can run an ordinal logistic model and obtain a linear prediction.

The ordinal logistic model takes the following form:

$$Log\left(\frac{P(Y_i \leq k)}{1-P(Y_i \leq k)}\right) = \alpha_k + \beta X_i$$

Where Yi is the treatment level received by individual *i*, *k* is the treatment level indicator. k =1,2,3. The propensity score (balancing score) is simply the linear predicted value βX_i . If the model fits the data well, within the same propensity score "neighborhood", it is expected that different treatment groups are balance on covariates.

Following the standard procedure of stratification in Lu et al. (2001) and Zanuto, Lu, & Hornik (2005), I stratify propensity scores into 5 strata and remove observations in propensity score ranges that do not cover all treatment levels. This is analogous to dividing observations into 5 groups and randomly assigning the treatment within each group. According to Rosenbaum and Rubin (1984), stratifying this way removes approximately 90% of the initial imbalance in each of the covariates. If balance is achieved, the covariates of students in the same stratum (but different treatment groups) should look as balanced as if they are randomly assigned to treatment groups. To assess the initial imbalance in observed covariates between treatment groups, I run a One-Way ANOVA for each covariate on treatment levels. To check whether post-stratification balance is achieved, for each covariate, I run a Two-Way ANOVA, where the covariate being the dependent variable, and treatment and stratum indicator being the two factors.

Balance is achieved in a covariate if the main effect of treatment and the interaction of strata indicator and treatment are not statistically significant for that covariate. The assessment of pre and post stratification balance is presented in Appendix 4.3.

Once treatment groups are balanced, we can proceed to calculating the average treatment effect. I first estimate means and standard deviations of treatment levels within each stratum. The overall means of treatment levels are weighted averages of the strata level means. The overall standard deviations are standard deviations of the weighed averages.

$$M_i = \sum_{k=1}^{5} \left(\frac{N_k}{N} * M_{k_i}\right)$$

$$SD_i = \sqrt{\sum_{k=1}^{5} \left(\frac{N_k}{N} * sd_{k_i}\right)^2}$$

Where M_i is the overall mean of treatment level i $(i = 1,2,3)$, M_{k_i} is the mean of treatment level i in stratum k. N is total sample size. And N_k is sample size of stratum k; SD_i is the overall standard deviation of treatment level i; sd_{k_i} is the standard deviation of treatment level i in stratum k. I then calculate treatment effects within each stratum and test for statistically significance by a two-sample Z test.

Because the NLSY97 is a survey data, it is necessary to adjust for sampling weight when making population inference about the effect size after stratification. For that reason, I have generated a post-stratification weight. The idea is to think of each observation in a given strata as it is randomly assigned to a treatment level (Zanutto, Lu & Hornik, 2005). The post-stratification weight (as adapted from Zanutto, Lu & Hornik (2005)) is given by:

$$W_{kij}^{new} = W_{kij}\left(\frac{\sum_{i}\sum_{j} W_{kij}}{\sum_{j} W_{kij}}\right)$$

Where W_{kij}^{new} is the post-stratification weight, and W_{kij} is the survey weight of observation *j*, treatment level *i*, and stratum *k*.

RESULTS

We are now ready to estimate the effect of early adolescent romance on high school graduation, taking advanced math courses, and college enrollment. I will first discuss the impact of adolescent romance on the three outcomes using the "multiple-dose treatment". Then I will discuss the impact using the "dating only" treatment, and the "sex only" treatment separately. The means and standard deviations in each stratum in tables 4.1-4.9 are post-stratification weighted to make population inferences. The "overall" means and standard deviations are weighted means and standard deviations of individual strata.

Multiple-Dose Treatment

Analyses on all three outcomes show a common pattern, moderate daters are more likely to graduate from high school, take advanced math courses, and enroll in college than are non-daters and serious daters. However, the differences in high school graduation rate and taking advanced math courses between moderate daters and non-daters are not statistically significant (Table 4.1 and 4.2).

Serious daters perform the worst in two out of three outcomes. Table 4.1 shows that they graduate from high school at a much lower rate than other groups. Only 73 percent of serious daters graduate from high school, compared to 85 percent of non-daters, and 86 percent of moderate daters (the differences in graduation rates between serious daters and the other two groups are statistically significant). Serious daters are also much less likely to go to college, as indicated in Table 4.3. Only 59 percent of serious daters have enrolled in college by the last wave of data, compared to 71 percent of moderate daters and 66 percent of non-daters. Table 4.2 indicates that serious daters are also somewhat less likely

to take advanced math courses. Only 35 percent of serious daters have taken advanced math courses during high school, compared to 37 percent of moderate daters (even though the differences are not statistically significant)[19].

Table 4.1: Estimated effects of early adolescent romance on high school graduation

					Moderate daters Vs Non-daters	Serious daters Vs Non daters	Serious daters Vs Moderate daters
		N	Mean	Sd	Effect size	Effect size	Effect size
Stratum 1	Non-daters	104	0.82	0.39	0.07	-0.08	-0.16
	Moderate	31	0.89	0.31			
	Serious	7	0.73	0.48			
Stratum 2	Non daters	374	0.92	0.28	-0.03	-0.13*	-0.10
	Moderate	210	0.89	0.32			
	Serious	64	0.79	0.41			
Stratum 3	Non-daters	485	0.88	0.33	0.00	-0.12*	-0.12*
	Moderate	573	0.88	0.33			
	Serious	287	0.76	0.43			
Stratum 4	Non-daters	138	0.75	0.44	0.03	-0.10*	-0.14*
	Moderate	229	0.78	0.41			
	Serious	229	0.64	0.48			
Stratum 5	Non-daters	15	0.76	0.44	0.00	-0.36*	-0.36*
	Moderate	20	0.76	0.44			
	Serious	60	0.39	0.49			
Overall	Non-daters	1,116	0.85	0.19	0.01	-0.12*	-0.13*
	Moderate	1,063	0.86	0.19			
	Serious	647	0.73	0.25			
N		2,826					

NOTE. * indicates statistical significance at 0.05 level

[19] It is important to note that in this data set, “taking advanced math courses” might not be a strong proxy of college readiness because it is not highly correlated with actual college enrollment.

Table 4.2: Estimated effects of early adolescent romance on taking advanced math courses

		N	Mean	Sd	Moderate daters Vs Non-daters Effect size	Serious daters Vs Non daters Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non-daters	95	0.41	0.49	-0.11	-0.34*	-0.23
	Moderate	31	0.30	0.47			
	Serious	6	0.07	0.29			
Stratum 2	Non daters	302	0.44	0.50	0.05	0.11	0.05
	Moderate	156	0.49	0.50			
	Serious	46	0.55	0.50			
Stratum 3	Non-daters	400	0.37	0.48	0.02	-0.02	-0.03
	Moderate	451	0.39	0.49			
	Serious	189	0.36	0.48			
Stratum 4	Non-daters	168	0.23	0.42	0.04	0.02	-0.02
	Moderate	269	0.27	0.45			
	Serious	195	0.25	0.44			
Stratum 5	Non-daters	19	0.23	0.43	-0.05	-0.05	0.01
	Moderate	39	0.18	0.39			
	Serious	60	0.19	0.39			
Overall	Non-daters	984	0.35	0.26	0.02	0.00	-0.02
	Moderate	946	0.37	0.26			
	Serious	496	0.35	0.26			
	N	2,426					

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.3: Estimated effects of early adolescent romance on college enrollment

		N	Mean	Sd	Moderate daters Vs Non-daters Effect size	Serious daters Vs Non daters Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non-daters	104	0.72	0.45	0.04	0.02	-0.02
	Moderate	31	0.75	0.44			
	Serious	7	0.73	0.48			
Stratum 2	Non daters	374	0.75	0.44	-0.02	-0.08	-0.06
	Moderate	210	0.72	0.45			
	Serious	64	0.66	0.48			
Stratum 3	Non-daters	485	0.69	0.46	0.08*	-0.10*	-0.18*
	Moderate	573	0.77	0.42			
	Serious	287	0.59	0.49			
Stratum 4	Non-daters	138	0.56	0.50	0.05	-0.05	-0.10*
	Moderate	229	0.61	0.49			
	Serious	229	0.51	0.50			
Stratum 5	Non-daters	15	0.21	0.42	0.16	0.10	-0.06
	Moderate	20	0.37	0.50			
	Serious	60	0.31	0.47			
Overall	Non-daters	1,116	0.66	0.26	0.05*	-0.07*	-0.12*
	Moderate	1,063	0.71	0.25			
	Serious	647	0.59	0.28			
N		2,826					

NOTE. * indicates statistical significance at 0.05 level

Dating Only

Generally consistent with the multiple dose treatment analysis, the analysis using binary treatment of dating versus no dating in 9th grade shows a small difference in high school graduation rate. According to the results presented in Table 4.4, the graduation rate of daters is 81 percent, only 3 percentage points lower than that of non-daters. Daters have a bit lower rate (statistically significant) probably because some of them dated frequently (we already learned from the multiple dose treatment analysis that these frequent daters are much less likely to graduate). In addition, dating does not show any impact on the probability of taking advanced math courses during high school and going to college after high school. Table 4.5 shows that both daters and non daters have 36

percent taking advanced math courses, and Table 4.6 shows that both groups have 66 percent enrolling in college.

