ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis Policy Economics

The effect of drinking on academic performance for young people: investigating the results of raising the Dutch legal drinking age

Name student: Hugo de Lange

Student ID number: 531510

Supervisor: Otto Swank

Second assessor: Robert Dur

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Abstract

Alcohol has been known to be damaging to health and cause problematic behavior, especially for young people. Since people tend to start drinking alcohol during high school, alcohol consumption among adolescents has often been linked to academic performance. While there exists a general agreement on the association between the two, the exact dynamic between the two has been notoriously hard to disentangle. In 2014, the minimum legal drinking age was changed from 16 to 18 in the Netherlands. Using data from a sample representative of the Dutch population, I estimate the effect of drinking alcohol on school performance for young people aged 16-19. Alcohol consumption is instrumented by the different levels of the drinking age. The sample contains data from years prior and after the drinking age was changed, and I exploit this in an instrumental variable probit model. High school graduation is used as a proxy for academic performance. From the first stage evidence is found that the intervention caused drinking levels to decline for young people. A statistically significant negative effect of alcohol use on the odds of graduating is found for females.

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Introduction

For many years, the topic of alcohol has been very important among policymakers and members of the public alike. There is a lot of discussion surrounding the level of regulation appropriate for alcohol consumption. Research has often shown that consuming too much alcohol can have adverse effects on people's health. It has proven to be a major predictor of many diseases, such as liver disease (Becker et al, 1996). Alcohol abuse has also been shown to increase the risk of cardiac diseases (Whitman et al, 2017). Additionally, drinking alcohol can have undesirable effects by affecting people's behavior and impairing their ability to think, such as an increased risk of car accidents. Alcohol impairs driver performance even at low blood-alcohol volumes (Ogden & Moskowitz, 2004). As such, the governments of certain countries have limited or banned alcohol consumption altogether. On the other hand, there are 'positive' effects of drinking, though mostly short-term. Adolescents report that the most important reasons for why they tend to drink are to enhance meals, celebrate and be sociable (Kairouz et al, 2002). At young ages, people experience higher levels of risk associated with alcohol use. This is mainly because they have the least experience with the effects of alcohol and get higher blood alcohol volumes due to their lower body mass combined with their sometimes unpredictable behavior.

From this, it seems reasonable that alcohol consumption at the very least needs to be regulated. Many governments across the world do so, and one of the most common regulations is to set a legal drinking age: the minimum age a person needs to be to purchase and consume alcohol. This age varies across the world, but it is 18 in most countries (Misachi, 2020). In the Netherlands, the legal drinking age was 16 for a long time, but it was raised to 18 as of January 1st, 2014 (Cotten, 2023). In their rationale for setting a higher drinking age, the government strongly emphasizes the higher protection of young people's health as their brains are not fully developed (Ministerie van Volksgezondheid, Welzijn en Sport, 2022). However, there are many other effects associated with alcohol use that are left to be investigated. These are mostly related to how alcohol shifts people's behavior. One of them is the academic performance of young people. Many people start drinking alcohol during high school ('middelbare' school in the Netherlands), and this may affect how well they perform at school. Drinking can decrease the time spent on academic activities, by substituting time spent on schoolwork for social activities that include drinking. It can also affect people the next day through 'hangovers' depending on how much the individual has drunk, causing students to not study or work hard enough to perform as well as they could if they were sober. Another adverse effect on school performance can come from alcohol's effects on the brain. This leads to the central research question of this analysis*:* how does alcohol consumption affect the academic performance of adolescents? This is an important topic for policymakers because the accumulation of human capital is largely determined by how well educated the population is. Rather than solely focusing on improving the quality of education, schools can develop their understanding of how external influences like alcohol consumption affect student behavior and performance at school. The government can then decide to make policy changes, such as raising the purchase age. This paper contributes to the existing literature on the effects of alcohol consumption by modeling academic performance as the odds of graduating (a long-term goal) whereas research tends to use test scores (a short-term goal) as academic performance outcomes.

The main hypothesis is that consuming alcohol has a negative effect on academic performance. While the majority of researchers agree that there is an association between drinking and lower school performance, investigating this relationship is not straightforward. This is because there are many factors contributing to alcohol use as well as academic performance, making it difficult to accurately estimate the isolated effect of drinking. Reverse causality also poses a major risk, because it can reasonably be argued that school performance affects alcohol use. Lacking results at school or the prospect of not graduating may cause young people to turn to drinking alcohol to deal with the resulting stress. As a result, the directionality and size of the true effect are unclear.

