Does Recreational Marijuana Legalization Increase Adolescent Use?

An analysis of YBRS data in Alaska, Maine, and Nevada

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Introduction

Since 2012, 18 states have legalized recreational marijuana and recent polling has shown that federal legalization is supported by almost two thirds of American adults.[2] Legalization offers many benefits: reduction in black market activity, increased tax revenue, and regulation and quality control of drug content and potency. However, there are also many concerns, a major one being that legalization may increase the use of marijuana by adolescents. This could be caused by the lowering of barriers to marijuana access; high school students may be able to get marijuana from older friends or by using fake IDs. The other pathway in which legalization could effect adolescents drug use behavior is if it creates a change in the culture around drug use, increasing the social acceptance and lowering the perceived risk thereby making the drug more appealing.

Despite a large literature on the effects of marijuana on the brain, researchers still disagree on the prolonged impacts of marijuana use on cognition.[4,5,9] While further research may prove the drug is safer than previously believed, the CDC's position is that: "developing brains, such as those in babies, children, and teenagers, are especially susceptible to the harmful effects of marijuana and THC."[3] Regardless of what we think about the strength of the evidence, lawmakers and most of the public would be concerned if the consequence of legalization were a large increase in marijuana use by teenagers.

The existing literature on the effect of marijuana legalization on teenage marijuana use is mixed. Cerdá et al.[6] use the Monitoring the Future Survey and find a significant increase in Washington State, but not in Colorado, while Dilly et al.[7] use the Washington Healthy Youth Survey and find a significant decrease after legalization. In this paper, I use the Youth Behavior Risk Survey to determine the effect of legalization on high school students in Alaska, Maine, and Nevada.

Figure 1: Timeline of Recreational Legalization
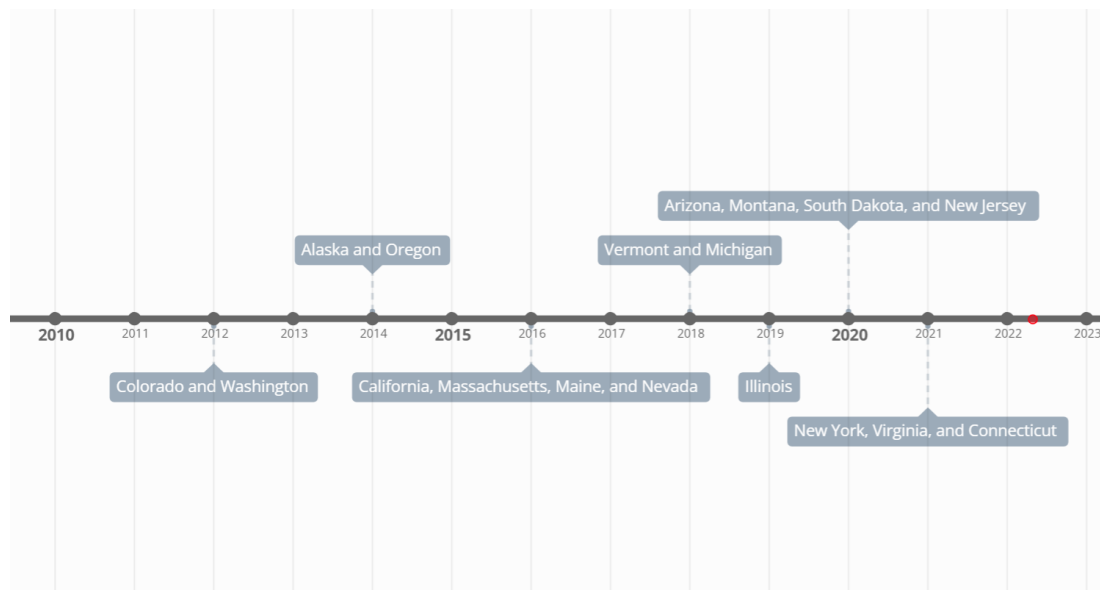
Data