Table 4.4: Estimated effects of dating on high school graduation

		N	Mean	Sd	Effect size
Stratum1	Non-dater	78	0.93	0.25	-0.09
	Dater	20	0.85	0.37	
Stratum2	Non-dater	398	0.88	0.32	-0.08*
	Dater	214	0.80	0.40	
Stratum3	Non-dater	470	0.88	0.32	-0.03
	Dater	716	0.85	0.35	
Stratum4	Non-dater	154	0.83	0.38	-0.04
	Dater	566	0.79	0.41	
Stratum5	Non-dater	21	0.47	0.51	0.12
	Dater	185	0.59	0.49	
Overall	Non-dater	1,121	0.84	0.18	-0.03*
	Dater	1,701	0.81	0.20	
	N	2,822			

NOTE. * indicates statistical significance at 0.05 level

Table 4.5: Estimated effects of dating on taking advanced math courses

		N	Mean	Sd	Effect size
Stratum1	Non-dater	108	0.33	0.47	-0.14
	Dater	34	0.19	0.40	
Stratum2	Non-dater	407	0.40	0.49	0.00
	Dater	220	0.40	0.49	
Stratum3	Non-dater	366	0.38	0.49	0.00
	Dater	650	0.38	0.49	
Stratum4	Non-dater	103	0.27	0.44	0.06
	Dater	423	0.32	0.47	
Stratum5	Non-dater	11	0.36	0.50	-0.16
	Dater	116	0.20	0.41	
Overall	Non-dater	995	0.36	0.26	0.00
	Dater	1,443	0.36	0.26	
	N	2,438			

Table 4.6: Estimated effects of dating on college enrollment

		N	Mean	Sd	Effect size
Stratum1	Non-dater	78	0.70	0.46	-0.15
	Dater	20	0.54	0.51	
Stratum2	Non-dater	395	0.68	0.47	-0.02
	Dater	210	0.66	0.47	
Stratum3	Non-dater	469	0.74	0.44	-0.04
	Dater	707	0.70	0.46	
Stratum4	Non-dater	153	0.60	0.49	0.05
	Dater	556	0.66	0.48	
Stratum5	Non-dater	21	0.30	0.47	0.19
	Dater	184	0.49	0.50	
Overall	Non-dater	1,116	0.66	0.25	0.00
	Dater	1,677	0.66	0.25	
	N	2,793			

Sex Only

While dating presents almost no effects on student outcomes, early sexual activities show significant effects on high school graduation and college enrollment. Students who had sex in or before 9th grade are much less likely to graduate from high school. Table 4.7 shows that the graduation rate of these students is only 72 percent, compared to 84 percent of students who chose to have sex after 9th grade. Similarly, only 60 percent of those who had sex in or before 9th grade enrolled in college, compared to 65 percent of those who had sex after 9th grade (Table 4.9). The differences in high school graduation rates and college enrollment rates are statistically significant at 0.05 level. The results presented in Table 4.8, however, shows that students who had sex in 9th grade are 4 percentage points more likely to take advanced math courses than students who did not have sex in 9th grade.[20]

[20] This is somewhat inconsistent with other two outcomes, but consistent with the multiple-dose treatment analysis that taking advanced math courses is a poor predictor of actual college enrollment.

Table 4.7: Estimated effects of early sex on high school graduation

		N	Mean	Sd	Effect size
stratum1	No sex	239	0.97	0.18	0.00
	Sex	20	0.97	0.18	
stratum2	No sex	526	0.95	0.21	0.03
	Sex	9	0.98	0.15	
stratum3	No sex	876	0.85	0.36	-0.19*
	Sex	97	0.66	0.48	
stratum4	No sex	486	0.78	0.42	-0.18*
	Sex	337	0.60	0.49	
stratum5	No sex	36	0.56	0.50	-0.15
	Sex	127	0.41	0.49	
Overall	No sex	2,163	0.84	0.19	-0.12*
	Sex	572	0.72	0.23	
	N	2,753			

NOTE. * indicates statistical significance at 0.05 level

Table 4.8: Estimated effects of early sex on taking advanced math courses

		N	Mean	Sd	Effect size
stratum1	No sex	233	0.55	0.50	0.00
	Sex	20	0.55	0.50	
stratum2	No sex	492	0.49	0.50	0.24
	Sex	9	0.73	0.47	
stratum3	No sex	794	0.33	0.47	-0.07
	Sex	74	0.25	0.44	
stratum4	No sex	413	0.16	0.37	0.04
	Sex	251	0.21	0.41	
stratum5	No sex	28	0.12	0.33	0.15
	Sex	76	0.26	0.44	
Overall	No sex	1,960	0.33	0.23	-0.04*
	Sex	412	0.37	0.22	
	N	2,390			

NOTE. * indicates statistical significance at 0.05 level

Table 4.9: Estimated effects of early sex on college enrollment

		N	Mean	Sd	Effect size
stratum1	No sex	239	0.90	0.30	0.00
	Sex	20	0.90	0.30	
stratum2	No sex	524	0.84	0.37	0.01
	Sex	9	0.85	0.38	
stratum3	No sex	872	0.69	0.46	-0.13*
	Sex	96	0.56	0.50	
stratum4	No sex	478	0.49	0.50	-0.05
	Sex	330	0.44	0.50	
stratum5	No sex	34	0.28	0.46	-0.03
	Sex	123	0.25	0.44	
Overall	No sex	2,147	0.65	0.24	-0.05*
	Sex	560	0.60	0.25	
	N	2,725			

NOTE. * indicates statistical significance at 0.05 level

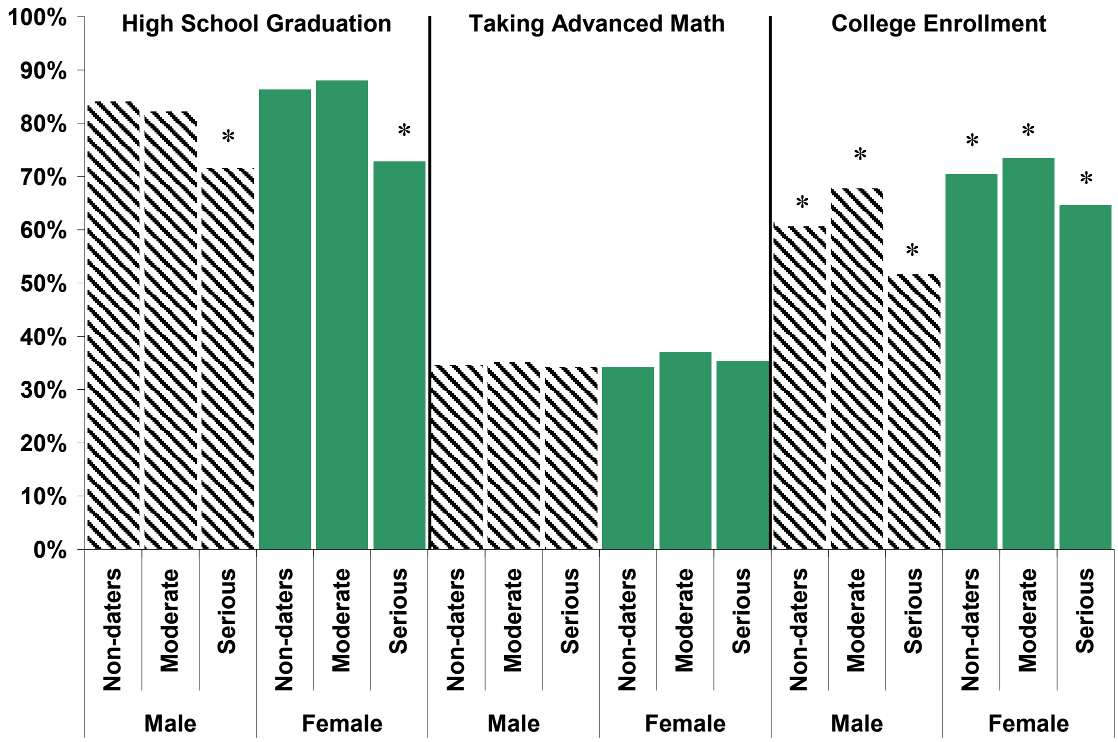
Effects by Gender

The multiple-dose treatment analysis by gender, described in Figure 4.3, shows little evidence that early adolescent romance affects females differently than males. In terms of high school graduation rate, for both males and females, there are no significant difference between moderate daters and non-daters, and serious daters are least likely to graduate. In addition, the gaps in high school graduation rates between serious daters and non-daters for males and for females are about the same (12 percentage points for males, and 13 percentage points for females). Similarly, the college enrollment rates across treatment levels by gender share the same pattern, with the highest rates for moderate daters, followed by non-daters and a significant drop when we move to serious daters, but serious dating appears to affect boys a bit more than girls, with the gap in college continuation rates between serious daters and non-daters for boys being 10 percentage points, while this gap for girls is only 6 percentage points (both statistically significant at the 0.05 level). I also detect no significant differences across three treatment levels in the proportion of students taking advanced math courses for both males and females.

