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Abstract

This paper leverages a discontinuity in legal access to alcohol at age 16 to estimate its impacts on teenage drinking and crime in Germany, a country with very high consumption levels. Using detailed survey data and administrative crime records from 2005 to 2015, I detect considerable increases in drinking participation, frequency, and intensity at the legal cutoff along the middle and lower end of the distribution. These increases coincide with discrete jumps in criminal engagement under the influence of alcohol, mostly due to violent and property crimes. I provide evidence that changes in drinking intensity induce these crimes, implying a drinking-crime elasticity of 0.4 at age 16.

JEL-Code: I12, I18, K42

Keywords: Alcohol; crime; minimum legal drinking age

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1 Fabian T. Dehos, RGS Econ, RUB, RWI, and UDE . *– I thank Thomas Bauer, Philipp Breidenbach, Marco Horvath, Carlos Dobkin, Markus Nagler, Marie Paul, Sandra Schaffner, and Colin Vance for valuable remarks and suggestions. I also thank participants of the NGE network at the University of Hohenheim, Tübingen, and Mannheim as well as internal seminar participants for helpful comments and discussion. I gratefully acknowledge financial support from the RWI Transatlantic Program and the hospitality of the Economics Department of UC Santa Cruz for hosting me.* *- All correspondence to: Fabian T. Dehos, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: fabian.dehos@rwi-essen.de*

1. Introduction

Worldwide, governments aim to moderate teenage alcohol consumption and its unintended consequences through age-based access regulations. For the US, Canada, and Australia, existing research documents the effectiveness of a minimum legal drinking age in reducing harmful alcohol consumption (e.g. Carpenter and Dobkin, 2009; Carpenter et al., 2016; Lindo et al., 2016).[1] Considering the undergoing physical development of teenagers and a strong path dependence of consumption habits into adulthood (Abboud et al., 2019), these policies are crucial to mitigate the adverse consequences on short- and long-term health and other detrimental outcomes (WHO, 2009).

A particularly costly outcome commonly linked to drinking is crime. Within the EU, the estimated burden of consumption induced offenses amounts €33 billion annually, which adds substantially to the overall social costs associated with alcohol (WHO, 2009). While causal estimates on the drinking-crime relationship stem primarily form the US, evidence from the EU is scarce, despite the world's highest levels of alcohol consumption and very low access regulations in several EU member states (WHO, 2010, 2016b).

In this study, I investigate the impact of the German minimum legal drinking age (MLDA) on teenage alcohol consumption and criminal engagement using detailed individual survey data and administrative crime records over the years 2005 to 2015. I employ a regression discontinuity design (RD) and leverage the 16^{th} birthday when teenagers in Germany are legally allowed to access fermented alcohol, that is beer, wine and sparkling wine.[2] I thus draw on an age cutoff which is among the lowest in the world (WHO, 2016b).

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[1]Using a regression discontinuity (RD) approach, these studies exploit the minimum legal drinking age (MLDA) to evaluate the consumption behavior and alcohol-related outcomes, i.e. mortality and traffic accidents, around the legal cutoff. Further RD studies on these countries focus on the MLDA and its impact on morbidity (Carpenter and Dobkin, 2017), marijuana use (Crost and Guerrero, 2012; Yörük and Yörük, 2013), academic performance (Carrell et al., 2011; Lindo et al., 2013), and risky sexual behavior (Yörük and Yörük, 2015; Koppa, 2018). A related strand of the literature rests on policy changes of the MLDA at the state level. But since the implementation of new regulations are often an endogenous response to alcohol-related incidences, these cross-sectional studies are likely to lack internal validity (Carpenter and Dobkin, 2009).

[2]Despite further access to distilled alcohol at the 18^{th} birthday, I refrain from this cutoff since it constitutes the age of adulthood in Germany, which is accompanied by additional rights and legal changes that are likely to confound the cost of misconduct and thus, the likelihood to engage in drinking and crime. For details on these confounders and background information on the institutional setup, see Section 2.

In a first step of the analysis, I evaluate the impact of the access regulation at age 16 on different dimensions of alcohol consumption looking at potential changes in drinking participation, drinking frequency, and drinking intensity at age 16. I also investigate the impact of the access regulation at age 16 along the whole distribution of drinking frequency and drinking intensity (Carpenter et al., 2016), drawing on very recent consumption questions that allow a clear distinction between both dimensions. This is crucial since alcohol consumption and its pathway on adverse outcomes might neither evolve linear nor similar for both types of drinking. In a second step, I examine the criminal engagement of teenagers around the legal cutoff along different types of offenses. The information on whether an individual acted under the influence allows a separate analysis of drunk and sober offenders. In a third step, I exploit further features of the data to learn more about the mechanisms of alcohol control. The daily structure of the crime records and the option to track individuals over time provide useful information to trace out potential pathways. I thus disentangle the dimensions of teenage alcohol consumption that are likely to induce crime.

My results reveal substantial increases in teenage drinking at age 16, which coincide with discrete jumps in criminal engagement under the influence of alcohol, mostly due to violent crimes, i.e. light and aggravated assaults, and property crimes, i.e. vandalism and theft. These findings prove robust to a broad set of falsification checks and a conservative randomization-based inference approach. Besides, crime increases under the influence appear mostly at the weekend, i.e. outside the structured school day that teenagers at age 16 usually attend in Germany. I also disentangle whether frequency or intensity changes in teenage drinking induce the crime increases at age 16. Since I detect shifts in criminal engagement only for first-time offenses under the influence of alcohol, this pinpoints intensity shifts in teenage drinking as the underlying pathway. That is, individuals at the margin of committing an alcohol-induced offense do so for the first time at age 16 by exceeding their critical blood alcohol concentration (BAC) level to become criminal. Taken together, a one percent increase of the drinking intensity at age 16 implies a 0.4 percent increase of crimes committed under the influence of alcohol.

This paper adds to recent RD studies on the impact of a MLDA on crime (Carpenter and Dobkin, 2015, henceforth CM, 2015; Hansen and Waddell, 2018, henceforth HW, 2018), while looking at a country where alcohol is broadly available and socially accepted. In Germany, overall consumption levels and teenage drinking prevalence are among the highest in the world and substantially above the US average where most evidence on the crime impact of a MLDA originates.[3] Alcohol is also extremely cheap in Germany and almost a quarter below the purchasing-power-adjusted global average (World Bank, 2011). While focusing on a very early cutoff at age 16, I further expand the external validity of CM (2015) and HW (2018), who document a strong impact of the US access regulations at age 21 on criminal engagement.[4]

This paper also contributes to a better understanding of the mechanisms through which MLDA regulations operate. The nuanced crime data provide policy-relevant insights while evaluating the occurrence of criminal activities over the course of the week. By differentiating crimes not only by previous engagement (HW, 2018) but also whether the offender acted under the influence of alcohol, I link the analysis of drinking and crime to gain further insights on the mechanism. My analysis also advances the work of Kamalow and Siedler (2019) on the German MLDA by systematically evaluating the different dimensions of alcohol consumption and respective discontinuities along the entire drinking distribution. Overall, my findings thus provide detailed insights on relevant margins of the drinking-crime relationship, which are important to consider when constructing effective interventions.