The data source I use is the Youth Behavior Risk Survey (YBRS), a survey of United States high school students conducted biannually by the CDC. The survey focuses on drug use (with special attention given to tobacco and alcohol), sexual behavior related to pregnancy and infection, suicidal ideation, diet, and physical activity levels. Unfortunately, not every state participates in the survey. Oregon and Washington are two of these states and they also legalized recreational marijuana earlier than many other states. Because of additional challenges with unrepresentative data in certain years, I limit my analysis to states where we observe four consecutive surveys centered on legalization (two immediately before, two immediately after.) This limits the set of states which I can study to Alaska, Maine, and Nevada. Alaska legalized recreation marijuana in 2014 and Maine and Nevada did so in 2016. Table 1 shows the data quality and availability for the eight states that legalized marijuana before 2018. The table is a condensed form of a table published by the CDC.[1]

Table 1: Data Availability by State

High School YRBS Participation History, Data Quality, and Data Availability by State and Year							
○Data is not representative, ● Representative Data, -- Did not Participate							
States	2009	2011	2013	2015	2017	2019	Permission to Distribute
Alaska	●	●	●	●	●	●	Yes
California	○	○	○	●	●	●	Yes
Colorado	●	●	○	○	●	●	Yes
Maine	●	●	●	●	●	●	Yes
Massachusetts	●	●	●	●	●	●	**No**
Nevada	●	○	●	●	●	●	Yes
Oregon	--	--	--	--	--	--	N/A
Washington	--	--	--	--	--	--	N/A

Table 2 displays summary statistics for each state. We can see the racial makeup of states varies significantly, but because I use an event time research design I compare states to themselves and therefore this should not be a reason for concern. Changes in survey sample demographics over time could bias results, but further analysis shows that there are no concerning trends in demographics (see Figure A1 and Table A1.) Additionally, when I include controls for sex, grade, and race there is no change in results (Table 3).

Table 2: Summary Statistics

	Alaska	Maine	Nevada
9th Grade	0.30 (0.46)	0.27 (0.45)	0.27 (0.44)
10th Grade	0.27 (0.45)	0.26 (0.44)	0.30 (0.46)
11th Grade	0.24 (0.43)	0.25 (0.43)	0.25 (0.43)
12th Grade	0.19 (0.39)	0.22 (0.41)	0.18 (0.39)
White	0.48 (0.50)	0.79 (0.41)	0.36 (0.48)
American Indian/Alaska Native	0.14 (0.35)	0.03 (0.17)	0.01 (0.10)
Asian	0.07 (0.26)	0.03 (0.17)	0.06 (0.24)
Black/African American	0.03 (0.17)	0.03 (0.17)	0.06 (0.25)
Hispanic/Latino	0.10 (0.30)	0.05 (0.21)	0.40 (0.49)
Other Race	0.14 (0.34)	0.04 (0.19)	0.09 (0.28)
Female	0.51 (0.50)	0.51 (0.50)	0.53 (0.50)
Observations	8369	53350	8591

Standard Deviation in parenthesis

Empirical Approach

I use a staggered event study method to attempt to measure the causal effect of legalization on teenage use rates. I generate a variable for event time with event time zero corresponding to the year marijuana was legalized in that state, negative values being before, and positive values being after. The event time regression is presented below:

$$Y_{st} = \alpha + \beta_t T + \gamma_s S + \epsilon_{st}$$

Where Y_{st} is the outcome of interest in event time t and state s. T is a vector of event time indicator variables, S is a vector of state fixed effects, and α is some constant term. β_t is interpreted as the relative change in the outcome in event time t relative to event time -1 (the omitted event time indicator) and is our coefficient of interest. If legalization were to increase teenage use, we would expect to see positive and significant coefficients on all beta's with positive event years.

One concern with the event study approach is the shape of the pre-trends. To address this, I plot the means of my two outcome variables by state and event time in Figure 2. We can see a clear downward pre-trend in Alaska, but for the other states there is no concerning trend. I further address the possibility that legalization could reverse a downward secular trend later in the Results and Discussion section.

Further analyzing Figure 2 we can see that the shape of the curves for "ever used marijuana" and "used marijuana in the past 30 days" look very similar with approximately half of students who have tried marijuana having used it in the past 30 days. Additionally, the confidence intervals are much tighter in Maine because the sample size is about six times larger than the other states (Table 2.) Maine also is missing a data point for "ever used marijuana" in 2013 because data on that question does not appear in the data set, implying it was not asked or was omitted for some other reason.