In an effort to disentangle the relationship, I use an instrumental variable to address these confounding issues. The increase in the legal drinking age is central to this approach. In theory, raising the legal drinking age makes it more difficult for those below this age to obtain and consume alcohol. However, it is not impossible because alcohol distributors do not always comply with the law. Servers or cashiers may fail to verify the age of the alcohol purchaser by mistake or out of convenience, although they risk a fine by doing so. A more convenient and reliable way for young people to get alcoholic drinks is through family members and friends who are over 18 years old. Along with blocking access to alcohol to those under 18, a higher purchase age can raise more awareness on the topic, which can even decrease alcohol consumption among those beyond the legal drinking age. If raising the drinking age was effective in limiting the alcohol consumption of young people, this intervention could function as an instrument for drinking. Using graduation as an outcome variable, I model the effect of drinking alcohol on academic performance. I first investigate the effect of raising the drinking age. There appears to be strong evidence for a discontinuity in drinking behavior among adolescents before and after 2014. This discontinuity is exploited in a two-stage model in order to estimate the true effect of alcohol consumption of adolescents on their performance at school.

Literature review

The literature surrounding the effects of drinking alcohol on academic performance is extensive and varied. There are many different indicators for both alcohol consumption and academic achievement. The consensus is that alcohol consumption is associated with lower results in school, but causality is hard to establish because of endogeneity. Latvala et al. assert that substance use among adolescents is associated with lower achievement, but the exact directionality between the two is uncertain (2014). In their paper, they analyzed longitudinal data about school achievement and substance use from Finnish twins at four different time points. They found that adolescent drinking is associated with lower future educational achievement.

Using a fixed effects model, Balsa et al. (2011) found that increased alcohol consumption resulted in reduced grade point averages (GPAs) for students, but only in males; the changes for females were not significant. However, women did report academic difficulty caused by drinking. This highlights the relevance of gender differences in this research area. They also mention the strong differences with estimates derived from OLS, once again underlining the need to address endogeneity.

Schoolwork can also be impacted by alcohol consumption through peer effects, but it is often difficult to estimate them. In a paper analyzing alcohol consumption among students roommates were randomly assigned to each other (Kremer & Levy, 2008). The random assignment of roommates made it possible to isolate the effect of peers. The study found that students who were assigned roommates who drank alcohol before college got lower GPAs than those who were assigned nondrinking roommates. Once again, this effect was only observed among males.

A paper that also exploits the discontinuity caused by the legal drinking age found a significant reduction in exam scores among young adults (Carrell et al, 2010). Using a regression discontinuity design, the researchers found that American college students who turned 21 (the legal drinking age in the United States) the week before taking a final exam scored significantly lower than their peers. In this setting, the legal drinking age was strictly enforced: underage drinking could lead to being expelled. This caused a significant jump in alcohol consumption at age 21 and a subsequent drop in academic performance.

In contrast to these papers, there are studies that find no significant effect of alcohol. By conducting a random experiment in which participants were assigned either an alcoholic beverage or a placebo the night before taking a test, researchers were able to determine that the test scores of those who had drunk alcohol did not significantly differ from those who were given the placebo (Howland et al, 2010). The study analyzed college students of legal drinking age. This result signifies the distinction between the long- and short-term effects of drinking alcohol. Although having a drink may not immediately affect the performance on tests the next day, drinking alcohol regularly over an extended period of time may still negatively impact academic performance through behavioral shifts or by affecting the brain. Another explanation is that those who drink are significantly different from those who do not, in many other characteristics.

Alcohol is not the only drug that has been associated with lower student results. Soft drugs such as cannabis, which is legal in the Netherlands, can also impact academic performance. In a study analyzing an exceptional policy temporarily implemented in Maastricht that blocked access to cannabis shops for certain individuals based on their nationality, academic performance was found to increase substantially for those who were no longer able to buy cannabis (Marie & Zölitz, 2017). The researchers used a difference-in-difference approach on data about the course grades of students enrolled in Maastricht University. Importantly, based on course evaluations, they found that the higher performance was driven by an improved level of understanding of the material. This suggests that the effect of substance use on the brain may be a significant driver of academic performance.

Another paper studied the relationship between the use of various other drugs among adolescents and academic achievement (Jeynes, 2002). The researcher gathered self-reported data on whether the students had ever been under the influence of cocaine, marijuana or alcohol while at school. He then regressed test scores for multiple school subjects on these indicators. Using regression models with varying combinations of indicators, statistically significant negative effects were found for substance use on academic performance.

It is clear that present research has not yet conclusively determined the effect of alcohol on academic performance. Depending on identification strategy, setting, gender, variations in alcohol consumption measurement and outcome measurement studies arrive at different conclusions. This will be taken into account in the analysis to provide a contribution to the literature.

Data

The LISS panel

Data is retrieved from the LISS (Longitudinal Internet studies for the Social Sciences) panel. This panel consists of approximately 5000 households and 7500 individuals in the Netherlands and has existed since 2007. It is representative of the Dutch population aged 16 or older. The panel is sampled from Statistics Netherlands, and those that would otherwise not be able to participate are given access to a computer and access to the Internet to avoid selection bias. The panel members answer questionnaires about many different themes on an annual basis. They receive monetary compensation in return. The questionnaires of interest to this study are "Health" and "Work and Schooling". From these, data about alcohol consumption and education can be retrieved, as well as other personal characteristics.