The remainder of the paper is structured as follows: Section 2 describes the legal setup that regulates teenage alcohol consumption in Germany. Section 3 presents the data and the empirical strategy. Section 4 covers the results of the consumption and crime analysis, robustness checks, and evidence on potential mechanisms. Section 5 concludes.

[3] Annual per capita consumption of pure alcohol among adults amounts 12.6 l in Germany, 9.4 l in the US, and 6.2 l worldwide (WHO, 2010). For teenagers, global data coverage is incomplete but differences persist: The 12-month drinking prevalence among 15-year-old teenagers is 89% in Germany and only 50% in the US (WHO, 2011).

[4] Previous studies on the US exploit state-level variation in drinking age regulations: Joksch and Jones (1993) and Carpenter (2005), for instance, show significant crime reductions in response to drinking age increases. For a review of existing research on the impact of alcohol on crime and a critical evaluation of previous methodological approaches, see Carpenter and Dobkin (2011).

2. Institutional Background

In Germany, the federal Youth Protection Act (YPA) regulates the protection of children and adolescents in the public sphere and, among others, their legal access to alcohol. Since its enactment in 1952, YPA sets out a stepwise, age-dependent alcohol law (YPA, Section 9).[5] Restaurants, stores and other points of sale must not vend undistilled, i.e. fermented alcohol (beer, wine and sparkling wine), to teenagers below 16 nor must they tolerate their consumption. The only exception from this regulation are teenagers older than 14 who can access fermented alcohol in the company of a custodial person. The legal cutoff for sale and consumption of distilled alcohol, e.g. spirits and spirit-containing beverages, is - without any exception - the 18^{th} birthday.

Approximately 90% of teenagers in Germany aged 14 to 18 know about the age restrictions to alcohol, but the majority does not consider them as a major hurdle.[6] Since possession of alcohol is not illegal, the German legislator aims to enforce the MLDA by sanctioning people with fees of up to 50,000 Euros if they sell alcohol to non-entitled teenagers or if they permit their consumption.[7] But in reality, enforcement appears weak: 80% of teenagers aged 14 to 16 state that they could (very) easily access beer or wine for own consumption, even though they are not entitled to.[8] A similar pattern holds true for spirits or spirit-containing beverages: Despite restrictions for minors below 18, more than 62% of the 14- to 18-year-old teenagers consider its access as (very) easy.

Drinking is socially accepted in Germany and alcohol is broadly available for a low price. Off-premise sales do not restrict to liquor stores but range from supermarkets to gas stations, up to newsstands. Open container laws do not exist either and it is generally legal to drink in public. The purchasing-power-adjusted price of alcoholic beverages in Germany ranks 24% below global average and 27.5% below US average, which is among the lowest in the world (World Bank, 2011). The price for beer is particularly cheap (Blecher et al., 2018):

[5] The current regulations of the German MLDA are historically anchored and trace back to the Imperial Licensing Act from 1930.

[6] Own calculations based on FCHE (2015, 2011, 2008) data.

[7] Non-commercial adult bystanders who do not intervene in underage drinking can also be sanctioned.

[8] Own calculations based on ESPAD (2007, 2011) data.

For historical reasons, Germany levies the lowest possible beer tax, i.e. EU's minimum rate.[9] The German advertising regime is also very liberal and prescribes partial restrictions only or voluntary self-regulation (WHO, 2016a). In sum, all these factors constitute a consumption-stimulating environment which coincides with high teenage drinking rates. But affordable prices and a broad availability of alcohol may also induce indecisive teenagers to start and increase drinking once they are legally entitled (Harding et al., 2016).

The 18^{th} birthday constitutes the age of adulthood in Germany which comes along with further rights and obligations apart from further access to distilled alcohol. Most importantly, teenager gain unrestricted access to all establishments for the entire night. From 18 onwards, individuals must also bear the financial consequences of their behavior and judges can apply the more severe adult criminal law. These legal changes impact the cost of misconduct and thus, the likelihood to engage in drinking and crime. At the same time, individuals obtain full contractual capacity, the youth protection ends, and Germans acquire the right to vote in federal elections. The sum of all these changes and the social acceptance as an adult are likely to confound the pure effect of a legal access to distilled alcohol at age 18. I thus refrain from an analysis at this cutoff.

Another confounder specifically related to accidents is the option to obtain a license for unaccompanied driving of regular vehicles at age 18, and for light motorcycles at age 16. At both cutoffs, the number of fatal traffic accidents increases notably for non-alcohol-related incidents (Kamalow and Siedler, 2019), which points to an increased vehicle use. Given the study's focus on the 16^{th} birthday, a greater use of light motorcycles could facilitate the acquisition of alcohol and thus, drinking and criminal engagement.[10] To alleviate respective concerns, I further address this issue in the robustness section.

[9] In 2009, a half-liter bottle of standard domestic lager beer costs on average €0.72 in a German supermarket (Eurostat, 2009). Considering the average price of €0.60 for a similar sized bottle of carbonated soft drink consumed by a German household at that time (Hoffmann and Bronnmann, 2019), this corresponds to a relative beer-to-soft-drink price of 1.2.

[10] Since the German crime statistic does neither include traffic accidents nor traffic offenses (e.g. DUI), I do not consider them as criminal engagement either (see Section Appendix B.1). I only focus on crimes where a causal association is possible but not mechanically apparent (Carpenter and Dobkin, 2011).

3. Data and Empirical Strategy

3.1. Consumption Data

Data on teenage drinking behavior stem from two sources covering the years 2005 to 2015. The first source is the German Federal Centre for Health Education (FCHE).[11] It provides nationally representative survey data on the drinking behavior of individuals aged 12 to 25 for the years 2005, 2007, 2008, 2011, and 2015. Following Carpenter et al. (2016), I add data from a second source to maximize the sample size. These data come from the European School Survey Project on Alcohol and Other Drugs (ESPAD) capturing the years 2007 and 2011. ESPAD data are representative for all participating states and include students in grade 9 and 10 across all German school types.

The pooled data set includes about 20,800 individuals aged 14.5 to below 17.5 years and several measures of alcohol consumption. Due to a larger number of survey participants and a narrower definition of the target population, ESPAD data makes up a larger share of the overall sample despite fewer waves. In contrast to most previous studies, ESPAD includes a set of detailed questions on very recent drinking within the past week. I can thus investigate the impact of the MLDA at different intensity and frequency stages. To clearly separate between both dimensions, I focus the intensity analysis on the last drinking occasion within the last week and the frequency analysis on the number of drinking days within the last week. The short reference period of seven days further reduces overlaps in reporting. That is, individuals above the MLDA are less likely to refer their answers to the time prior to the MLDA. Besides, it is easier to recall a tighter time horizon which reduces overall underreporting in consumption surveys (Stockwell et al., 2008).