Figure 2: Marijuana Use Trends by State
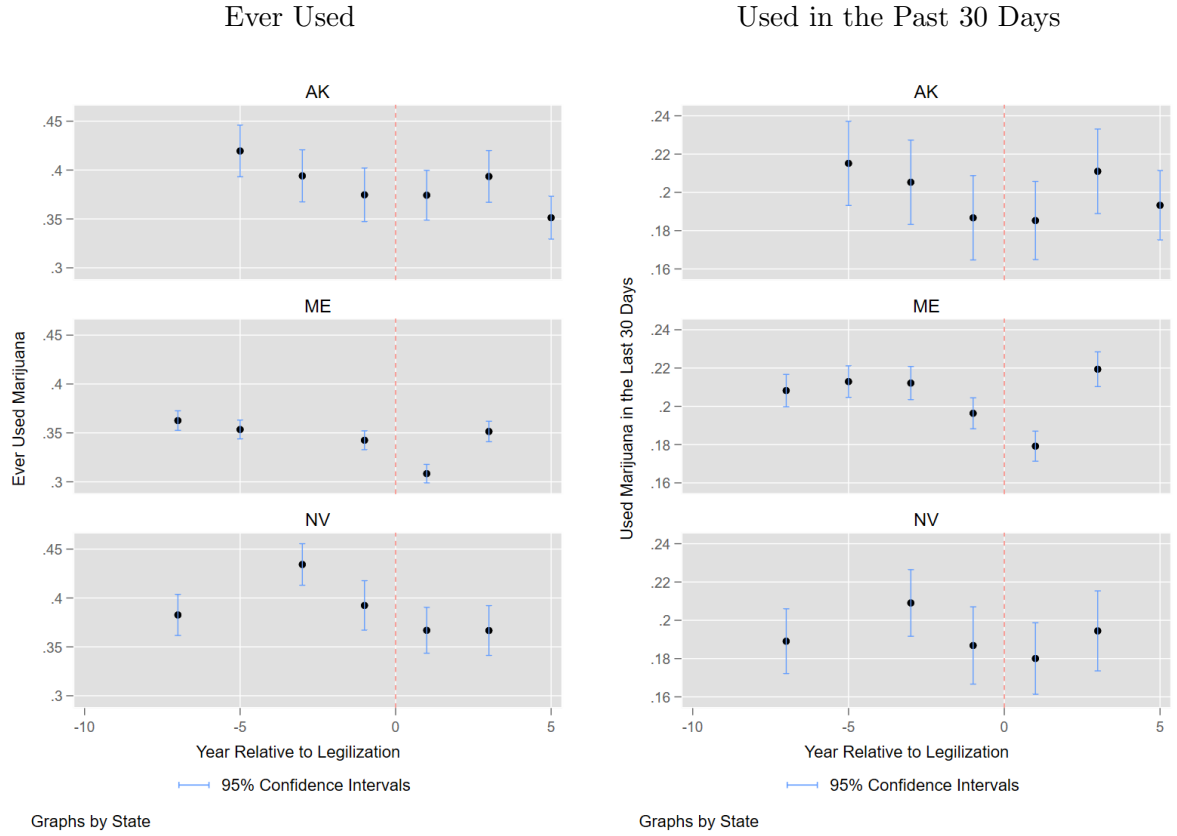
Results and Discussion

Figure 3 is a coefficient plot of all the β_t's when no controls are added. The point for event time of -1 is zero because it is the dropped year. The years preceding event time -1 have barely significant positive coefficients. We might think this reflects that states chose to legalize when teenage use is low, but even when significant the coefficients are small enough that this seems unlikely. In the post-period we surprisingly see a drop before an immediate rebound and then a reversion to the mean or, in the case of "ever used marijuana," a slight decrease. Overall, the results we see in Figure 3 do not suggest any sizeable increase in marijuana use by adolescents in either the short or long term. It is important to note that for the event time of positive five, only Alaska is included for this point since the 2021 YBRS data is not available yet.