A variety of questions related to alcohol consumption are posed to the panel members. The first and most important in this study is "How often did you have a drink containing alcohol over the last 12 months?" They give their answer on a 1-8 score, where 1 means "almost every day" and 8 means "not at all" [1]. The intervals differ between each point on the scale. For the purpose of the actual analysis, this scale is changed to 0-7 and flipped, such that 0 means not at all and a higher value implies drinking alcohol more often. Those who did not drink at all over the past year will be referred to as 'nondrinkers'. This binary indicator and the ordinal scale are the two indicators that will be used to measure the effect of alcohol consumption.

In terms of academic achievement indicators, the questionnaires do not include many options. The respondents are asked only a few questions relating to school performance, but they are very limited. In an ideal scenario, we would have access to every individual's specific average grades during their school career, as grades are a good and direct reflection of a student's performance and work rate. However, the only question asked about concrete school results is: "What is the highest level of education that you have completed with diploma or certificate?" [2] As such, the only information relating to school performance is whether the individual has graduated high school or not. The answer to this question will therefore be used as the outcome variable of this study. Specifically, whether the individual has graduated high school will function as a proxy for academic performance.

Lastly, the gender and age of each individual are retrieved to be used as control variables. Age affects alcohol consumption as well as graduating, and previous literature has shown how alcohol can have different effects for each gender. To answer the question about gender, respondents can choose male, female or other. The sample retrieved from the panel contains almost only male and female respondents, except for one single individual. This individual was dropped from the sample. For the analysis, gender is used as a binary variable. Since there is only one person who identified as 'other' it

[1] A list of all the possible answers to this question can be found in Appendix A.
[2] A list of all the possible answers to this question can be found in Appendix B.

would not significantly alter the results to remove this individual from the sample.

The group of interest in this research consists of young people aged 16-19. This analysis focuses on the alcohol consumption of adolescents and their performance at school, instrumented by the legal drinking age increase of 2014. Relative to before 2014, the increase in the legal drinking age has only forbidden 16- and 17-year olds from drinking alcohol. In theory, it seems reasonable that anyone aged 18 or over from after 2014 is going to drink as much as someone from before 2014. However, it might not be correct to assume that their drinking behaviors are identical. Changing the drinking age may have affected the sentiment surrounding alcohol consumption. Through parental influence or even personal convictions, a higher drinking age may have decreased alcohol consumption even beyond the age of 18. To what extent this assumption holds will be tested further.

The age at which people graduate is primarily dependent on their education level. There are three main high school education levels in the Netherlands: mavo/vmbo, havo, and vwo. The duration of these are 4, 5 and 6 years respectively. Given that the age at which students on average start their high school careers is 12, students would be expected to graduate at age 16, 17 and 18. But if a student fails to perform sufficiently, their graduation may be delayed. In line with the hypothesis of this analysis, drinking alcohol may decrease effort spent on academic activities, and thus delay graduation. If increasing the legal drinking age was effective, adolescents will start drinking less as a result. This allows for an instrumental variable estimation, such that we can observe the effect of alcohol on academic performance in one direction. This can be done by calculating the effect of the intervention on the odds of graduating through alcohol consumption.

After removing any incomplete or missing survey responses, there are 2261 observations left from the years 2008-2022. There is no data from 2010 (key question missing), 2014 (health questionnaire was not held) and 2019 (key question missing). The descriptive statistics are shown in table 1.

Table 1: Descriptive statistics

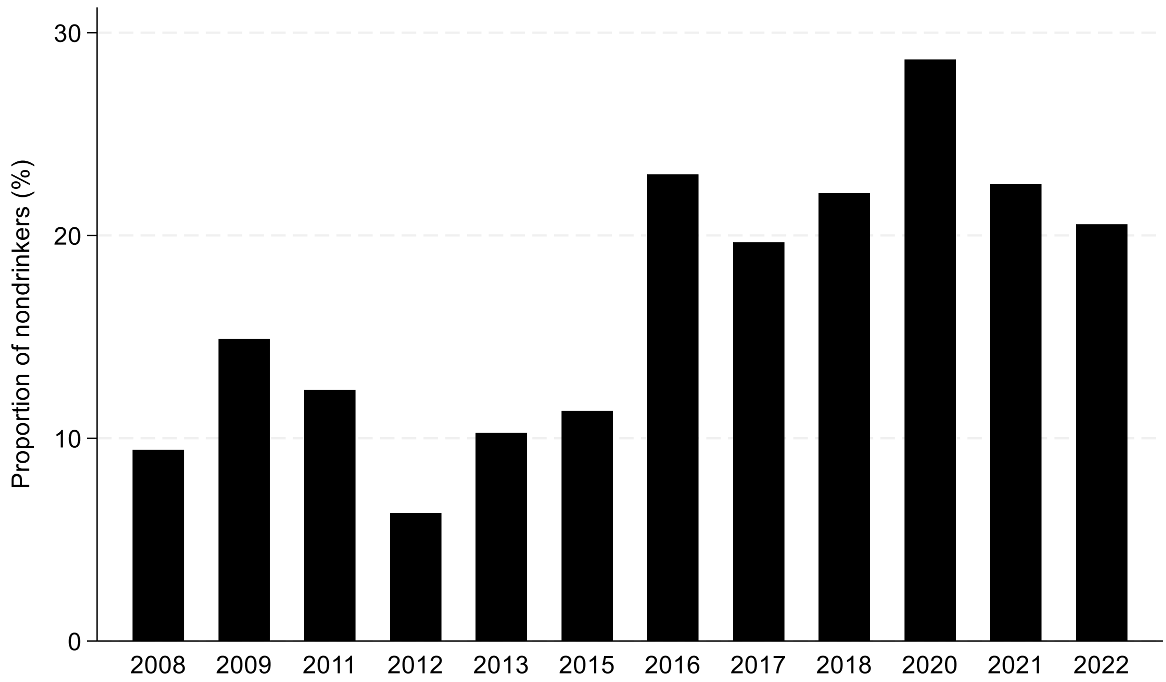
Variables	**Obs.**	**Mean**	**Std. dev.**	**Min.**	**Max.**
Gender	2261	0.586	0.493	0	1
Age	2261	17.720	1.023	16	19
Drinking level	2261	2.786	1.623	0	7
Drinker	2261	0.842	0.365	0	1
Graduated	2261	0.543	0.498	0	1
Drinking age	2261	0.465	0.499	0	1