Using the year and month of birth in combination with the survey date, I can calculate the respective age in months, i.e. the running variable, for each individual of the sample.[12] A first visual inspection of the age distribution provides no indication for manipulation of the running variable or systematic sorting to one side of the cutoff at the 16^{th} birthday (see Fig. B.7 of

[11] FCHE, commonly known as *Bundeszentrale für gesundheitliche Aufklärung (BZgA)*, is a central institution of the German Federal Government engaged in prevention and health promotion.

[12] See Appendix B.1.1 for details on the age calculation.

Appendix B). I address this issue more formally in the robustness section.

Panels A, B, and C of Table 1 provide summary statistics of all outcome measures used in the analysis. Since some measures are surveyed in ESPAD only, they include fewer observations. Panel D adds information on the individual characteristics of survey participants. Since covariates evolve smoothly across the 16^{th} birthday (see Section 4.3), their inclusion should not affect the analysis except for an improved precision.

Table 1: Summary Statistics – Consumption Data

	Mean	s.d.	N	Source
Panel A: Drinking Participation				
Within Lifetime	0.94	0.24	20,789	ESPAD; FCHE
Within Last 30 Days	0.73	0.44	20,789	ESPAD; FCHE
Within Last 7 Days	0.51	0.50	15,725	ESPAD
Panel B: Drinking Frequency				
Drinking Occasions Within Last 30 Days	6.17	8.64	15,725	ESPAD
Drinking Days Within Last 7 Days	1.12	1.36	15,725	ESPAD
Panel C: Drinking Intensity in Gram (g) of Pure Alcohol				
Overall Amount on Last Occasion Within Last 7 Days	32.51	46.60	15,725	ESPAD
Undistilled Alcohol on Last Occasion Within Last 7 Days	17.31	25.67	15,725	ESPAD
Distilled Alcohol on Last Occasion Within Last 7 Days	15.20	27.68	15,725	ESPAD
Panel D: Covariates				
Gender	0.49	0.50	20,789	ESPAD; FCHE
Preparatory High School	0.42	0.49	20,789	ESPAD; FCHE
Technical/Pre-Vocational School	0.39	0.49	20,789	ESPAD; FCHE
Comprehensive School	0.15	0.36	20,789	ESPAD; FCHE
Apprenticeship, Job, Other	0.03	0.18	20,789	ESPAD; FCHE
College Degree of a Parent	0.28	0.45	20,789	ESPAD; FCHE

Notes: Survey data on alcohol consumption stem from the Federal Centre for Health Education (FCHE, *Bundeszentrale für gesundheitliche Aufklärung*) and the European School Survey Project on Alcohol and Other Drugs (ESPAD) covering different waves over the years 2005 to 2015 and teenagers aged 14.5 to 17.5.

For a comprehensive assessment of the MLDA, I investigate the consumption behavior along three dimensions: prevalence of drinking (Panel A), consumption frequency (Panel B), and consumption intensity at a specific drinking occasion (Panel C). Panel B and C are of particular importance. Following previous research by Carpenter et al. (2016), I exploit the detailed consumption measures of both panels to investigate the impact of the MLDA along the entire distribution of drinking frequency and drinking intensity.

Table 1 provides additional insights on the overall consumption level of teenagers in Germany, which is among the highest in the world. Panel A reveals that 94% of teenagers aged 14.5 to 17.5 have already consumed alcohol once in their life and 73% within the last 30 days. For students of comparable age, the 30-days drinking prevalence averages only 57% in Europe (Hibell et al., 2012) and about 30% in the US (Eaton et al., 2012). The overall pattern of Table 1, however, is similar to other countries: Teenage consumption behavior decreases with a tighter reference period and more severe types of drinking. In Section 4.1, I share further descriptive insights on the age profile of teenage consumption patterns, before I turn to the RD estimates.

3.2. Crime Data

Detailed administrative crime records stem from the Federal Police Offices of the two German states of Baden-Wuerttemberg and Schleswig-Holstein.[13] The data cover the full universe of teenage offenders for the years 2005 to 2015 and include additional information on the delinquents' gender, nationality, and type of the incident. Since offenders are not necessarily convicted yet, data records are similar to criminal charges used in HW (2018). But mere suspicion is not sufficient to enter the German crime statistics as an offender. Investigative results of the police have to provide substantial evidence of legal misconduct to initiate a criminal proceeding and thus, a data entry.

For each criminal, the data set covers the precise age in days at the time of the incident, i.e.

[13] See Appendix C for further background information on the states of Baden-Wuerttemberg and Schleswig-Holstein. A comparison with national aggregates documents a similar crime structure within the two included states. Also note that the National German Police Office provides countrywide but aggregated crime data only. Since temporal information restricts to completed years and annual counts, national aggregates prove inappropriate for the present analysis.

the running variable. This information is either directly included or calculated using the dates of birth and offense. Following the literature on the economics of crime, I derive for each age cell the respective crime rate per 10,000 person-years.[14] This rate allows a comparison across studies and countries and serves as an outcome measure which I differentiate by major types of criminal engagement. In contrast to previous studies, German crime records include the information whether an offender was under the influence of alcohol. I can thus distinguish criminal engagement by sober and drunken offenders. Following HW (2018), I can also track individuals over time to investigate first-time and repeat criminal engagement, separately.[15] As a further feature, I can disentangle the crime data by weekdays.

Table 2: Summary Statistics – Crime Outcomes

	Crime Rate in 10,000 Person Years		
	Overall	w/o the Influence of Alcohol	Under the Influence of Alcohol
all crimes	692.1	609.9	82.2
violent crimes	174.2	141.3	32.9
crimes against life	0.4	0.3	0.1
sexual offences	8.9	7.8	1.1
aggravated assaults	56.2	42.7	13.5
slight assaults	72.0	58.2	13.8
other violent crimes	36.7	32.3	4.4
property crimes	392.5	354.7	37.8
theft	224.4	209.9	14.4
domestic burglary	20.7	19.0	1.7
property fraud	56.0	54.5	1.5
vandalism	91.5	71.2	20.2
drug crimes	56.5	54.3	2.2
other crimes	69.0	59.6	9.3

Notes: This table contains for different types of offenses the respective crime rates in 10,000 person-years for teenagers aged 14.5 to 17.5. The crime data stem from the Federal Police Offices of the two German states of Baden-Wuerttemberg and Schleswig-Holstein covering the years 2005 to 2015. See Table B.8 for an classification of the different crime categories and Appendix B.2.1 for further information on the construction of the crime rate.

[14] See Appendix B.2.1 for a detailed outline on the construction of the crime rate.

[15] Note that tracking depends on staying within the same state. Since most teenagers are still in school and living with their families, this assumption seems plausible.