Since the 2000s there has been a secular decrease in marijuana consumption by American teenagers (see Table A2.) One hypothesis could be that legalization would reverse this downward trend. If this was the case we might still see a decrease immediately after the policy, but a upward trend in the post period with the coefficient plot resembling a V-shape. While this is a plausible hypothesis, there is no clear

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evidence in our data. Since we cannot pick up a change in trends five years after legalization it seems doubtful that there are long run trends we are missing. A regression discontinuity design would be ideal to address this issue, but given that our observations are spaced by two years and the analysis already lacks precision I decided that including a regression discontinuity design would not add any useful insights.

Figure 3: Coefficient Plots for Marijuana Use

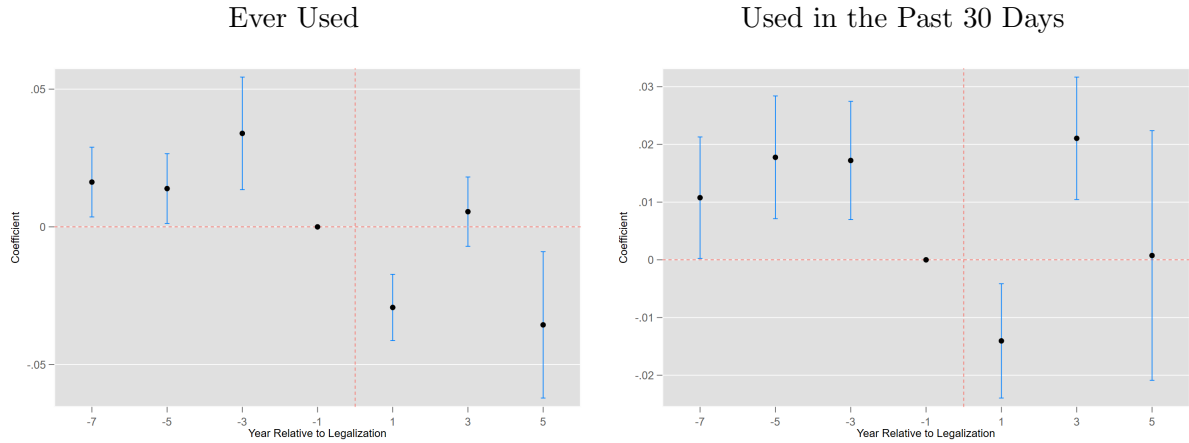Ever Used   Used in the Past 30 Days

Table 3 includes the no controls regression as discussed above in columns one and five. In the other columns, I include controls for sex, race, and grade to address the potential that survey population changed over time. For example, it would be concerning if the share of 12th grade students declined since we would expect older students to be more likely to use marijuana. As we can see, the coefficients and standard errors are almost identical with and without controls. This is reassuring because it suggests that the original research design was sound and that changes in survey demographics did not have any effect on our findings.

Table 3: Event Time Regressions

	Ever Used				Used in Past 30 Days			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
-7	0.016	0.019	0.013	0.016	0.011	0.013	0.010	0.011
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
-5	0.014	0.012	0.013	0.011	0.018	0.017	0.017	0.016
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
-3	0.034	0.032	0.029	0.026	0.017	0.019	0.016	0.017
	(0.010)	(0.010)	(0.010)	(0.010)	(0.005)	(0.005)	(0.005)	(0.005)
1	-0.029	-0.025	-0.031	-0.028	-0.014	-0.012	-0.015	-0.014
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
3	0.006	0.008	0.004	0.007	0.021	0.024	0.020	0.022
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
5	-0.036	-0.025	-0.032	-0.022	0.001	0.008	0.002	0.010
	(0.014)	(0.014)	(0.013)	(0.013)	(0.011)	(0.011)	(0.011)	(0.011)
Sex Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Race Controls	No	No	Yes	Yes	No	No	Yes	Yes
Grade Controls	No	Yes	No	Yes	No	Yes	No	Yes

Standard Error in parenthesis

Finally, I analyze subpopulations in an attempt to see whether there are any changes in the makeup of who uses marijuana. Figures A3 show the no-controls coefficient plots for marijuana use in the past 30 days by subpopulation. Due to a small sample size I group non-white students together to analyze if they responded differently than white students. I find no real differences in trends, with the exception of females who seem to have an upward pre-trend but not clear continuation of this trend. Additionally, Table 4 presents the coefficients on the variables for being white or female from the regressions with controls. It shows that white students in this sample use significantly less marijuana and there is a significantly lower level of habitual use among female students. This is somewhat surprising given that national data consistently shows that white students use marijuana at equal or slightly higher rates than non-white students.[8]