Notes: this table contains the descriptive statistics of the main variables of this analysis, including the amount of observations, mean, standard deviation, minimum and maximum for each variable. For gender, 0 means male and 1 means female. For drinking age, 0 means the observation is from before 2014, and 1 means after.

Effectiveness of raising the drinking age

To justify there being an effect of the intervention in the first place, it is relevant to check whether we can observe a trend in alcohol consumption that aligns with raising the legal drinking age. Considering the government has made it illegal to distribute alcohol to young people until they turn 18 and keeping in mind that there may be an additional effect beyond the age of 18, it is to be expected that young adults will on average consume alcohol less frequently after 2014. To test if this assumption holds, we can perform a significance test. The question about alcohol consumption is answered on an ordinal scale with varying intervals. To address this a nonparametric test such as the Wilcoxon rank sum test is required. This tests for equality of medians rather than means. It compares all individuals before 2014 to those after 2014, essentially a treated versus control group test. The result of this test implies a significant difference in medians: the median score is significantly higher after 2014 than before[3]. Since a higher score in the survey represents less frequent alcohol consumption, we can conclude that individuals drink less frequently after 2014 than before.

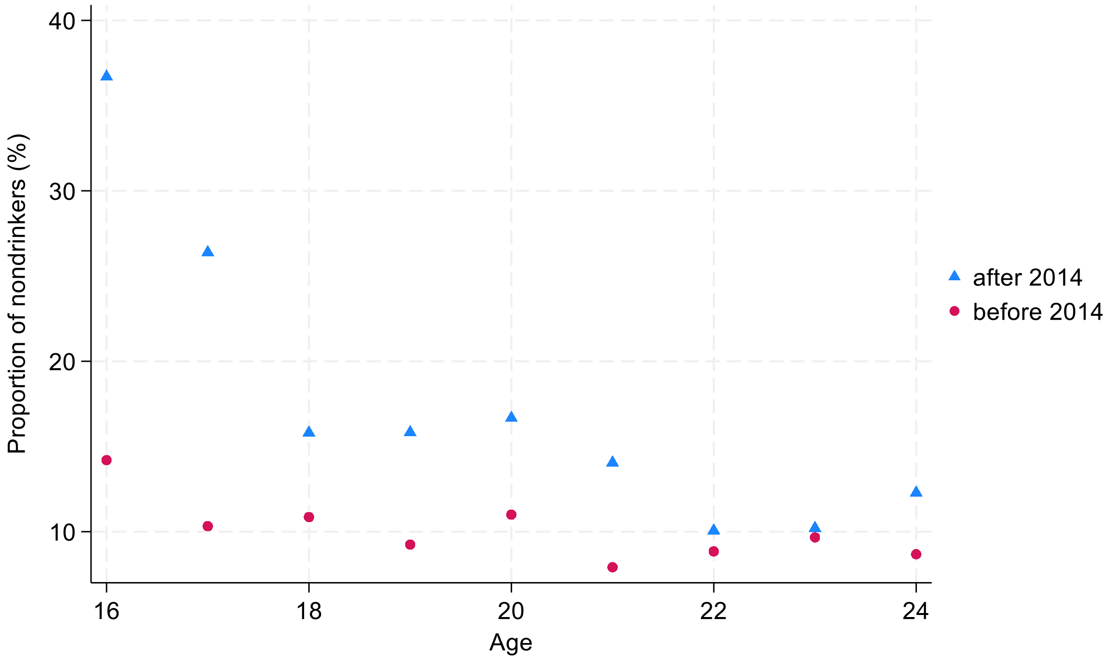
The effectiveness of increasing the drinking age can also be represented visually. Along with the median answer to the drinking question, an important statistic is the proportion of the panel that reports not drinking at all, the 'nondrinkers'. A prediction in line with the higher drinking age would be that the proportion of nondrinkers among the adolescents of this sample increases after 2014. This relationship is present in our data and can be seen in graph 1.