Binary treatment analysis for dating only reveals no difference between males and females. According to Figure 4.4, the gaps in high school graduation rate between daters and non-daters for males and females are about the same (3 and 4 percentage points respectively, both statistically significant). In addition, dating presents no significant differences in college enrollment rates between daters and non daters, for both males and females. However, it appears that dating has some impact on males, while there is no impact on females in terms of taking advanced math courses.

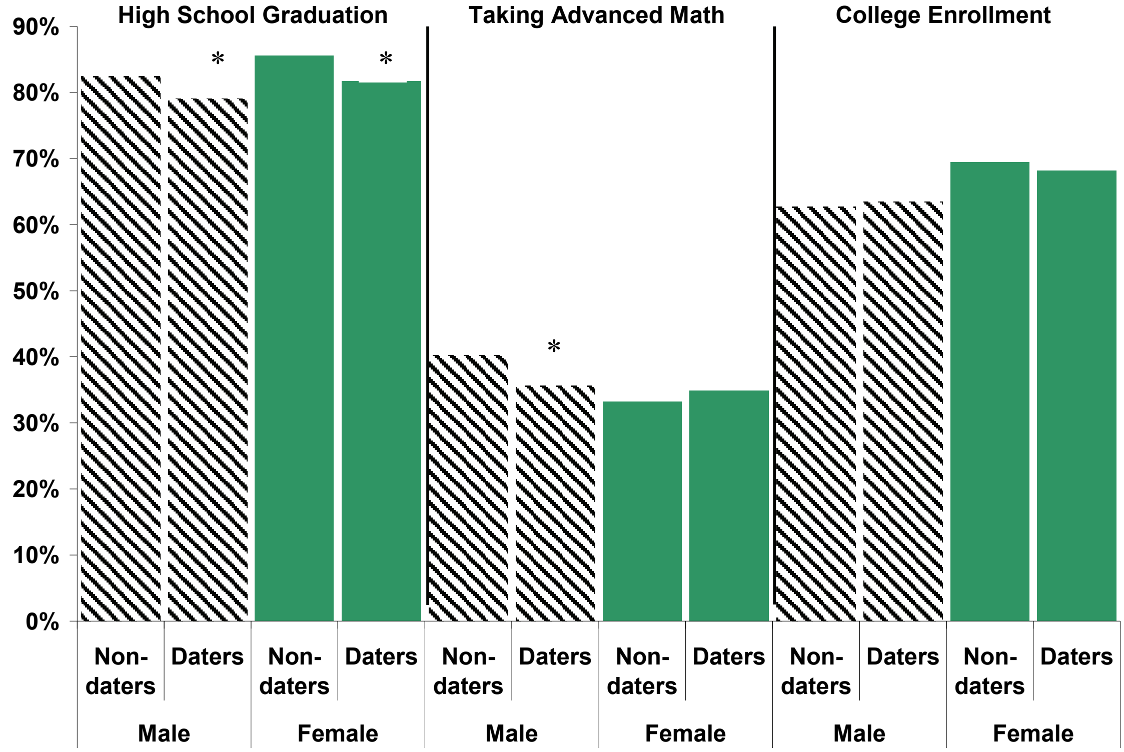
Slightly different from the analysis for dating only, early sexual activities appear to affect females more than males (demonstrated in Figure 4.5). For instance, in terms of high school graduation rate, the impact on males is 11 percentage points while the impact on females is 14 percentage points. Similarly, in terms of college enrollment rate, the impact on males is 6 percentage points while the impact on female is 7 percentage points. However, early sexual activities have no statistically significance impact on taking advanced math courses for both genders. Detailed analyses by gender are presented in Appendix 4.4.

Figure 4.3: Summary of high school graduation rates, likelihood of taking advanced math courses, and college enrollment rates across levels of treatment by gender- multiple dose treatment analysis.



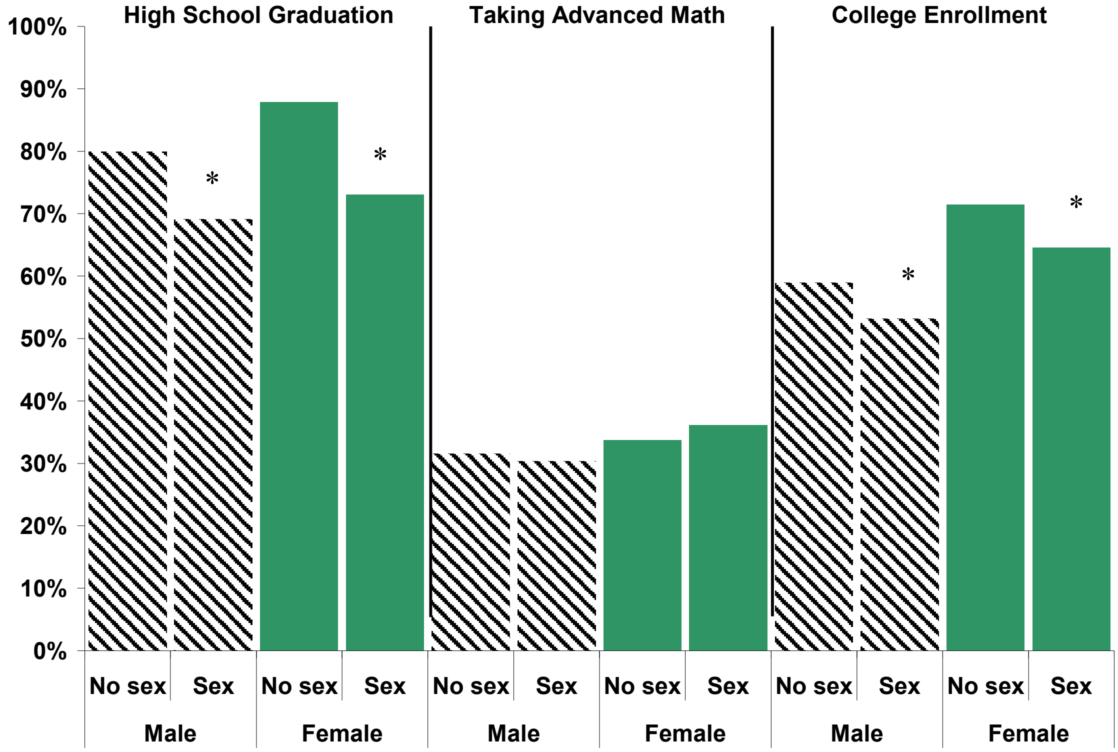
NOTE: * implies statistically significant compared to the remaining two treatment groups at 0.05 level.

Figure 4.4: Summary of high school graduation rates, likelihood of taking advanced math courses, and college enrollment rates across levels of treatment by gender- non-daters versus daters.



NOTE: * implies statistically significant compared to the remaining treatment group at 0.05 level.

Figure 4.5: Summary of high school graduation rates, likelihood of taking advanced math courses, and college enrollment rates across levels of treatment by gender- students who had sex after 9th grade versus students who had sex in or before 9th grade.



NOTE: * implies statistically significant compared to the remaining treatment group at 0.05 level.

DISCUSSION AND CONCLUSIONS

Early adolescent romance shows mixed effects on youth's education achievement. On the one hand, moderate dating does not show any impact on high school graduation, and shows a positive impact on college enrollment, compared to non-daters[21]. On the other hand, serious dating, consisting of early sexual intercourse and high dating frequencies, shows significant negative impact. These behaviors are linked to a 12 percentage point decrease in high school graduation rate, and a 7 percentage point decrease in college enrollment rate[22].

High dating frequencies and sexual intercourse associated with dating might be harmful, first because it takes away too much time from studying. Second, students with serious relationship too early may not be experienced enough to behave in relationship, leading to significant amounts of time spent on dealing with "drama" caused by their own inexperience. Finally, other problems associated with early sexual intercourse such as teenage pregnancy and birth out-of-wedlock (Rector et al. 2003) could also contribute to poor academic performance. This study suggests that these consequences tend to affect female students a bit more than male students.

On the other hand, moderate dating may be beneficial, first because it does not take away too much time from studying and the time taken away might be necessary for the students to develop social skills[23] (e.g. interpersonal skills, or skills in coping with

[21] When separating the impact of dating, I find that it has no impact on college enrollment and taking advanced math courses, and has a small impact on high school graduation (3 percentage points)
[22] When separating the impact of early sex, I find that it has negative impact on both high school graduation (12 percentage points) and college enrollment (5 percentage points).
[23] It has been shown that dating can facilitate the process through which youth understand who they are and what they value, and provide a training ground for youth to develop interpersonal skills (Sorensen, 2007).

relatively complex relationships), which in turn may be good for school. Second, dating may also provide students with a higher level of self-esteem through earning respect from peers for being "cool" enough to attract a girlfriend or boyfriend, or through social interaction (Furman & Schaffer, 2003; Kopfler, 2009). In addition, daters may find mental support from their partners when schools do not go well for them, or learn more effectively when they study together. Finally, another advantage for moderate daters is they do not have to spend significant amounts of time looking for a relationship and deal with rejection like non-daters, or deal with too much drama in serious relationships.