Table 2 outlines for the sample of 14.5- to 17.5-year-old teenagers summary statistics on their criminal engagement. The overall crime rate amounts 692 offenses per 10,000 person-years. That is, a group of 10,000 teenagers aged 14.5 to 17.5 commits on average 692 offenses in each year over the time frame under consideration. Out of these 692 offenses, approximately 12%, i.e. 82 cases, are committed under the influence of alcohol. Due to study-specific differences in the composition of crime statistics, I follow previous research to group the data into comparable sub-categories (CM; HW, 2015; 2018). As Table 2 shows, the three major categories are violent, property, and drug crimes, which account for approximately 90% of all offenses.[16]

But some types of potential misconduct do not enter German crime statistics despite a clear link to alcohol. Since teenagers do not commit an offense if they drink in public or below the German MLDA, there are no such crime records. This is different to other countries, but the German regulations aim at adults who sell alcohol to non-entitled teenagers or those who permit respective drinking (see Section 2). Traffic violations are not included in the German crime statistics either even though they are considered as illegal misconduct. I thus focus on crimes where a causal impact of alcohol is possible but not directly apparent (Carpenter and Dobkin, 2011).

3.3. Empirical Strategy

Drawing on a RD design, I leverage the German MLDA at age 16 to estimate its impact on alcohol consumption and crime. The idea is to compare outcomes of similar teenagers who differ only in their costs of accessing alcohol depending on whether they exceed the legal age cutoff or not. The following reduced-form model formalizes the empirical approach:

$$y_i = X_i'\beta + \delta D_i + f(age_i) + \varepsilon_i \tag{1}$$

In the preferred specification, I include observations one-and-a-half years around age 16. But I also vary the bandwidth over a broad range and employ current methods for optimal bandwidth selection (see Section 4.3).

[16]Table B.8 of Appendix B provides an overview of the coding of offenses.

y indicates either a consumption measure or a crime outcome of individual i. Vector X denotes a set of individual characteristics, survey indicators and state dummies. X also includes birthday indicators to absorb potential celebration effects. In the analysis of monthly consumption data, these indicators turn one in the first month after the birthday. In the crime analysis, I can narrow the time frame of the indicators to the precise birthday and the subsequent day given the daily structure of the crime data. Since crime records include criminals only, I also aggregate the number of offenders at each age cell to the respective crime rate.[17]

D_i represents a dummy variable for being over age 16 or not. $f(age_i)$ is a flexible polynomial of the age variable re-centered at 16. Following previous RD studies on alcohol consumption (Carpenter et al., 2016; HW, 2018), I model the age profile of outcome y by a second order polynomial which can take different forms on either side of the cutoff.[18]

The focus of the analysis rests on the identification of coefficient δ which indicates the discontinuous jump in outcome y at age 16, i.e. the MLDA. Since not every individual takes advantage of a legal access to alcohol, δ interprets as an intention-to-treat (ITT) effect.

For a causal interpretation of $\hat{\delta}$ the following key identifying assumption must hold: Any relationship between age and the error term ε_i has to trend smoothly through the cutoff to ensure local randomization of D_i. That is, $f(age_i)$ has to be sufficiently flexible to absorb age-related changes in y and no other unobserved determinants of y should increase discontinuously at the treatment threshold. The graphical representation of the results and the robustness to other functional forms suggest an appropriate fit of the age profile through a quadratic polynomial (see Section 4).

To further strengthen the credibility in the continuity assumption, I examine the smoothness of observables characteristics and potential manipulation of the running variable. Similarly, there might be additional confounding treatments such as mobility changes at age 16 that coincide with the MLDA. I address all these concerns in detail in the robustness section.

[17] This approach is standard in the MLDA literature but rules out the inclusion of individual characteristics. For details on the construction of the crime rate, see Appendix B.2.1.

[18] See Section 4.3 for sensitivity checks on the robustness of this choice.

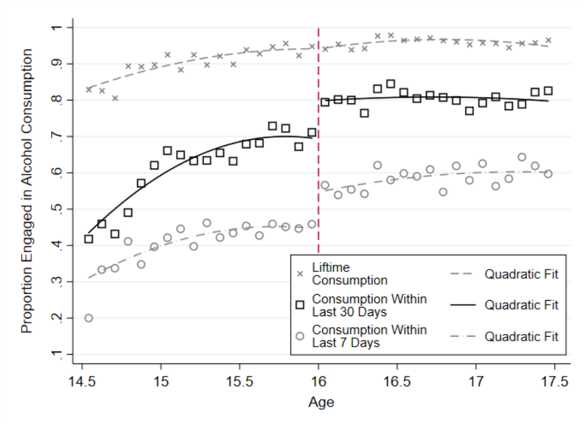
4. Results

4.1. The Impact of the MLDA on Teenage Alcohol Consumption

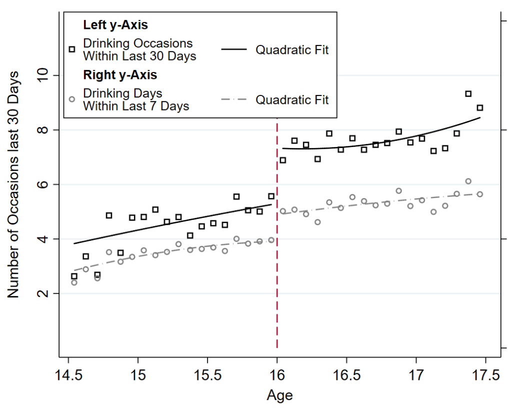
Before turning to the RD estimates, I first outline a graphical overview of the findings. Figure 1 documents the age pattern of teenage alcohol consumption around the 16^{th} birthday. I distinguish three major dimensions of consumption, i.e. prevalence of drinking (Fig. 1a), consumption frequency (Fig. 1b), and consumption intensity (Fig. 1c). Within each figure, I superimpose a quadratic fit on all outcomes along the monthly age. These fits are estimated separately on both sides of the cutoff.

Figure 1: Age Profiles of Alcohol Consumption Around Age 16

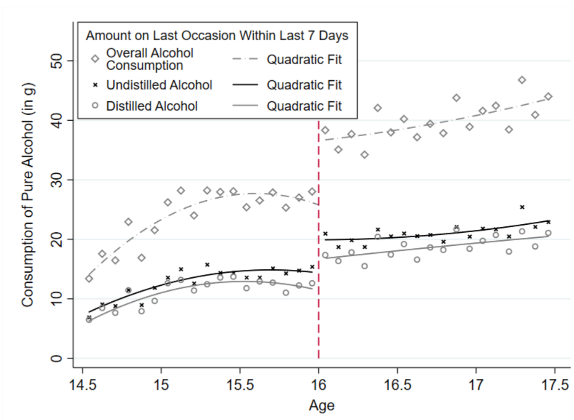
(a) Drinking Participation



(b) Drinking Frequency



(c) Drinking Intensity



Notes: Figures (a) to (c) show for each age cell and consumption type the average monthly drinking behavior. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. See notes from Table 1 for further details on the sample.

Figure 1a reveals that approximately 95% of teenagers right below age 16 have already consumed alcohol once in their lives. In contrast to all other consumption measures, there is no jump in lifetime prevalence at age 16 which points to the non-binding nature of the MLDA in restricting first-time alcohol exposure. This finding coincides with anecdotal evidence and provides indirect but compelling evidence that individuals do not fall for dishonest response or potential underreporting at the MLDA. It is also evident that the drinking participation increases in age and with a broader reference window (see Fig. 1a). This pattern is consistent across all other consumption measures (see Fig.1b and 1c) and adds to the general observation that less-severe consumption behavior occurs more frequently.