Graph 1: Proportion of nondrinkers among individuals aged 16-19 in 2008-2022

[3] The exact results can be viewed in Appendix C.

Similarly, one would expect the proportion of pre-intervention nondrinkers to be lower than their post-intervention peers, especially for 16- and 17-year olds. This is visible in graph 2. In fact, there appears to be an effect until the age of 22, where the proportions of nondrinkers are almost identical.



Graph 2: Proportion of nondrinkers before and after 2014 by age

In conclusion, there is evidence that the higher drinking age has lowered the alcohol consumption of adolescents in the dataset. Nevertheless, there is a caveat worth mentioning: the possibility of dishonest answers. Underage drinking is illegal, and although the data cannot be tracked back to specific individuals (thus they face no risk of legal repercussions for answering truthfully), people may still be tempted to give 'desirable' answers in line with social and legal norms. This is one of the problems with using survey data; we cannot always observe the objective truth. The reliability of survey data can be diminished by respondents either intentionally or unintentionally misreporting, and this may affect the results of the analysis.

Gender differences

The literature has often pointed out the gender differences in alcohol consumption. To test if these are present in this sample, another Wilcoxon rank sum test is performed for the drinking level variable. The results show that on average, adolescent males drink significantly more frequently than females[4].

[4] The exact results can be viewed in Appendix D.

Methodology

The instrumental variable approach

When estimating the relationship between alcohol consumption and academic performance, the possibility of reverse causality comes to mind. Consuming alcohol might affect the likelihood of graduating, yet the likelihood of graduating may also affect alcohol consumption. This would result in endogeneity and render equation (1) invalid.

$$(1) GraduationOdds_i = \beta_0 + \beta_1 AlcoholConsumption_i + \beta_3 ControlVariables_i + \varepsilon_i$$

A solution to this problem is to use an instrumental variable. If a variable (referred to as an instrument) is known to significantly affect alcohol consumption but not the other way around we can observe the effect of alcohol, generated by this instrument, on graduating. The advantage of this method is we only observe the effect of alcohol in one direction.

Considering our data comes from periods where the legal drinking age was 16 and 18, a variable that measures whether the individual was able to drink at age 16 or 18 can be used as an instrument for drinking behavior. To ensure the validity of the instrument, three main requirements must be met. These are relevance, the exclusion restriction and exogeneity. Relevance implies that the instrument has a strong effect on the endogenous variable. In the case of this analysis, this condition is met; as previously demonstrated, the increase in the legal drinking age seems to have affected the drinking levels of 16- to 19-year olds. The exclusion restriction refers to the assumption that the instrument cannot affect the dependent variable directly; the only effect the instrument is allowed to have is through the endogenous variable. Though this assumption is hard to measure, in theory it also appears to be met. Raising the drinking age from 16 to 18 does not directly affect a student's odds to graduate, but it may do so by changing their drinking habits. Exogeneity requires that the instrument must be random, and not be affected by other variables that are correlated with drinking alcohol. Whether this condition is met is ambiguous; it is certainly possible that the decision to raise the drinking age was affected by a change in public opinion surrounding alcohol, which also affects the drinking behavior, meaning the exogeneity assumption does not hold. It is also possible that the change in public opinion surrounding alcohol comes from raising the drinking age, in which case exogeneity does apply. To conclude, there is evidence that the instrument is valid. but whether all the assumptions hold has not been proven beyond all doubt.

Model

The standard approach for instrumental variables is two-stage least squares regression (2SLS). It computes coefficient estimates for two stages. The first stage has the endogenous variable as the dependent variable and the instrument as the independent variable. The second stage has the outcome variable as the dependent variable and the fitted values for the endogenous variable derived from the first stage as the independent variable. However, this method assumes that the outcome variable and the endogenous are continuous. In this model, alcohol consumption will be measured in two ways using different measurements: it can be defined as a binary term, by classifying people as drinkers and nondrinkers, but also using an ordinal scale as the LISS panel does with the 1-8 score. It is clear that the variable types of the analysis do not fit the requirement of continuity: the outcome variable graduation is binary and the endogenous variable alcohol consumption is ordinal or binary. As a result, the two-stage least squares method would not produce interpretable estimates. Probit and ordered probit are the appropriate methods for such dependent variables. The alternative that will be used is instrumental variable probit regression. Similar to 2SLS, estimates are derived for two stages. The only difference is that the second stage is estimated using probit. This means that this method still assumes the endogenous variable is continuous. As a result, the coefficient estimates cannot be interpreted as easily. For the ordinal variable ‘drinking level’ a positive coefficient would imply that the instrument increases the drinking level. But the drinking levels are discrete, so any decimal values are not interpretable. For the variable drinker, one could imagine the first stage as a linear probability model. A coefficient of 0.1 implies that the instrument increases the odds of being a drinker by 10%. The trouble arises when the coefficients require the outcome of being a drinker to be outside of the 0-1 range, because this is not possible in practice.