Table 4: Coefficients for Race and Sex

|	Ever Used		Used in Past 30 Days	
	(1)	(2)	(3)	(4)
Female	-0.005	-0.004	-0.021	-0.020
	(0.004)	(0.004)	(0.003)	(0.003)
White		-0.030		-0.026
		(0.005)		(0.004)

Standard Error in parenthesis

Conclusion

In my analysis of the YRBS, I find that there is no significant effect of recreational marijuana legalization on adolescents' use of marijuana. Due to limitations in data availability and quality I only focus on 3 of the 8 US states to have legalized marijuana before 2018. Because of this, the external validity of this paper is weakened. It may be the case that we only observe states in which legalization had no impact since there is a disincentive for politicians to administer surveys if they believe the results will reflect poorly on them. Even if this is not the case, these states are not the most representative sample of US states. In states like Colorado or California there seems to have been a larger acceptance and celebration of legalization in popular culture that may have led to different effects than those found in this paper. As more data becomes available for a larger number of states and additional years, this research question should certainly be revisited.

References

[1] High School YRBS Participation History & Data Quality, 1991-2019. Technical report, CDC.

[2] Large majority favor legal recreational marijuana under federal law - CBS News poll.

[3] Marijuana: What We Know. Technical report, CDC.

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[5] Albert Batalla, Sagnik Bhattacharyya, Murat Yücel, Paolo Fusar-Poli, Jose Alexandre Crippa, Santiago Nogué, Marta Torrens, Jesús Pujol, Magí Farré, and Rocio Martin-Santos. Structural and functional imaging studies in chronic cannabis users: a systematic review of adolescent and adult findings. *PloS One*, 8(2):e55821, 2013.

[6] Magdalena Cerdá, Melanie Wall, Tianshu Feng, Katherine M. Keyes, Aaron Sarvet, John Schulenberg, Patrick M. O'Malley, Rosalie Liccardo Pacula, Sandro Galea, and Deborah S. Hasin. Association of State Recreational Marijuana Laws With Adolescent Marijuana Use. *JAMA Pediatrics*, 171(2):142–149, February 2017.

[7] Julia A. Dilley, Susan M. Richardson, Beau Kilmer, Rosalie Liccardo Pacula, Mary B. Segawa, and Magdalena Cerdá. Prevalence of Cannabis Use in Youths After Legalization in Washington State. *JAMA Pediatrics*, 173(2):192–193, February 2019.

[8] Katherine M. Keyes, Melanie Wall, Tianshu Feng, Magdalena Cerdá, and Deborah S. Hasin. Race/ethnicity and marijuana use in the United States: Diminishing differences in the prevalence of use, 2006–2015. *Drug and Alcohol Dependence*, 179:379–386, October 2017.

[9] National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, Board on Population Health and Public Health Practice, and Committee on the Health Effects of Marijuana: An Evidence Review and Research Agenda. *The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research*. The National Academies Collection: Reports funded by National Institutes of Health. National Academies Press (US), Washington (DC), 2017.