The 30- and 7-day drinking participation of Figure 1a increases discontinuously at age 16. This increase is driven by frequency changes as shown in Figure 1b. The number of drinking days within the last week, for instance, rises by 0.2 days at the 16^{th} birthday, which corresponds to a 20% increase relative to the average drinking frequency of a single day right below the MLDA cutoff. The overall consumption intensity on the last drinking occasion within the last 7 days also increases discontinuously at age 16 (Fig. 1c). Since a higher intensity at a specific drinking occasion does not necessarily induce a higher frequency, it is important to present both dimensions separately.

I also subdivide the overall consumption intensity into distilled and undistilled alcohol (Fig. 1c). Both consumption measures evolve in parallel and exhibit a similar increase at age 16, even though the 18^{th} birthday constitutes the legal age to access distilled alcohol, i.e. spirits and spirit-containing beverages. This finding suggests a complementarity between both types of alcohol and points to a potential gateway mechanism of beer and wine to distilled beverages.[19]

RD Estimates of Consumption Changes

Table 3 summarizes the graphical findings of Figure 1 and outlines for each consumption measure the point estimate of coefficient δ, i.e. the discontinuous jump at age 16. All regres-

[19]There is no consensus whether certain types of alcohol complement each other. Estimates of cross price elasticities are mixed (see e.g. Meng et al., 2014). Since the consumption data does not include the chronological order of different drinks, I cannot test the gateway hypothesis formally. But as outlined in column 6 of Table D.12, it is indeed the joint consumption of both types of alcohol at one sitting which drives the result.

sions use a bandwidth of one and a half years and include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables that indicate the birthday if the interview was conducted within the same month. Even columns include additional individual characteristics, survey indicators and state dummies. Their inclusion hardly changes the coefficient of interest, which suggests that they are uncorrelated with the treatment.[20]

Table 3: Change in Consumption Behavior at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Drinking Participation	Lifetime Consumption		Consumption Within Last 30 days		Consumption Within Last 7 days	
Increase at 16	0.001	-0.002	0.106***	0.096***	0.097***	0.085***
	(0.010)	(0.010)	(0.019)	(0.019)	(0.025)	(0.025)
Mean just under 16	0.945	0.945	0.696	0.697	0.444	0.448
Observations	20,789	20,789	20,789	20,789	15,725	15,725
Panel B: Drinking Frequency	Number of Drinking Occasions Within Last 30 Days		Number of Drinking Days Within Last 7 Days			
Increase at 16	2.251***	2.072***	0.226***	0.197***		
	(0.437)	(0.425)	(0.068)	(0.066)		
Mean just under 16	5.372	5.394	0.985	0.998		
Observations	15,725	15,725	15,725	15,725		
Panel C: Drinking Intensity (in g of Pure Alcohol)	Overall Amount on Last Occasion Within Last 7 Days		Undistilled Alcohol on Last Occasion Within Last 7 Days		Distilled Alcohol on Last Occasion Within Last 7 Days	
Increase at 16	10.041***	9.116***	4.876***	4.371***	5.166***	4.745***
	(2.317)	(2.260)	(1.285)	(1.243)	(1.368)	(1.352)
Mean just under 16	25.551	25.928	14.294	14.399	11.257	11.528
Observations	15,725	15,725	15,725	15,725	15,725	15,725
Full Set of Controls	No	Yes	No	Yes	No	Yes

Notes: See notes from Table 1 for a description of the sample and the respective data sources. All regressions use a bandwidth of one and a half years and include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. Even columns include additional dummy variables for the survey wave, the federal state of residence, the current type of school/training, gender, and whether one of the parents visited college. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. To assess the relative size of an increase, all specifications report the "Mean just under 16" which is the predicted average of the outcome variable for an individual right below age 16 holding all other covariates at their means. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

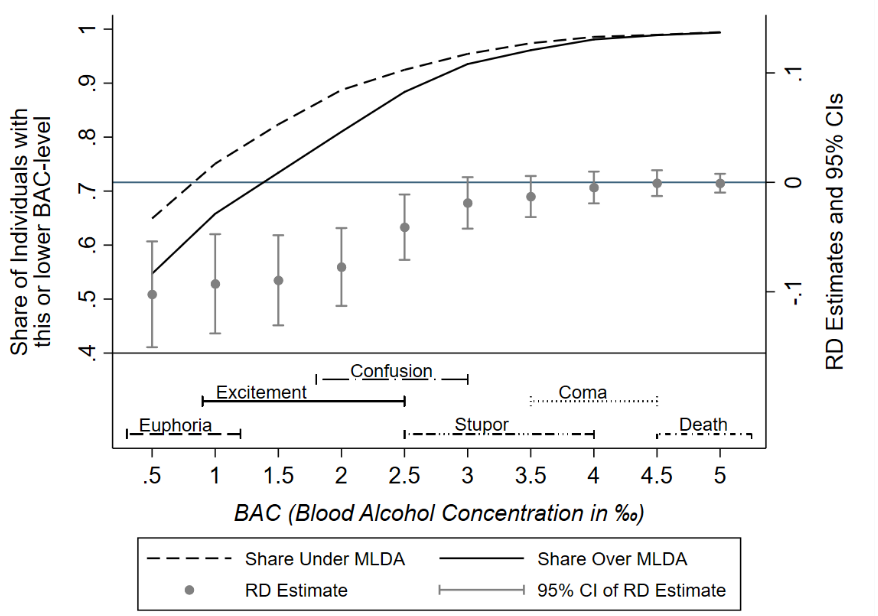
Since the age variable is centered on the MLDA, the treatment coefficient δ indicates the discontinuous change of the outcome at the cutoff and can be directly interpreted with respect

[20]In Section 4.3, I document the stability of the regression estimates of Table 3 in more detail along a comprehensive set of robustness checks.

to the mean just below age 16. The 9.1gram consumption change of pure alcohol on the last occasion within the last week (Table 3, Column 2 of Panel C), thus constitutes a 35% increase (9.1/25.9) of the overall drinking intensity at age 16. Similarly, there is a 20% increase in the number of drinking days within the last 7 days right at the cutoff (Table 3, Column 4 of Panel B).

Given that the overall consumption changes might hide potential working mechanisms, I follow Carpenter et al. (2016) and trace out the effect of the MLDA along the full drinking intensity distribution. This is crucial since the pharmacological effect of alcohol and its pathway on adverse outcomes varies greatly for different consumption levels.

Figure 2: Drinking Intensity Distribution at Age 16
BAC level at Last Drinking Occasion within Last 7 Days



Notes: The dashed (solid) line shows the share of individuals right below (above) the 16^{th} birthday who reached a certain BAC level or stayed below it during the last drinking occasion within the last 7 days. The gray dots represent the estimated BAC difference between dashed and solid line and the vertical bars the respective 95% confidence intervals. Each point estimate, i.e. gray dot, and confidence interval are obtained from a regression on the full sample (N=15,725) using a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. The BAC conversion draws on the Widmark formula (see Appendix B.1.2).