Two probit models will be estimated, each with a different form of the endogenous variable of alcohol consumption. To test for gender differences, each regression will be performed 3 times: once including the full sample, once including only males and once more including only females. The model then looks as follows:
the first stage is given by equation (2),

$$(2)\ A_i = \gamma_0 + \gamma_1 Z_i + \gamma_2 \theta_i + \upsilon_i$$

And the second stage is given by equation (3).

$$(3)\ \phi(Y)_i = \phi(\beta_0 + \beta_1 \hat{A}_i + \beta_2 \theta_i + \varepsilon_i)$$

where Y_i is a binary variable representing whether the individual has graduated high school or not, A_i is one of the two different variables measuring alcohol consumption caused by the instrument, $\hat{A}_i$ is the fitted value for alcohol consumption produced by the first stage, θ_i is the age of the individual, Z_i is the instrumental variable that measures whether the individual was able to drink at 16 or 18 and ε_i

and υ_i are the error terms.

Along with analyzing the coefficient estimates, it is important to verify endogeneity by conducting a Wald test of exogeneity. It tests whether the correlation between the error terms of the first and second stages is significantly different from zero. If this is not the case, the null hypothesis of no endogeneity of alcohol consumption cannot be rejected. While this does not mean that any potential effect is uninterpretable, failing to prove a variable is endogenous for a given instrument may mean regular probit regression is preferable. To account for this, a standard probit regression will be performed, where the effect of the instrument is ignored.

Results

Full sample

The results of instrumental variable probit regression using the full sample are listed in table 2. Alcohol consumption appears not to have a significant effect on the odds of graduating in the 'drinking level' and 'drinker' models: the coefficients are not significantly different from zero. In fact, the only variable that is significantly different from zero is age; it significantly increases individuals' odds of graduating. This is not surprising, as older people have spent more years in school and are thus on average closer to graduation. Upon examining the results of the first stage, one will notice the effect of the instrumental variable is significant for both models. However, the fact that the variables do not fit the model cannot be ignored. Drinking level is an ordinal variable, yet the model treats it as if it were continuous, so interpreting the magnitude of the coefficients is complicated. An interpretation would be that those after 2014 drink more frequently than those from before 2014, which is synonymous with the results of the Wilcoxon rank sum test results. As for the drinker model, the higher drinking age decreases the chance of being a drinker by 10.9%. Age also has a significant positive effect on drinking level. Being 1 year older increases the odds of being a drinker by 3.7%. The correlation between the errors of the first and second stages is not significantly different from zero. Therefore the null hypothesis of no endogeneity cannot be rejected and a standard probit regression is preferable over the use of an instrumental variable.

Table 2: Instrumental variable probit regression results: full sample

Second stage	**Graduation (all)**	
Endogenous var. (alcohol cons.)	-0.162 (0.105)	-0.714 (0.465)
Age	0.494*** (0.027)	0.486*** (0.028)
Constant	-8.197*** (0.568)	-7.905*** (0.687)
First stage	**Drinking level**	**Drinker**
Instrumental var. (drinking age)	-0.478*** (0.067)	-0.109*** (0.015)
Age	0.225*** (0.033)	0.037*** (0.008)
Constant	-0.987* (0.583)	0.233* (0.136)
Correlation	0.291 (0.167)	0.277 (0.167)

Notes: this table contains the instrumental variable regression results for the full sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the endogenous variable, the third column gives the coefficient estimates with nondrinker as the endogenous variable. The estimates for the second stage have graduation as the dependent variable. The estimates for the first stage have the endogenous variable as the dependent variable. Beneath the coefficient estimates the correlation between the first and second stage is given. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Male sample

The results for the male sample are listed in table 3. Once again, alcohol consumption does not have an effect on the odds of graduating in both models. The coefficients are extremely close to zero. The results are largely similar to those of the full sample. Age is once again significant, and so are the variables in the first stage. All of the signs are the same. The correlation estimate is also insignificant and close to zero, implying that there is no need for the use of an instrument.