Nevertheless, the results of this study should be viewed with caution because the propensity score method, even when balance on covariates is well achieved, only controls for observables. This method can remove imbalances in almost all important observed covariates that I can find in the literature, but there is still a potential problem if there are imbalances in unobservable covariates. In addition, the NLSY97 is a self reported survey data, and thus is subject to measurement errors when the individuals do not report truthfully. This dataset also has significant attrition problem. This could be problematic if, for instance, daters who are high school dropouts also tend to drop out of the sample more than non-daters. Given the NLSY97 data, I was not able to test if it is the case. Moreover, the mixed findings may be due to the nature of the relationship, which I was unable to control for[24]. For example, Berndt & Keefe (1995) and Furman & Shaffer (2003) argue that the effect could be positive or negative depending on the characteristics of the partner and the nature of the relationship, just as in the case of friendship. Those

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Even breakups, despite being depressing, could help youth develop emotional resiliency and coping skills needed to handle difficulties in life (Barber & Eccles, 2003).

[24] Information about nature of relationship is available in the NLSY97, but there are too many missing values for the key sample used in this study.

with supportive partners tend to become more involved in school because they may study together, helping each other with homework, provide each other emotional support, and encouraging each other to achieve higher academically. Others with disruptive or abusive partners, or who experienced events such as contracting STDs or pregnancy, tend to become less involved in school.

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APPENDIX 4.1
DETAILED DESCRIPTION OF COVARIATES

"Gender" is a dummy variable indicating whether the student is female or male. It is shown that female students, in general, perform better academically (Hirschman, Pharris-Ciurej, & Willhoft, 2006), but are more matured than male students for their age, and thus might be more likely to be involved in dating.

"Race/ethnicity" is a categorical variable with 3 categories: White, African American, and Hispanic. Even though race does not have a causal effect on education achievement, the literature shows that African-American and Hispanic students (Hirschman, Pharris-Ciurej, & Willhoft, 2006) are less likely to graduate from high school. At the same time, Wood, Avellar, & Goesling (2008) find that white teens are more likely, and African American teens are less likely to date than are other teens. African Americans are also more likely to initiate early sexual activities than do white and Hispanics.[25]

"Age at the start of 9th grade" is a continuous variable measuring the age of each individual as he/she is enrolled in 9th grade the first time[26]. Earlier grade retention (and hence being old for grade) is an important determinant of school failing (Alexander, Entwistle, & Horsey, 1997; Goldschmidt & Wang, 1999; Grisson & Shepard, 1989; Jimerson, 1999; Kaufman & Bradby, 1992; Roderick, 1994; Roderick, Nagaoka, Bacon, & Easton, 2000). Being old for grade also means the students are physically more matured, and thus would be more likely to date.

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[25] The number of Asians, Pacific Islanders, and Native Americans in our sample is too small so I have decided to exclude them from the analysis.

[26] It should be noted that students in the 9th grade cohort in 1997 are not all first time students due to left censoring.

"Mother education" is a continuous variable indicating the number of years of education completed [27]. Mother education is positively correlated with student achievement (Astone & McLanahan, 1991; Rumberger, 1995), and higher mother education might be associated with reduced chances of early romantic relationship because educated parents may be "stricter".

Student ability is undoubtedly causally correlated with academic achievement, and high intelligent students are more likely to delay their dating activities to safeguard their educational plan (Halpern et al., 2000). I use two variables to proxy for student ability: student Arm Force Qualification Test score ("AFQT"), and student "8th grade performance". It is expected that both variables provide close proximity of the student ability. However, AFQT score is derived from a test that is administered only one time in 1999, so some students have taken the test before their 9th grade, some have taken it at 9th grade, and some have taken it after. This might not fully reflect the ability of the student since AFQT score is expected to be correlated with the highest grade completed. For this reason, I have also included in the analysis the "8th grade performance" variable. This is a continuous variable measuring the overall grade the individual got in 8th grade, with 8 levels: Mostly below Ds, mostly Ds, about half Cs and half Ds, mostly Cs, about half Cs and half Bs, mostly Bs, about half Bs and half As, and mostly As.

"Both parents live together" is a dummy variable indicating whether both biological parents of the student are married and live together[28]. This is an indicator of an intact

[27] This variable is measured only once at the beginning of the study, but it is expected to remain stable throughout the study as it is unlikely that the mother of a 9th grader will change her education achievement significantly.

[28] Information on this variable is not collected every year, so I could not create an indicator of intact family when the student is exactly at 9th grade. However, this variable is quite stable since the data shows that only 7% of the couples reported living together in 1997 have divorced each other by 2005.

family, as oppose to living with a single parent or a parent and a step parent, etc. Single-parenthood and step families are found to be positively associated with high school dropout (Astone & McLanahan, 1991; Ekstrom et al., 1986; Goldschmidt & Wang, 1999; McNeal, 1999; Rumberger, 1995; Rumberger & Larson, 1998; Swanson & Schneider, 1999; Teachman, Paasch, & Carver,1996). At the same time, Wood, Avellar, & Goesling (2008) find that teenagers from non-intact families are typically likely to be involved in romantic relationship and cohabitation.

It is established that family income[29] is an important determinant of school performance (Hirschman, Pharris-Ciurej, & Willhoft, 2006; Neild & Balfanz, 2006), and students from low-income families are more likely to be involved in early adolescent romance (Wood, Avellar, & Goesling, 2008).

"Student urbanicity" is defined as the urban/rural status of the student at the beginning of the study in 1997[30]. Greene (2001) finds that students from urban school districts are more likely to drop out from high school. Even though I am not aware of any literature on the likelihood of dating among urban students compared to their rural counterparts, I expect that urban students may be more likely to date than are rural students due to differences in lifestyle.

"Pubic school" is the indicator of whether the student's high school is a public school. This variable in NLSY97 was only collected once at the beginning of the survey.

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[29] Because the information on family income was not available every year, I could not create an indication of family income when the student is exactly at 9th grade. Instead, the "family income deciles" variable is constructed based on the average of incomes in 3 years with largest sample coverage (1997, 2002 and 2003). The income deciles of each household are quite stable (check the histograms in appendix A). If one year is missing, I took average of the non missing two years, to impute the variable.

[30] Similar to the case of family income, I could not collect information on student rural urban status every year. I assume that the urbanicity status is stable, and that their 1997 status reflects their 9th grade status.

“Neighborhood gang” is an indicator of whether the student reported that there are gang activities in the home neighborhood or at school area. This variable is measured multiple times but the definition of gang activities seems to differ across wave, so I’ve decided to use the one administered in year 2000, when most of the students in my sample are covered.