Figure 2 outlines the impact of the MLDA on the consumption intensity at the last drinking occasion within the last 7 days, separately for different levels of the blood alcohol concentration (BAC).[21] The dashed line of Figure 2 shows the cumulative distribution function of the teenage drinking intensity right below the MLDA, while the solid line denotes the intensity distribution right above the MLDA. The difference between both lines is shown by a dot. Each dot thus represents an estimate of the impact of the MLDA at this specific consumption level including the 95% confidence interval. Following the medical literature, I add to Figure 2 for different BAC levels the corresponding symptoms.[22] It is evident that the impact of the MLDA tends to be stronger at lower BAC levels where alcohol induces euphoria and excitement. But the legal regulations also impact more severe impairments like stupor and confusion. The upper part of the drinking distribution, where coma and death occur, remains unaffected.

I also investigate the impact of the access regulation at age 16 along the frequency distribution while looking at the number of drinking days within the last week before the survey. Figure A.4 in the Appendix shows the cumulative distribution function of the consumption frequency for individuals right below and right above age 16. For almost up to two drinking days, there are significant difference in the drinking frequency. In sum, MLDA regulations at age 16 thus induce changes in the consumption frequency and consumption intensity which could trigger more offenses. In Section 4.4, I aim to quantify the impact of both dimensions of alcohol consumption as potential working mechanisms on criminal engagement.

4.2. The Impact of the MLDA on Teenage Crime

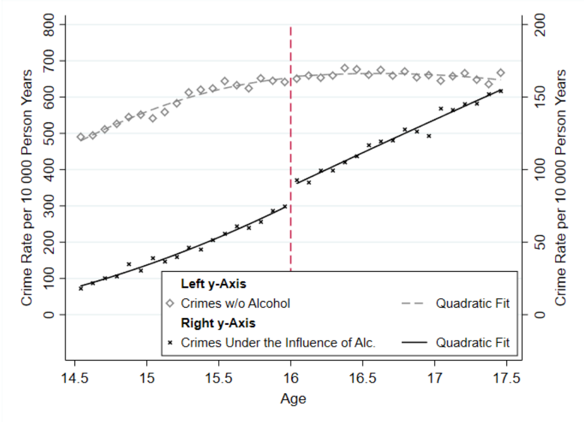
In this section, I analyze the criminal engagement of teenagers around the MLDA at age 16. In a first step, I visualize the age profile of teenage offenders who commit a crime under or without the influence of alcohol, as outlined in Figure 3a. Offenses with the mention of alcohol occur less frequently but show a steeper relative increase over the age frame under consideration with a discontinuous jump at the 16^{th} birthday. The latter observation points to a potential impact of the MLDA, whereas crimes without the influence tend to evolve smoothly.

[21]I derive the BAC level from the pure amount of consumed alcohol. This adjustment takes gender specific differences and the physis of teenagers into account. For details on the conversion, see Appendix B.1.2. Figure D.13 proves the robustness of Figure 2 using an alternative BAC conversion.

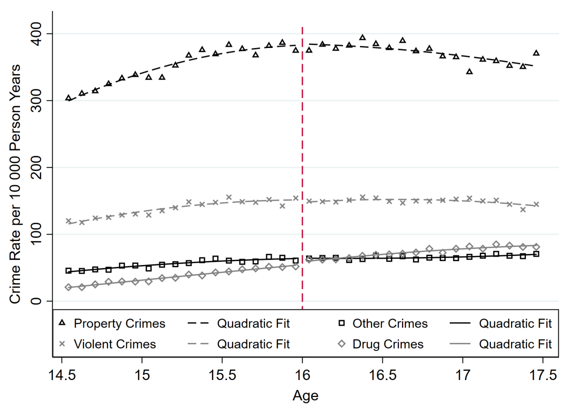
[22]Despite individual pathways, intoxication usually proceeds in subsequent stages. The included stages in Figrue 2 follow studies by Dubowski (1980) and Vonghia et al. (2008) who categorize symptoms that correlate with overlapping ranges of BAC. Prevention offices like the American Addiction Centers propose the same assignment.

Figure 3: Age Profiles of Criminal Engagement Around Age 16

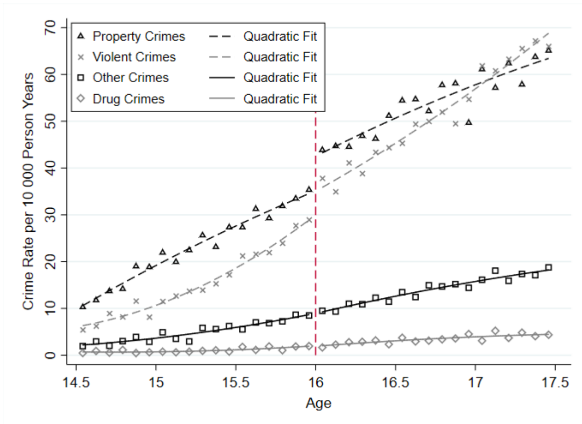
(a) Overall Criminal Engagement



(b) Criminal Engagement Without Mention of Alcohol (w/oI)



(c) Criminal Engagement Under the Influence of Alcohol (UI)



Notes: Figures (a) to (c) show for different types of offenses at each age cell the respective crime rate per 10,000 person years. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. For further details on the sample, see notes from Table 2.

I further disaggregate overall criminal engagement into violent, property, and drug crimes, and a complementary category which comprises all remaining offenses. Figure 3b outlines the respective age profiles of these categories for offenders without mention of alcohol. All crime categories tend to evolve continuously with increasing age.

Figure 3c turns to crimes committed under the influence of alcohol. Property and violent crimes with the mention of alcohol rise sharply with increasing age and show a discontinuous jump at the MLDA. Drug crimes and all remaining offenses evolve less pronounced and without any discontinuities. In Figures A.5a and A.5b of the Appendix, I further break down property and violent crimes with the mention of alcohol into their underlying components. The increasing age pattern of intoxicated violent offenders depends strongly on aggravated and slight assaults (Fig. A.5a). The rise of property crimes under the influence is driven by vandalism and theft (Fig. A.5b). In addition to the steep age profiles, there are pronounced discontinuities at age 16 for the previously mentioned subgroups.