Table 3: Instrumental variable probit regression results: males only

Second stage	**Graduation (males)**	
Endogenous var. (alcohol cons.)	-0.011 (0.123)	-0.054 (0.632)
Age	0.510*** (0.048)	0.509*** (0.045)
Constant	-8.895*** (0.777)	-8.868*** (0.858)
First stage	**Drinking level**	**Drinker**
Instrumental var. (drinking age)	-0.706*** (0.106)	-0.137*** (0.023)
Age	0.221*** (0.051)	0.023** (0.011)
Constant	-0.563 (0.920)	0.491** (0.203)
Correlation	0.044 (0.202)	0.027 (0.227)

Notes: this table contains the instrumental variable regression results for the male sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the endogenous variable, the third column gives the coefficient estimates with nondrinker as the endogenous variable. The estimates for the second stage have graduation as the dependent variable. The estimates for the first stage have the endogenous variable as the dependent variable. Beneath the coefficient estimates the correlation between the first and second stage is given. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Female sample

The results for the female sample are listed in table 4. Interestingly, there is an effect of alcohol consumption on graduation odds for both models. The coefficients for drinking level and drinker are statistically significant at the 5% significance level. They are both negative, implying that drinking more frequently and being a drinker decrease the odds of graduating for women. The rest of the results are largely in line with the estimates of the other samples, with no differences in signs. The correlation between the errors of the first and second stages is also significantly different from zero, albeit at the 10% significance level. This leaves the need for an instrument ambiguous.

Table 4: Instrumental variable probit regression results: females only

Second stage	Graduation (females)	
Endogenous var. (alcohol cons.)	-0.354** (0.156)	-1.259** (0.606)
Age	0.454*** (0.054)	0.463*** (0.044)
Constant	-7.021*** (1.266)	-7.041*** (1.131)
First stage	**Drinking level**	**Drinker**
Instrumental var. (drinking age)	-0.294*** (0.085)	-0.088*** (0.020)
Age	0.223*** (0.041)	0.047*** (0.010)
Constant	-1.198 (0.735)	0.043 (0.172)
Correlation	0.579* (0.235)	-0.480* (0.216)

Notes: this table contains the instrumental variable regression results for the female sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the endogenous variable, the third column gives the coefficient estimates with nondrinker as the endogenous variable. The estimates for the second stage have graduation as the dependent variable. The estimates for the first stage have the endogenous variable as the dependent variable. Beneath the coefficient estimates the correlation between the first and second stage is given. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.

The correlations between the first and second stages among the full and male samples are not significantly different from zero, implying there is no need for an instrument. A probit regression is performed, leaving the instrument out of the equation.[5] However, no significant effects are found. Alcohol consumption has no significant effect on the odds of graduating. Both with drinking level and nondrinker as the independent variable, the coefficient is not significantly different from zero. Only age affects the odds of graduating: it has a significant positive effect, but this is to be expected. Without the use of an instrument, reverse causality is left unaddressed, meaning the validity of regular probit is lacking.

[5] Probit regression results can be viewed in Appendix E.

Discussion and conclusion

Discussion and conclusion of the results

This analysis attempted to discover the effect of alcohol consumption on academic performance by analyzing the dynamics between adolescents drinking patterns and their odds of graduating. I addressed the reverse causality associated with this dynamic by using an instrument. In general, there does not appear to be an effect. For males and the full sample, the instrumental variable probit estimates imply that there is no effect of alcohol consumption on the odds of graduating. The same holds true for the standard probit estimates. The results are very different when examining only female individuals. For women aged 16-19, it appears that there is an effect of alcohol consumption on graduating. Being a drinker and drinking more frequently decreases female students' chances of graduating. The null hypothesis of no effect of alcohol on graduating can therefore be rejected, but only for women. Interestingly, the results from the standard probit regression for the female sample do not show any significant effects of alcohol consumption. This adds evidence to the effectiveness of the use of an instrument in this case. It is possible that the instrumental variable solves reverse causality.

This finding is at odds with the results of other studies on this subject. The majority of papers that analyze the effect of alcohol on academic achievement reach the opposite conclusion: that is, the effect is stronger for males than for females. In fact, some studies do not even find an effect for females at all. Adding to this surprising result, it was shown that women drink less frequently than men, yet are affected by alcohol consumption more for their odds of graduating. Perhaps this finding is most in line with the paper by Balsa et al., who noted that alcohol use increased women's odds of having difficulty with schoolwork whereas this was not the case for men. It is possible that this difficulty shows itself more so in the long term, because the major difference of this paper is the outcome variable. Graduation is vastly different from the outcomes other papers use to measure performance, like test scores and GPAs. Graduating high school is a long-term result that takes years to achieve, whereas grades and test results are short-term results and change over time. It is certainly possible that alcohol has different effects on student performance, depending on how performance is measured. While there is more than one way to measure alcohol consumption in this analysis, the same is not true for academic performance. The analysis might have shown different results that are in line with the general literature if the LISS sample offered more specific data about how well high school students do. Nevertheless, since a significant relationship does exist it may be interesting to study a larger variety of academic performance outcomes for future research.

The results from the first stage consistently show significant effects of the instrument, for each type of model. It shows that individuals on average drink less frequently and are less likely to drink after 2014 than before, adding to the evidence that raising the drinking age to 18 was effective at reducing alcohol consumption among adolescents.

Validity

The internal validity of this research is limited by the unavailability of an effective outcome variable and important control variables. The data from the LISS panel is lacking when it comes to questions about how well people perform at school. Because of this, the dataset may not be appropriate for this research question. While graduation can serve as a novel proxy for academic outcome, the long-term nature of the variable makes it difficult to quantify the effect of alcohol in a meaningful way. A more accurate model would benefit from an outcome variable that is current and can vary over time such as average grades at school, which is why the majority of studies analyze those outcomes instead.