Appendix

Figure A1: Share Female by Survey Year
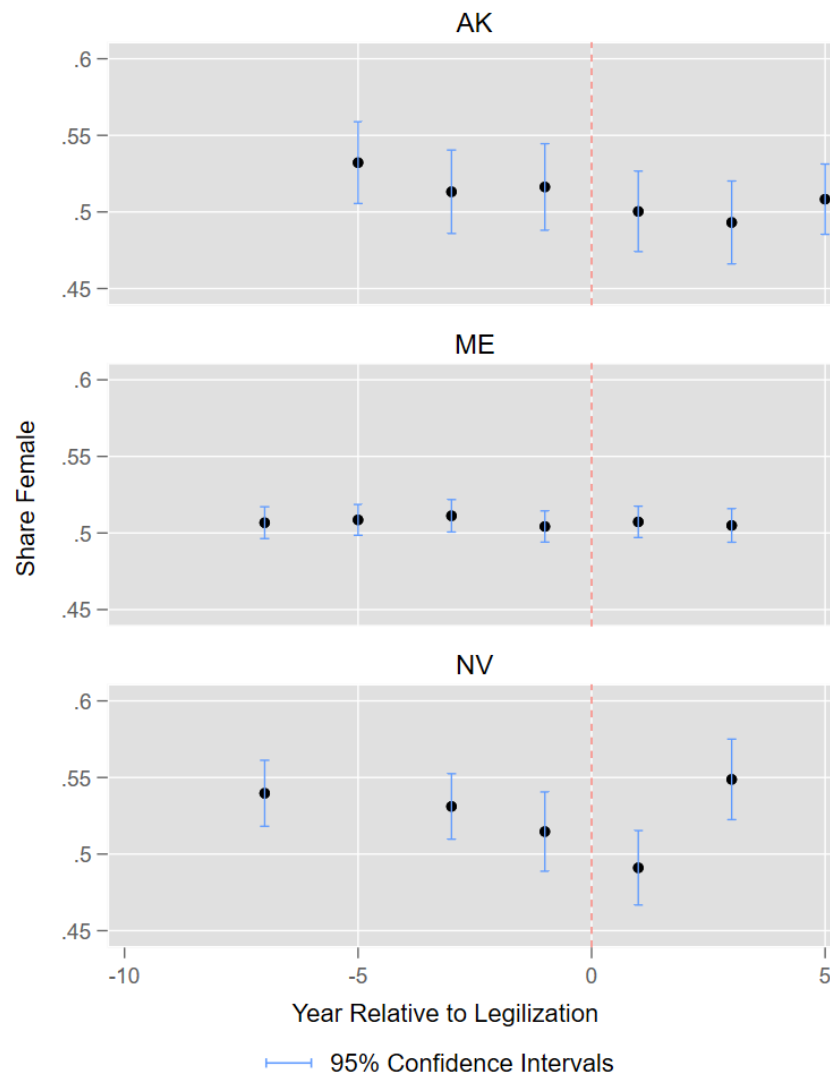
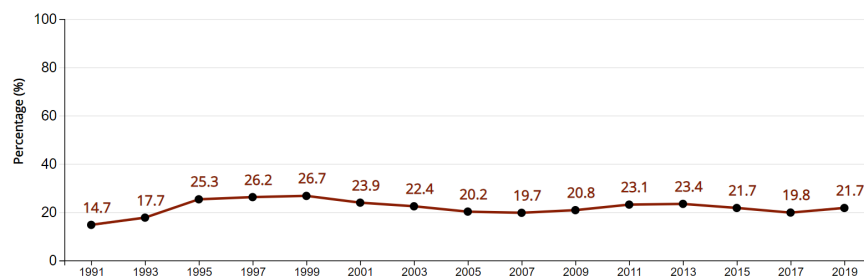Figure A2: YBRS National Data on Marijuana Use in the Past 30 Days

Table A1: Min and Max of Yearly Demographic Variables

	Alaska	Maine	Nevada
(mean) g_1	0.24	0.27	0.22
	0.33	0.28	0.30
(mean) g_2	0.26	0.25	0.26
	0.31	0.27	0.33
(mean) g_3	0.22	0.24	0.22
	0.27	0.26	0.28
(mean) g_4	0.16	0.19	0.15
	0.22	0.23	0.21
(mean) r_w	0.44	0.78	0.31
	0.50	0.80	0.40
(mean) r_ami	0.12	0.03	0.01
	0.16	0.04	0.01
(mean) r_as	0.06	0.02	0.04
	0.09	0.04	0.08
(mean) r_b	0.03	0.02	0.05
	0.03	0.04	0.07
(mean) r_h	0.09	0.04	0.35
	0.12	0.05	0.44
(mean) r_o	0.12	0.03	0.08
	0.16	0.04	0.10
(mean) sex	0.49	0.50	0.49
	0.53	0.51	0.55

Purpose of this table is to show that while demographics varied year by year they did not change drastically.

Figure A3: Coefficient Plots for Subpopulations

Male Students

Female Students

White Students

Non-White Students