Table 4: Change in Criminal Engagement at Age 16

	(1)	(2)	(3)	(4)	(5)
	All Crimes	Violent Crimes	Property Crimes	Drug Crimes	Other Crimes
Panel A: W/o the Influence					
Increase at 16	2.579	-2.435	1.597	3.849*	-0.432
	(7.618)	(3.309)	(5.610)	(2.016)	(2.216)
Mean under 16	641.464	148.700	376.071	53.677	63.017
Panel B: Under the Influence					
Increase at 16	11.682***	4.926***	7.085***	-0.135	-0.195
	(2.990)	(1.608)	(1.903)	(0.401)	(0.837)
Mean under 16	74.696	29.388	34.539	1.945	8.824

Notes: See notes from Table 2 for a description of the sample and the respective data sources. Each observation is the crime rate per 10,000 person-years at a specific day-of-age cell. Using a bandwidth of one and a half years, each regression includes 1 095 observations and a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday and the day immediately after. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

RD Estimates of Crime Changes

The regression results of Table 4 confirm the graphical findings and point to a substantial impact of the MLDA on crimes committed under the influence of alcohol. The overall criminal engagement of alcohol-induced crimes increases by 11.7 offenses per 10,000 person years at age 16 (Table 4, Column 1 of Panel B), which interprets as a 15.7% jump (11.7/74.7). The main contributors of this jump are slight and aggravated assaults, vandalism, and theft which increase by 3.3, 2.4, 3.9, and 3.2 offenses per 10,000 person years, respectively (see Table A.7 of Appendix). While drug crimes under the influence remain constant, there is a slight jump of drug crimes without mention of alcohol at age 16 which is significant at a ten percent level (Table 4, Panel A, Column 4). Due to scaling issues, this increase is not visible in the previous graphical representations. But Figure A.6 of the Appendix zooms closer into the age cutoff and confirms a small discontinuity, which coincides with other MLDA studies on the US (see CM, 2015; HW, 2018).[23] All other crime categories without mention of alcohol, however, evolve smoothly and do not reveal any significant changes at age 16 as shown in Panel A of Table 4.

4.3. Robustness Section

4.3.1. Falsification and Sensitivity Checks

I check the previous findings of the consumption and crime analysis along several dimensions and show that they are robust. Appendix D provides a detailed overview of all falsification and sensitivity test and outlines the respective figures and tables. In the following, I briefly summarize the the main findings.

Permutation Tests: I apply two different permutation tests drawing either on placebo ages or placebo cutoff regulations. The appeal of this approach is twofold: Firstly, I can check for potential confounders given that there should be no placebo impact on the outcome. Secondly, I can conduct a more conservative inference approach by comparing the randomization distribution of the placebo simulation with the actual t-statistic from the baseline regression. As outlined in Figures D.8 - D.10, the placebo distributions do not falsely suggests spurious effects. Besides, all previously identified consumption and crime increases remain statistically significant.[24]

RD Specific Sensitivity Checks: The next checks present a battery of RD specific falsification test. As shown in Figures D.11 and D.12, I successively increase the bandwidth from 5 months up to 24 months. The results are robust over a broad range of different bandwidths and confirm the previous findings. In Tables D.9 and D.10, I model age profiles as third order polynomials

[23] Despite inconclusive evidence whether other drugs complement alcohol (Wen et al., 2015), I observe an increased marijuana use at the MLDA in my consumption data (Table D.12, column 7).

[24] See Appendix D.1 for further details on both test.

and I apply local linear regressions using a MSE-optimal bandwidth selector. Overall, results prove robust to these adjustments. In a subsequent step, I stress the smoothness of observable characteristics around the age cutoff. Columns $1-6$ of Table D.11 do not reveal significant changes in the sample characteristics at age 16, which strengthens the credibility in the continuity assumption. As a further balancing test, I consider potential bunching of the running variable to one side of the cutoff. A visual inspection of the consumption data (Fig. B.7) does not reveal systematic distortions of the age distribution around the cutoff. In the last column of Table D.11, I address this issue more formally using a regression approach. Since there is no discontinuous change in the number of surveyed teenagers at age 16, the concern of systematic sorting or manipulation of the running variable proves unfounded.

4.3.2. Discussion of Potential Limitations

Desirability Bias: Structural understatement of alcohol consumption prior to age 16 might bias the consumption analysis. Compared to previous studies, desirability bias tends to be less of a concern in the present setting: Firstly, teenagers below the MLDA do not behave illegally in Germany if they drink given that the regulations aim at adults who sell alcohol to non-entitled teenagers or those who permit respective drinking (see Section 2). Secondly, all surveys guarantee complete anonymity to their respondents. Thirdly, pre-MLDA consumption levels are already substantial across all types of drinking and, in line with prior expectations, there is no discontinuity at the cutoff for the prevalence of lifetime consumption. Fourthly, overall increases in alcohol consumption at age 16 coincide with administratively measured discontinuities in criminal behavior under the influence of alcohol. This provides indirect but convincing evidence that I do not fall for dishonest response at age 16.

Locational Shifts: Discontinuities in crimes under the influence might just reflect an increased documentation at age 16 that comes along with locational shifts to bars and clubs and a higher reporting readiness in public. If this is the case, there should also be an impact an overall criminal engagement without mention of alcohol, which I do not observe in the present setting. Besides, alcohol-related increases do not restrict to offenses where interpersonal interactions of bars or clubs are salient. This line of argument coincides with CM (2015) who document crime increases at the US MLDA within the private and public sphere. Despite missing information about the crime scene, I add further indirect evidence from the consumption side. For Germany, ESPAD data reveals pronounced increases at age 16 for off-premise purchases of alcohol for private consumption and minor discontinuities for on-premise purchases (see Column 1 and 2 of Table D.12).[25] The legal regulations of the Youth Protection Act also diminish respective concerns. In Germany, teenagers below age 16 can already visit bars to drink non-alcoholic beverages and the new possibility to access clubs is still limited.[26] 16-year-old teenagers cannot stay a long time in clubs due to late opening hours and a legal restriction to leave by midnight. In sum, this mitigates the confounding impact of locational shifts.

Mobility Changes: In Germany, teenagers are legally allowed to obtain a license for light motorcycles once they turn 16. Even though the German crime statistics does not include traffic violations, a better mobility could facilitate the acquisition of alcohol, its consumption and the overall commission of crimes. As documented by the Federal Highway Research Institute (Kühne et al., 2019), teenagers in rural areas are much more likely to obtain a license for light motor vehicles. I thus, draw on a subset of the FCHE consumption data which allows a separate analysis by urban and rural areas. The 30-day consumption prevalence is considerably higher in rural areas. But since the relative changes do not differ, mobility gains at age 16 tend to be of minor importance for teenage alcohol consumption.[27]

Spurious Increases of Documented Crimes: Drunken offenders might act more careless and they are thus, more easily detected by the police even though the underlying number of crimes remains constant. If this holds true, alcohol-related imprudence should increase all types of crime under the influence in a systematic way. Since this is not the case, this concern seems

[25] Using self-collected consumption data from three East German states, Kamalow and Siedler (2019) provide similar evidence showing consumption increases within the private and public sphere at age 16.

[26] The German YPA also specifies the legal age to access restaurants and bars as well as dance events and clubs (YPA, Section 4). Teenagers below 16 are generally allowed to enter restaurants and bars between 5 a.m. and 11 p.m. if they want to eat something or if they want to drink a non-alcoholic beverage; 16- to 18-year-olds can extend their stay by one hour till midnight. Entry to dance events or clubs is generally not permitted below the age of 16, while 16- to 18-year-olds are allowed to attend till midnight. From age 18 onwards or in the company of a custodial person, there are no age restrictions and individuals have legal access to all localities at any time.

[27] See column 3-5 of Table D.12. Note that increases prove only weakly significant or insignificant given the small number of observations.

unfounded.