The accuracy of the model would have also benefitted from the inclusion of certain control variables such as the amount of study hours per week. In terms of the method used, the validity is not airtight. Not all the requirements of the instrumental variable have been demonstrably met. The exogeneity assumption in particular may not hold for this particular instrumental variable.

Since the sample is derived from a representative sample, this research is externally valid for the Dutch population aged 16-19. Because of the use of an instrumental variable, the estimates acquired using this method capture only the variation in alcohol consumption caused by the increasing the drinking age. The causal effect found of alcohol on graduation is therefore a local average treatment effect.

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Appendix A: alcohol drinking question

Now think of all the sorts of drink that exist. How often did you have a drink containing alcohol over the last 12 months?

1. almost every day
2. five or six days per week
3. three or four days per week
4. once or twice a week
5. once or twice a month
6. once every two months
7. once or twice a year
8. not at all over the last 12 months

Appendix B: highest level of education question

Note: answers that are counted as having graduated high school are highlighted.

What is the highest level of education that you have completed with diploma or certificate? This can be a day program or a part-time program. Part-time programs (such as evening secondary school) and learn-work programs (such as apprenticeships) also count. Individual courses do not count. If you were educated abroad, and your education is comparable to one of the listed Dutch programs, please select the (comparable) Dutch education program. If this is not possible, then select the button 'other'. You will then be presented a follow-up question.

1. did not complete any education
2. did not complete primary school
3. primary school
4. lower and continued special education
5. vglo (continued lower education)
6. lbo (lower professional education)
7. lower technical school, household school
8. **mulo, ulo, mavo (lower/intermediate secondary education; US: junior high school)**
9. **vmbo vocational training program (preparatory intermediate vocational school)**
10. **vmbo theoretical or combined program (preparatory intermediate vocational school)**
11. mms (intermediate girls' school)
12. hbs (former pre-university education, US: senior high school)
13. **havo (higher general secondary education; US: junior high school)**
14. **vwo (pre-university education, US: senior high school)**
15. **gymnasium, atheneum, lyceum (types of pre-university education programs)**
16. kmbo (short intermediate professional education), vhbo (preparatory higher professional education)
17. mbo professional training program (intermediate professional education) (BOL)
18. mbo professional training program (intermediate professional education) (BBL)
19. mbo-plus to access hbo, short hbo education (less than two years) (higher professional education)
20. hbo (higher professional education), institutes of higher education, new style
21. teacher training school
22. conservatory and art academy
23. academic education (including technical and economic colleges, former style) bachelor's degree (kandidaats)
24. academic education (including technical and economic colleges, former style) master's degree (doctoraal)

25. academic education, bachelor
26. academic education, master
27. doctor's degree (Ph.D, including doctoral research program to obtain Ph.D)
28. other

Appendix C: Wilcoxon rank sum test results – drinking age

Drinking age	Observations	Rank sum	Expected
0	1210	1263205.5	1368510
1	1051	1293985.5	1188681
Combined	2261	2557191	2557191

$z = -7.020$

$Prob > |z| = 0.000$

Appendix D: Wilcoxon rank sum test results – gender

Gender	Observations	Rank sum	Expected
0	937	1176222.5	1059747
1	1324	1380968.5	1497444
Combined	2261	2557191	2557191

$z = 7.862$

$Prob > |z| = 0.000$

Appendix E: Probit regression results

Full sample

	Graduation	
	Drinking level model	Drinker model
Alcohol cons.	0.018 (0.017)	0.043 (0.077)
Age	0.474*** (0.028)	0.477*** (0.028)
Constant	-8.335*** (1.528)	-8.364*** (0.495)

Notes: this table contains the probit regression results for the full sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the independent variable, the third column gives the coefficient estimates with nondrinker as the independent variable. The estimates have graduation as the dependent variable. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Male sample

	Graduation	
	Drinking level model	Drinker model
Alcohol cons.	0.016 (0.026)	0.020 (0.120)
Age	0.505*** (0.044)	0.508*** (0.043)
Constant	-8.886*** (0.778)	-8.906*** (1.528)

Notes: this table contains the probit regression results for the male sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the independent variable, the third column gives the coefficient estimates with nondrinker as the independent variable. The estimates have graduation as the dependent variable. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Female sample

	Graduation	
	Drinking level model	Drinker model
Alcohol cons.	0.022 (0.023)	0.063 (0.101)
Age	0.453*** (0.037)	0.455*** (0.036)
Constant	-7.967*** (0.642)	-7.994*** (0.641)

Notes: this table contains the probit regression results for the female sample. The first column lists the variables, the second column gives the coefficient estimates with drinking level as the independent variable, the third column gives the coefficient estimates with nondrinker as the independent variable. The estimates have graduation as the dependent variable. Robust standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01.