Figure 4.1.1. Changes in income deciles between 1997 and 2003

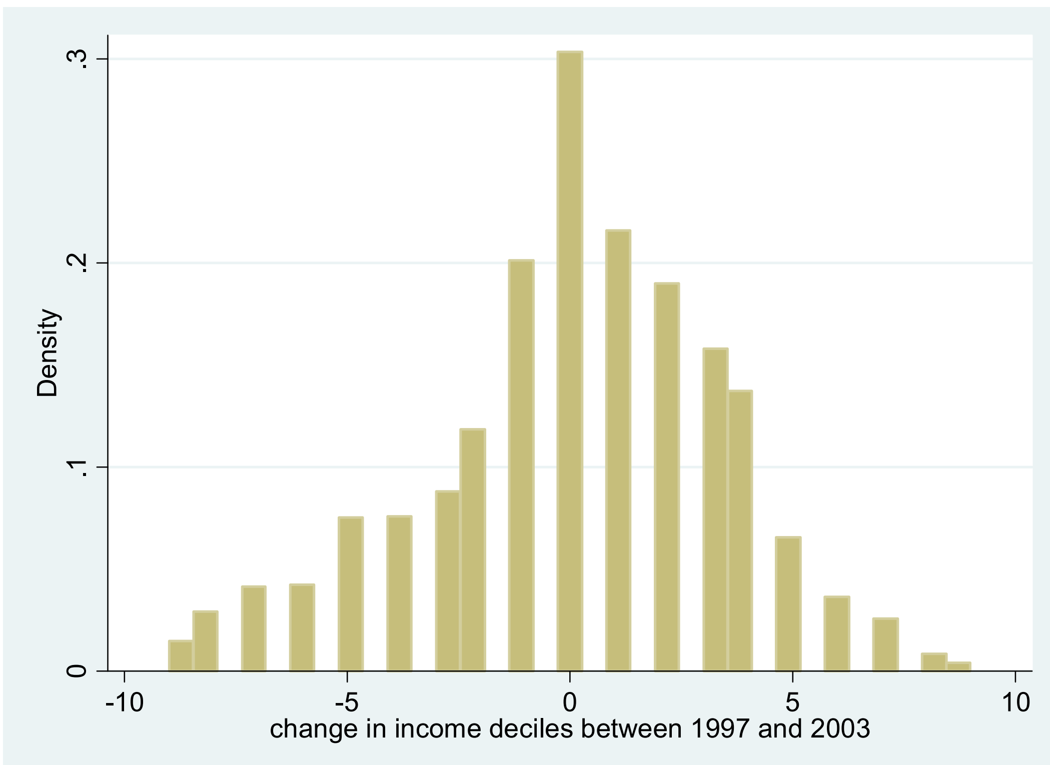


Figure 4.1.2. Changes in income deciles between 1997 and 2002

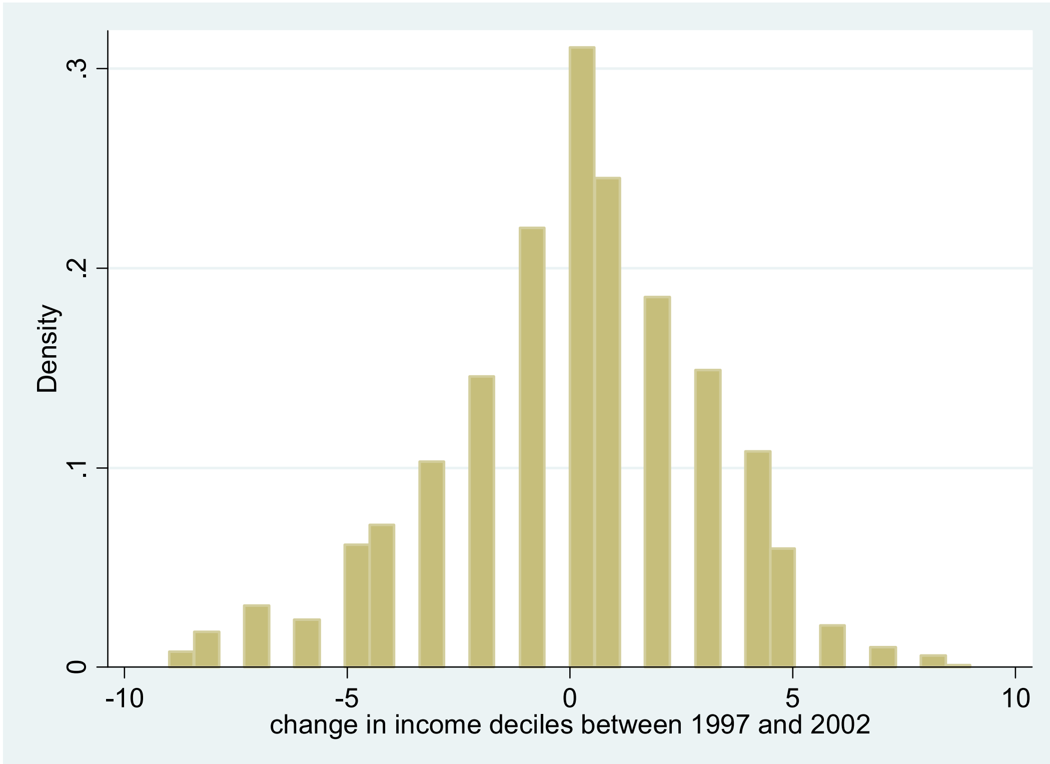
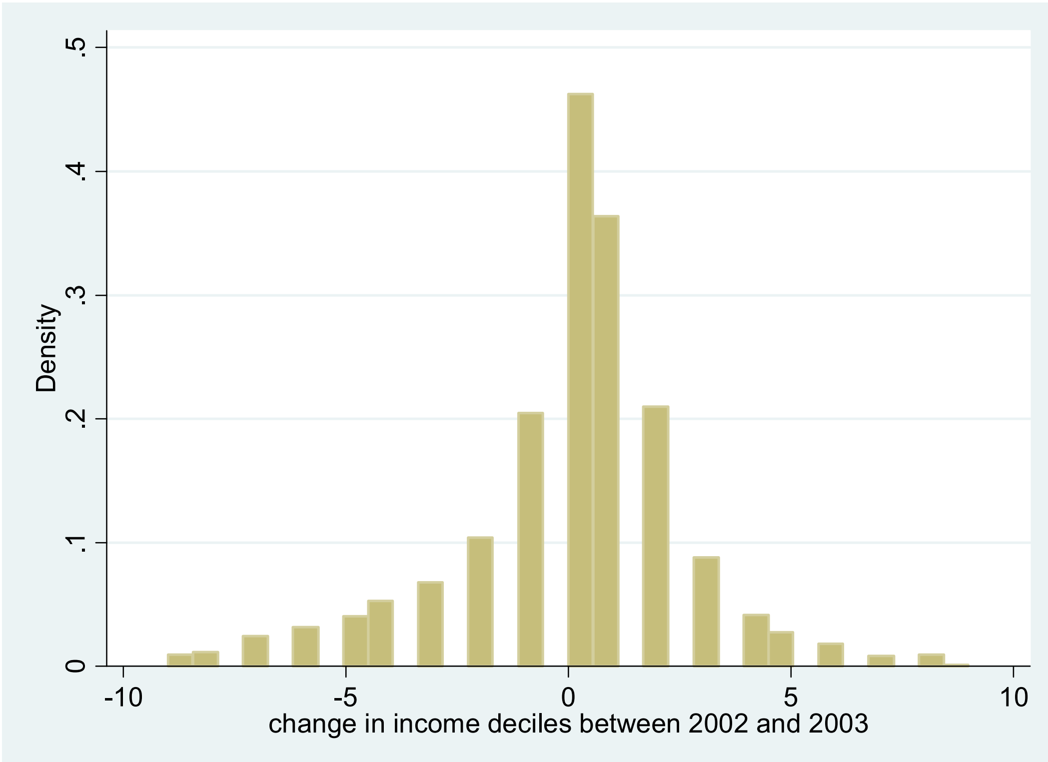


Figure 4.1.3. Changes in income deciles between 2002 and 2003



APPENDIX 4.2
DETAILED STEPS TO ESTIMATE EFFECT SIZES

Effect size= $(M_{k_{i_1}} - M_{k_{i_2}})$

$$Z \text{ statistic} = \frac{(M_{k_{i_1}} - M_{k_{i_2}})}{\sqrt{\frac{sd^2_{k_{i_1}}}{N_{k_{i_1}}} + \frac{sd^2_{k_{i_2}}}{N_{k_{i_2}}}}}$$

For stratum k, treatment levels i_1, i_2

Similarly, overall treatment effects can be estimated as follows:

Effect size= $(M_{i_1} - M_{i_2})$

$$Z \text{ statistic} = \frac{(M_{i_1} - M_{i_2})}{\sqrt{\frac{SD^2_{i_1}}{N_{i_1}} + \frac{SD^2_{i_2}}{N_{i_2}}}}$$

APPENDIX 4.3
ACCESSING PRE AND POST STRATIFICATION BALANCE

For the analysis with the multiple-dose-treatment, 68 observations in propensity score ranges that do not cover all treatment levels have been removed. I then examine pre and post-stratification imbalances on covariates among three treatment levels: non-daters, moderate daters, and serious daters. Table 4.3.1 suggests that before stratification, only the percentage of Hispanic students and mother's years of education are relatively balance among treatment groups. All other covariates show statistical significance in the One-Way ANOVA tests, implying initial biases, especially for "age at the start of 9th grade", student ability (both AFQT and 8th grade performance), percentages of females, whites, African Americans, and family income. Stratification has removed almost all initial biases on covariates (as indicated by small post-stratification F values). Only the percentage of African American students still shows statistical significance in the main-effect F statistic. This level of balance is as good as that of a randomized experiment, where we would expect about 1 F statistic significant at the 0.05 level.

Table 4.3.1: Assessing balance on covariates: Multiple-dose treatment.

	Pre Adjustment							Post Adjustment	
	Non-daters		Moderate		Serious		1 Way Anova	2 Way Anova	N=2827
	(N= 1,143)		(N=1,076)		N=676		N= 2,895	F values	
	Mean	Sd	Mean	Sd	Mean	Sd	F values	Main	Interaction
Female	0.58	0.49	0.48	0.50	0.42	0.49	23.62 *	0.56	0.91
White	0.45	0.50	0.59	0.49	0.46	0.50	25.61*	1.9	1.53
African American	0.32	0.47	0.21	0.41	0.33	0.47	20.90 *	3.85*	1.52
Hispanic	0.23	0.42	0.20	0.40	0.21	0.41	1.74	0.34	0.62
Mother education (years)	12.38	3.01	12.81	2.76	12.30	2.63	9.15*	0.12	1.26
AFQT percentile	45.51	28.00	49.82	26.30	39.48	24.94	31.25 *	1.01	1.64
8th grade performance	5.76	1.69	5.75	1.68	5.08	1.77	40.41*	1.97	1.9
Both parents live together	0.53	0.50	0.54	0.50	0.40	0.49	20.12 *	1.72	0.47
Family income deciles	5.14	2.31	5.62	2.37	4.96	2.4	19.84*	1.07	1.24
Age at start of 9th grade	14.25	0.80	14.34	0.77	14.60	0.83	42.65 *	1.68	1.24
Public school	0.91	0.28	0.91	0.29	0.93	0.25	1.65	0.29	1.04
Neighborhood gang	0.23	0.42	0.24	0.43	0.26	0.44	1.05	1.66	1.18
Urban	0.73	0.44	0.76	0.43	0.78	0.42	2.18 *	1.38	1.64

NOTE: * indicates statistical significance at 0.05 level

Similarly, Table 4.3.2 shows the balance/imbalance on covariates between daters and non-daters pre and post stratification in the analysis identifying effects of dating only. The initial sample is imbalanced on 9 out of 14 covariates. In particular, daters are much more likely to have had sex in 9^{th} grade, tend to be older, have lower GPA in 8^{th} grade, and have higher family income. The percentage of females, whites, African Americans are also very imbalance between the two groups. After dropping 73 observations whose propensity scores are not in ranges that cover all treatment levels, stratification has removed these biases completely. Out of 28 F statistics, only the interaction-effect (of dating and strata indicator) for the neighborhood gang dummy variable is still significant at the 0.05 level.

Table 4.3.2: Assessing balance on covariates: dating only

	Non-dater		Dater		Pre Adjustment	Post Adjustment	
					1 way Anova	2 Way Anova	N= 2,822
	(N= 1,143)		(N= 1752)		N= 2,895	F Values	
	Mean	Sd	Mean	Sd	F values	Main	Interaction
Had sex in 9th grade	0.38	0.49	0.46	0.50	111.52*	0.01	0.19
Female	0.58	0.49	0.46	0.50	41.11*	0.14	0.50
White	0.45	0.50	0.54	0.50	21.48*	2.58	1.09
African American	0.32	0.47	0.26	0.44	12.73*	2.15	1.20
Hispanic	0.23	0.42	0.20	0.40	2.97	0.10	0.40
Mother education (years)	12.38	3.01	12.62	2.72	4.86*	0.04	0.53
AFQT percentile	45.51	28.00	45.83	26.26	0.10	0.47	0.71
8th grade GPA	5.76	1.69	5.49	1.75	16.55*	1.04	1.10
Both parents live together	0.53	0.50	0.49	0.50	4.64*	0.67	0.64
Family income deciles	5.14	2.31	5.37	2.40	6.66*	0.02	0.55
Age at start of 9th grade	14.25	0.80	14.44	0.80	40.65*	1.07	1.31
Public school	0.91	0.28	0.92	0.27	0.28	0.92	0.94
Neighborhood gang	0.23	0.42	0.25	0.43	1.23	1.74	3.6*
Urban	0.73	0.44	0.76	0.43	3.73	0.03	1.25

NOTE. * indicates statistical significance at 0.05 level

By analogy, Table 4.3.3 describes the balance/imbalance on covariates between those who had sex in 9th grade and those who did not, pre and post stratification in the analysis identifying effects of early sexual activities only. 15 out of 16 pre-stratification F statistics are significant, indicating that the characteristics of the "sex" and "no sex" groups are highly different. After dropping 142 observations whose propensity scores are not in ranges that cover all treatment levels, stratification has removed all initial imbalances on covariates between the two groups (31 out of 32 post-stratification F statistics are insignificant).

Table 4.3.3: Assessing balance on covariates: early sexual activities only

	No sex		Sex		Pre Adjustment	Post Adjustment	
					1 way Anova	2 Way Anova	N= 2,753
	(N= 2,287)		(N=608)		N= 2,895	F Values	
	Mean	Sd	Mean	Sd	F values	Main	Interaction
No dating in 9th grade	0.44	0.50	0.21	0.41	114.61*	0.11	0.42
Infrequent dating	0.47	0.50	0.57	0.50	17.75*	0.00	0.76
Frequent dating	0.09	0.28	0.22	0.42	92.94*	0.18	1.49
Female	0.52	0.50	0.42	0.49	19.3*	0.12	0.83
White	0.55	0.50	0.33	0.47	100.09*	0.28	1.23
African American	0.23	0.42	0.47	0.50	136.76*	0.02	1.49
Hispanic	0.22	0.41	0.21	0.41	0.28	0.57	2.19
Mother education (years)	12.68	2.93	11.95	2.38	31.83*	0.24	0.96
AFQT percentile	49.09	26.93	32.98	22.96	182.41*	0.54	1.83
8th grade GPA	5.83	1.67	4.74	1.66	203.47*	1.30	2.54*
Both parents live together	0.55	0.50	0.31	0.46	114.74*	0.14	0.36
Family income decile	5.51	2.35	4.39	2.23	111.48*	0.64	0.37
Age at start of 9th grade	14.27	0.77	14.75	0.83	181.65*	0.49	2.01
Public school	0.91	0.29	0.94	0.23	7.54*	0.64	1.20
Neighborhood gang	0.23	0.42	0.27	0.45	5.6*	0.95	1.94
Urban	0.74	0.44	0.78	0.41	3.86*	0.00	1.83

NOTE. * indicates statistical significance at 0.05 level

Table 4.3.4: Assessing balance on covariates: dating only (for outcome "taking advanced math courses"). Multiple dose treatment.

	Pre Adjustment							Post Adjustment	
	Non dater		Moderate		Serious		1 Way Anova	2 Way Anova	N= 2,432
	(N= 1,021)		(N= 958)		N= 526		N= 2,505	F values	
	Mean	Sd	Mean	Sd	Mean	Sd	F values	Main	Interaction
Female	0.58	0.49	0.48	0.50	0.42	0.49	19.15*	1.83	1.68
White	0.46	0.50	0.62	0.49	0.48	0.50	26.27*	7.64*	0.84
African American	0.30	0.46	0.19	0.39	0.31	0.46	21.55*	8.57*	1.33
Hispanic	0.23	0.42	0.20	0.40	0.21	0.41	1.82	0.91	0.91
Mother education (years)	12.51	3.01	12.97	2.76	12.55	2.71	7.29*	1.08	1.08
AFQT percentile	47.12	27.92	51.66	25.94	41.90	25.35	23.28*	2.75	1.44
8th grade performance	5.87	1.66	5.87	1.63	5.35	1.71	20.83*	0.62	0.76
Both parents live together	0.55	0.50	0.57	0.50	0.45	0.50	10.62*	1.27	0.35
Family income deciles	5.30	2.30	5.80	2.34	5.22	2.39	15.46*	2.6	1.59
Age at start of 9th grade	14.20	0.78	14.31	0.74	14.53	0.80	31.64*	2.86	1.21
Public school	0.91	0.29	0.90	0.30	0.93	0.26	1.22	0.59	0.65
Neighborhood gang	0.22	0.42	0.23	0.42	0.25	0.44	0.99	1.13	1.27
Urban	0.73	0.45	0.75	0.43	0.78	0.41	2.98	0.99	1.91

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.3.5: Assessing balance on covariates: dating only (for outcome "taking advanced math courses"). Dating only.

	Non-dater		Dater		Pre Adjustment	Post Adjustment	
					1 way Anova	2 Way Anova	N= 2,444
	(N= 1,021)		(N= 1,484)		N= 2,505	F Values	
	Mean	Sd	Mean	Sd	F values	Main	Interaction
Sex	0.37	0.48	0.44	0.50	103.64*	2.52	1.05
Female	0.58	0.49	0.46	0.50	33.91*	0.11	0.7
White	0.46	0.50	0.57	0.50	26.57*	1.40	0.95
Black	0.30	0.46	0.23	0.42	17.98*	0.42	0.3
Hispanic	0.23	0.42	0.20	0.40	2.98	0.52	0.55
Mother education (years)	12.51	3.01	12.82	2.75	7.05*	0.40	0.6
AFQT percentile	47.12	27.92	48.20	26.15	0.98	1.18	0.4
8th grade GPA	5.87	1.66	5.69	1.68	7.29*	0.14	0.72
Both parents live together	0.55	0.50	0.52	0.50	1.43	1.43	0.82
Family income decile	5.30	2.30	5.60	2.37	9.95*	0.20	0.26
Age at start of 9th grade	14.20	0.78	14.39	0.77	35.88*	0.01	1.26
Public school	0.91	0.29	0.91	0.29	0.09	2.13	2.01
Neighborhood gang	0.22	0.42	0.24	0.43	0.79	0.17	2.24
Urban	0.73	0.45	0.76	0.43	4.02*	0.46	0.87

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.3.6: Assessing balance on covariates: dating only (for outcome "taking advanced math courses"). Sex only.

	No sex		Sex		Pre Adjustment	Post Adjustment	
					1 way Anova	2 Way Anova	N= 2,390
	(N= 2,071)		(N=434)		N= 2,219	F Values	
	Mean	Sd	Mean	Sd	F values	Main	Interaction
Non dater	0.45	0.50	0.19	0.39	105.01*	0.32	0.25
Infrequent dater	0.46	0.50	0.59	0.49	23.08*	0.06	0.35
Frequent dater	0.08	0.28	0.22	0.41	68.83*	0.19	1.01
Female	0.52	0.50	0.43	0.50	13.37*	0.06	0.76
White	0.57	0.50	0.33	0.47	85.53*	0.45	1.27
Black	0.22	0.41	0.46	0.50	110.83*	0.00	0.76
Hispanic	0.21	0.41	0.21	0.41	0.00	0.65	2.35
Mother education (years)	12.81	2.92	12.16	2.49	18.46*	0.28	0.68
AFQT percentile	50.45	26.73	34.91	23.73	125.84*	0.43	1.43
8th grade GPA	5.92	1.64	4.99	1.61	117.52*	1.65	2.81*
Both parents live together	0.57	0.50	0.36	0.48	66.02*	0.34	0.4
Family income decile	5.65	2.32	4.63	2.26	69.56*	0.49	0.32
Age at start of 9th grade	14.24	0.75	14.67	0.82	115.02*	0.44	2.24
Public school	0.90	0.30	0.94	0.24	5.27*	0.45	1.27
Neighborhood gang	0.23	0.42	0.27	0.44	3.60	0.91	2.09
Urban	0.74	0.44	0.78	0.42	2.69	0.00	1.01

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

APPENDIX 4.4
ANALYSES BY GENDER

Table 4.4.1: Estimated effects of adolescent romance on high school graduation for males. Multiple dose treatment.

		N	Mean	Sd	Moderate Vs Non dater Effect size	Serious daters Vs Non dater Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non daters	109	0.92	0.27	0.02	-0.01	-0.03
	Moderate	77	0.94	0.24			
	Serious	17	0.91	0.29			
Stratum 2	Non-daters	252	0.88	0.33	-0.02	-0.10*	-0.09*
	Moderate	312	0.86	0.35			
	Serious	162	0.77	0.42			
Stratum 3	Non-daters	91	0.74	0.44	-0.01	-0.13*	-0.12*
	Moderate	149	0.73	0.45			
	Serious	152	0.61	0.49			
Stratum 4	Non-daters	13	0.82	0.40	-0.17	-0.50*	-0.34*
	Moderate	16	0.65	0.49			
	Serious	42	0.31	0.47			
Overall	Non-daters	465	0.84	0.22	-0.02	-0.12*	-0.10*
	Moderate	554	0.82	0.23			
	Serious	373	0.72	0.26			
	N	1,392					

NOTE. * indicates statistical significance at 0.05 level
One stratum was removed due to lack of coverage in one or more treatment levels

Table 4.4.2: Estimated effects of adolescent romance on taking advanced math courses for males. Multiple dose treatment.

		N	Mean	Sd	Moderate Vs Non dater Effect size	Serious daters Vs Non dater Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non daters	93	0.54	0.50	0.04	0.07	0.03
	Moderate	55	0.58	0.50			
	Serious	10	0.60	0.52			
Stratum 2	Non-daters	192	0.39	0.49	0.00	-0.04	-0.05
	Moderate	248	0.40	0.49			
	Serious	103	0.35	0.48			
Stratum 3	Non-daters	108	0.22	0.42	0.02	0.05	0.03
	Moderate	168	0.24	0.43			
	Serious	127	0.27	0.44			
Stratum 4	Non-daters	17	0.28	0.46	-0.11	-0.06	0.05
	Moderate	23	0.17	0.38			
	Serious	40	0.21	0.41			
Overall	Non-daters	410	0.34	0.28	0.01	0.00	0.00
	Moderate	494	0.35	0.28			
	Serious	280	0.35	0.28			
	N	1,184					

NOTE. * indicates statistical significance at 0.05 level
One stratum was removed due to lack of coverage in one or more treatment levels

Table 4.4.3: Estimated effects of adolescent romance on college enrollment for males. Multiple dose treatment.

		N	Mean	Sd	Moderate Vs Non dater Effect size	Serious daters Vs Non dater Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non daters	109	0.72	0.45	0.09	-0.06	-0.15
	Moderate	77	0.80	0.40			
	Serious	17	0.65	0.49			
Stratum 2	Non-daters	252	0.67	0.47	0.07	-0.11*	-0.18*
	Moderate	312	0.74	0.44			
	Serious	162	0.56	0.50			
Stratum 3	Non-daters	91	0.53	0.50	0.04	-0.10	-0.14*
	Moderate	149	0.58	0.50			
	Serious	152	0.43	0.50			
Stratum 4	Non-daters	13	0.26	0.46	-0.10	0.08	0.19
	Moderate	16	0.16	0.38			
	Serious	42	0.35	0.48			
Overall	Non-daters	465	0.62	0.29	0.06*	-0.09*	-0.15*
	Moderate	554	0.67	0.28			
	Serious	373	0.52	0.30			
	N	1,392					

NOTE. * indicates statistical significance at 0.05 level
One stratum was removed due to lack of coverage in one or more treatment levels

Table 4.4.4: Estimated effects of adolescent romance on high school graduation for females. Multiple dose treatment.

					Moderate Vs Non dater	Serious daters Vs Non dater	Serious daters Vs Moderate daters
		N	Mean	Sd	Effect size	Effect size	Effect size
Stratum 1	Non-daters	92	0.83	0.38	0.05	-0.10	-0.15
	Moderate	30	0.88	0.32			
	Serious	7	0.73	0.48			
Stratum 2	Non daters	265	0.91	0.28	-0.07	-0.17*	-0.11
	Moderate	133	0.85	0.36			
	Serious	47	0.74	0.44			
Stratum 3	Non-daters	233	0.88	0.32	0.02	-0.15*	-0.17*
	Moderate	261	0.91	0.29			
	Serious	125	0.73	0.44			
Stratum 4	Non-daters	47	0.76	0.43	0.10	-0.06	-0.16*
	Moderate	80	0.86	0.35			
	Serious	77	0.70	0.46			
Stratum 5	Non-daters	2	0.51	0.71	0.49	0.02	-0.48*
	Moderate	4	1.00	0.00			
	Serious	18	0.52	0.51			
Overall	Non-daters	639	0.86	0.18	0.02	-0.13*	-0.15*
	Moderate	508	0.88	0.18			
	Serious	274	0.73	0.25			
	N	1,421					

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.5: Estimated effects of adolescent romance on taking advanced math courses for females. Multiple dose treatment.

		N	Mean	Sd	Moderate Vs Non dater	Serious daters Vs Non dater	Serious daters Vs Moderate daters
					Effect size	Effect size	Effect size
Stratum 1	Non-daters	83	0.39	0.49	-0.14	-0.32	-0.18
	Moderate	30	0.25	0.44			
	Serious	6	0.07	0.29			
Stratum 2	Non daters	209	0.39	0.49	0.06	0.15	0.09
	Moderate	101	0.44	0.50			
	Serious	36	0.53	0.51			
Stratum 3	Non-daters	208	0.36	0.48	0.02	0.01	-0.02
	Moderate	203	0.38	0.49			
	Serious	86	0.37	0.48			
Stratum 4	Non-daters	60	0.24	0.43	0.08	-0.01	-0.09
	Moderate	101	0.32	0.47			
	Serious	68	0.23	0.42			
Stratum 5	Non-daters	2	0.19	0.41	0.00	-0.05	-0.05
	Moderate	16	0.19	0.41			
	Serious	20	0.14	0.36			
Overall	Non-daters	562	0.34	0.26	0.03	0.01	-0.02
	Moderate	451	0.37	0.26			
	Serious	216	0.35	0.26			
	N	1,229					

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.6: Estimated effects of adolescent romance on college enrollment for females. Multiple dose treatment.

		N	Mean	Sd	Moderate Vs Non dater Effect size	Serious daters Vs Non dater Effect size	Serious daters Vs Moderate daters Effect size
Stratum 1	Non-daters	92	0.76	0.43	-0.02	-0.02	0.00
	Moderate	30	0.73	0.45			
	Serious	7	0.73	0.48			
Stratum 2	Non daters	265	0.76	0.43	-0.09	-0.09	0.00
	Moderate	133	0.67	0.47			
	Serious	47	0.67	0.48			
Stratum 3	Non-daters	233	0.72	0.45	0.08	-0.09	-0.17*
	Moderate	261	0.80	0.40			
	Serious	125	0.63	0.48			
Stratum 4	Non-daters	47	0.59	0.50	0.07	0.04	-0.03
	Moderate	80	0.66	0.48			
	Serious	77	0.63	0.49			
Stratum 5	Non-daters	2	0.00	0.00	0.86*	0.26*	-0.60
	Moderate	5	0.86	0.40			
	Serious	18	0.26	0.45			
Overall	Non-daters	639	0.71	0.25	0.03*	-0.06*	-0.09*
	Moderate	508	0.73	0.24			
	Serious	274	0.65	0.27			
	N	1,421					

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.7: Estimated effects of dating on high school graduation. Males.

		N	Mean	Sd	Effect size
stratum1	Non-dater	14	0.88	0.33	0.00
	Dater	11	0.88	0.00	
stratum2	Non-dater	103	0.88	0.33	-0.02
	Dater	62	0.85	0.36	
stratum3	Non-dater	245	0.88	0.32	-0.03
	Dater	393	0.85	0.36	
stratum4	Non-dater	99	0.84	0.37	-0.09
	Dater	348	0.75	0.43	
stratum5	Non-dater	14	0.40	0.51	0.13
	Dater	111	0.52	0.50	
Overall	Non-dater	475	0.83	0.20	-0.04*
	Dater	924	0.79	0.22	
	N	1,400			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.8: Estimated effects of dating on high school graduation. Females.

		N	Mean	Sd	Effect size
stratum1	Non-dater	64	0.95	0.23	-0.14
	Dater	17	0.80	0.41	
stratum2	Non-dater	295	0.89	0.32	-0.11
	Dater	152	0.77	0.42	
stratum3	Non-dater	225	0.88	0.32	-0.02
	Dater	323	0.86	0.35	
stratum4	Non-dater	55	0.81	0.40	0.04
	Dater	218	0.85	0.36	
stratum5	Non-dater	10	0.55	0.54	0.12
	Dater	74	0.67	0.47	
Overall	Non-dater	649	0.85	0.18	-0.04*
	Dater	784	0.82	0.20	
	N	1,433			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.9: Estimated effects of dating on taking advanced math courses. Males.

		N	Mean	Sd	Effect size
stratum1	Non-dater	16	0.54	0.52	-0.26
	Dater	11	0.28	0.50	
stratum2	Non-dater	128	0.40	0.49	0.02
	Dater	77	0.42	0.50	
stratum3	Non-dater	202	0.40	0.49	-0.01
	Dater	368	0.38	0.49	
stratum4	Non-dater	69	0.31	0.46	0.00
	Dater	254	0.30	0.46	
stratum5	Non-dater	7	0.84	0.40	-0.61*
	Dater	69	0.23	0.43	
Overall	Non-dater	422	0.40	0.28	-0.05*
	Dater	778	0.36	0.28	
	N	1,201			

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.4.10: Estimated effects of dating on taking advanced math courses. Females.

		N	Mean	Sd	Effect size
stratum1	Non-dater	92	0.28	0.45	-0.10
	Dater	29	0.17	0.38	
stratum2	Non-dater	279	0.39	0.49	-0.01
	Dater	143	0.38	0.49	
stratum3	Non-dater	164	0.37	0.48	0.02
	Dater	282	0.39	0.49	
stratum4	Non-dater	34	0.19	0.40	0.15
	Dater	169	0.34	0.48	
stratum5	Non-dater	10	0.17	0.38	0.00
	Dater	47	0.17	0.38	
Overall	Non-dater	579	0.33	0.25	0.02
	Dater	670	0.35	0.26	
	N	1,249			

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.4.11: Estimated effects of dating on college enrollment. Males.

		N	Mean	Sd	Effect size
stratum1	Non-dater	14	0.45	0.52	0.00
	Dater	11	0.45	0.61	
stratum2	Non-dater	103	0.62	0.49	0.12
	Dater	62	0.74	0.44	
stratum3	Non-dater	245	0.72	0.45	-0.04
	Dater	393	0.67	0.47	
stratum4	Non-dater	99	0.58	0.50	0.03
	Dater	348	0.61	0.49	
stratum5	Non-dater	14	0.40	0.51	0.01
	Dater	111	0.40	0.49	
Overall	Non-dater	475	0.63	0.27	0.01
	Dater	924	0.63	0.27	
	N	1,400			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.12: Estimated effects of dating on college enrollment. Females.

		N	Mean	Sd	Effect size
stratum1	Non-dater	64	0.77	0.42	-0.22
	Dater	17	0.55	0.51	
stratum2	Non-dater	295	0.71	0.46	-0.08
	Dater	152	0.62	0.49	
stratum3	Non-dater	225	0.77	0.42	-0.03
	Dater	323	0.74	0.44	
stratum4	Non-dater	55	0.65	0.48	0.08
	Dater	218	0.73	0.45	
stratum5	Non-dater	10	0.18	0.42	0.41
	Dater	74	0.59	0.49	
Overall	Non-dater	649	0.69	0.24	-0.01
	Dater	784	0.68	0.25	
	N	1,433			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.13: Estimated effects of early sex on high school graduation. Males.

		N	Mean	Sd	Effect size
stratum1	No sex	101	0.97	0.17	0.00
	Sex	11	0.97	0.17	
stratum2	No sex	231	0.95	0.21	0.05*
	Sex	10	1.00	0.00	
stratum3	No sex	423	0.84	0.37	-0.17*
	Sex	50	0.67	0.48	
stratum4	No sex	247	0.74	0.44	-0.18*
	Sex	174	0.57	0.50	
stratum5	No sex	27	0.43	0.50	-0.03
	Sex	97	0.40	0.49	
Overall	No sex	1,029	0.80	0.20	-0.11*
	Sex	341	0.69	0.23	
	N	1,371			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.14: Estimated effects of early sex on high school graduation. Females.

		N	Mean	Sd	Effect size
stratum1	No sex	138	0.96	0.19	0.00
	Sex	11	0.96	0.19	
stratum2	No sex	295	0.96	0.20	0.00
	Sex	10	0.96	0.30	
stratum3	No sex	453	0.86	0.34	-0.21*
	Sex	47	0.65	0.48	
stratum4	No sex	239	0.81	0.39	-0.19*
	Sex	163	0.62	0.49	
stratum5	No sex	9	0.88	0.34	-0.43*
	Sex	30	0.46	0.51	
Overall	No sex	1,134	0.88	0.17	-0.14*
	Sex	260	0.74	0.23	
	N	1,395			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.15: Estimated effects of early sex on taking advanced math courses. Males.

		N	Mean	Sd	Effect size
stratum1	No sex	100	0.58	0.50	0.00
	Sex	11	0.58	0.50	
stratum2	No sex	216	0.50	0.50	0.11
	Sex	10	0.62	0.53	
stratum3	No sex	391	0.33	0.47	-0.16*
	Sex	39	0.17	0.38	
stratum4	No sex	204	0.15	0.36	0.03
	Sex	132	0.18	0.38	
stratum5	No sex	20	0.08	0.28	0.24*
	Sex	57	0.32	0.47	
Overall	No sex	931	0.32	0.23	-0.01
	Sex	248	0.31	0.21	
	N	1,180			

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.4.16: Estimated effects of early sex on taking advanced math courses. Females.

		N	Mean	Sd	Effect size
stratum1	No sex	133	0.52	0.50	0.00
	Sex	11	0.52	0.50	
stratum2	No sex	276	0.47	0.50	0.00
	Sex	10	0.47	0.00	
stratum3	No sex	403	0.32	0.47	0.03
	Sex	35	0.36	0.49	
stratum4	No sex	209	0.18	0.38	0.05
	Sex	119	0.23	0.42	
stratum5	No sex	8	0.18	0.41	-0.02
	Sex	19	0.15	0.37	
Overall	No sex	1,029	0.34	0.24	0.02
	Sex	193	0.36	0.22	
	N	1,223			

NOTE. * indicates statistical significance at 0.05 level
Students who dropped out are excluded from the sample

Table 4.4.17: Estimated effects of early sex on college enrollment. Males.

		N	Mean	Sd	Effect size
stratum1	No sex	101	0.90	0.31	0.00
	Sex	10	0.90	0.31	
stratum2	No sex	231	0.83	0.38	-0.02
	Sex	10	0.81	0.43	
stratum3	No sex	422	0.66	0.47	-0.14
	Sex	49	0.52	0.50	
stratum4	No sex	241	0.42	0.49	-0.04
	Sex	169	0.38	0.49	
stratum5	No sex	25	0.16	0.37	0.07
	Sex	96	0.23	0.42	
Overall	No sex	1,020	0.59	0.24	-0.06*
	Sex	334	0.54	0.25	
	N	1,354			

NOTE. * indicates statistical significance at 0.05 level

Table 4.4.18: Estimated effects of early sex on college enrollment. Females.

		N	Mean	Sd	Effect size
stratum1	No sex	138	0.90	0.30	0.00
	Sex	10	0.90	0.30	
stratum2	No sex	295	0.85	0.36	0.00
	Sex	10	0.85	0.30	
stratum3	No sex	453	0.71	0.45	-0.11
	Sex	47	0.60	0.49	
stratum4	No sex	239	0.56	0.50	-0.07
	Sex	163	0.49	0.50	
stratum5	No sex	9	0.57	0.53	-0.26
	Sex	30	0.31	0.47	
Overall	No sex	1,134	0.72	0.23	-0.07*
	Sex	260	0.65	0.24	
	N	1,394			

NOTE. * indicates statistical significance at 0.05 level