Persistence of Effects: MLDA regulations at age 16 may just induce temporary shifts instead of permanent changes. A visual inspection of the pre-cutoff drinking patterns and its trajectories beyond age 16 reveal a persistent effect on teenage alcohol consumption which does not fade out with increasing age. However, this persistence does not necessarily translate to crimes if teenagers get used to higher permanent drinking levels through experimentation or learning (Carpenter and Dobkin, 2009, 2017). The increase in criminal engagement under the influence at age 16 may thus revert to pre-MLDA trajectories. For property crimes with mention of alcohol, there is no visual evidence for such a reversion and only slight tendencies for violent crimes under the influence. Besides, most teenagers have their first drinking experiences already before age 16 which further alleviates the experience and learning concern (CM, 2015). From a criminological point of view, the persistence of the MLDA regulations on offenses is also likely to occur at later stages due to a higher crime propensity of individuals who have already been criminal.

4.4. Mechanisms Behind the MLDA on Crimes Under the Influence

This section adds further insights on the underlying mechanisms while looking at important heterogeneities. This is crucial since it remains unclear whether frequency or intensity changes in teenage alcohol consumption contribute to the crime increases at age 16. While looking at first-time and repeat offenses under the influence, I aim to disentangle the impact of both consumption dimensions. First-time offenses with mention of alcohol indicate the first criminal engagement of an individual under the influence. Repeat offenses with mention of alcohol comprise all offenses under the influence that an individual commits at subsequent stages.[28] A mere increase of first-time offenses under the influence, suggests a pure intensity effect. Individuals at the margin of committing a crime under the influence, do so at the MLDA if they exceed their critical BAC level to become criminal. An increase of repeat offenses only implies a pure frequency effect. Individuals who have already been criminal under the influence before the MLDA do not need to increase their consumption intensity to

[28]Note that the present stratification allows the commission of a first-time offense by a repeat offender.

become criminal. Increases of the drinking frequency at the MLDA are sufficient to commit more crimes under the influence. Accordingly, a joint increase of first and repeat offenses with mention of alcohol implies a combined effect along the frequency and intensity dimension.

Table 5 shows the point estimates of the discontinuous jump at age 16 for first and repeat offenses under the influence of alcohol. First-time offenses with the mention of alcohol (Panel A) show pronounced discontinuities at age 16 for violent and property crimes. The absolute increases coincide with the previous findings of the main analysis. Repeat offenses, in contrast, evolve smoothly along the MLDA and do not show any significant discontinuity (Panel B). The overall crime increases under the influence of alcohol are thus entirely driven by first-time offenses. Following the previous line of argument, this also pinpoints a higher consumption intensity at age 16 as the underlying working mechanism implying a drinking-crime elasticity of 0.4. That is, a one percent increase of the consumption intensity at the MLDA induces a 0.4 percent increase of offenses committed under the influence of alcohol.[29]

Table 5: Change in Criminal Engagement Under the Influence at Age 16 by First-Time and Repeat Offenses

	(1)	(2)	(3)	(4)	(5)
	All Crimes	Violent Crimes	Property Crimes	Drug Crimes	Other Crimes
Panel A: First-Time					
Increase at 16	11.848***	5.380***	6.125***	0.089	0.254
	(2.032)	(1.202)	(1.323)	(0.272)	(0.578)
Mean under 16	41.963	16.866	19.740	0.890	4.467
Panel B: Repeat					
Increase at 16	-0.166	-0.454	0.961	-0.224	-0.449
	(1.902)	(1.033)	(1.195)	(0.280)	(0.594)
Mean under 16	32.732	12.522	14.799	1.055	4.357

Notes: See notes from Table 4. First-time offenses define the first criminal engagement of an individual. Repeat offenses capture all offenses that an individual commits at a subsequent stage. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

I also look at the occurrence of offenses under the influence of alcohol over the course of the week. The distinction between weekend and weekdays provides further policy-relevant insights.[30] Table 6 outlines the point estimates at age 16. Crime increases under the influence of alcohol occur almost entirely at the weekend (Table 6, Panel A). Only for property crimes,

[29]Using the estimates of Table 4 and 3, the elasticity reads as follows:

$$\frac{\text{\%change in crimes under the influence of alcohol at the MLDA}}{\text{\%change of drinking intensity at the MLDA}} = \frac{11.7/74.7}{9.1/25.9} \approx 0.4.$$

[30]Friday, Saturday, and Sunday define a weekend, while all remaining days count as weekdays.

there is also a small increment during the week which is significant at a ten percent level. The small but weakly significant decrease of drug crimes within the week is offset by a similar though insignificant increase at the weekend, which points to a mere shift in time. Even though the drinking data does not include information of the weekday, the overall findings of Table 6 suggest that the critical rise of consumption at age 16 happens at the weekend.

Table 6: Change in Criminal Engagement Under the Influence at Age 16 by Weekend and Weekday

	(1)	(2)	(3)	(4)	(5)
	All Crimes	Violent Crimes	Property Crimes	Drug Crimes	Other Crimes
Panel A: Weekend					
Increase at 16	24.453***	12.214***	11.894***	0.809	-0.464
	(5.736)	(3.241)	(3.740)	(0.674)	(1.527)
Mean under 16	118.889	49.558	52.719	2.066	14.546
Panel B: Weekday					
Increase at 16	2.104	-0.539	3.479*	-0.844*	0.007
	(2.893)	(1.387)	(1.998)	(0.458)	(0.923)
Mean under 16	41.551	14.260	20.904	1.854	4.532

Notes: See notes from Table 4. Friday, Saturday, and Sunday define a weekend, while all remaining days count as a weekday. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5. Conclusion

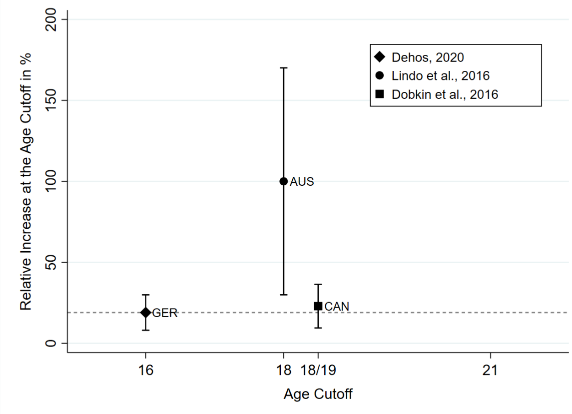
This paper provides new evidence on the drinking-crime relationship while looking at the German access regulation at age 16, which is among the lowest in the world. The analysis covers the years 2005 to 2015 and combines detailed consumption surveys with administrative crime records. Despite high pre-MLDA consumption levels and a broad social acceptance of alcohol in Germany, I detect substantial increases in drinking participation, drinking frequency, and drinking intensity at age 16, which coincide with discrete jumps in criminal engagement under the influence mostly due to violent crimes, i.e. light and aggravated assaults, and property crimes, i.e. vandalism and theft. I further pinpoint intensity changes as the underlying pathway to a higher criminal engagement under the influence of alcohol. Consistently, the impact of the MLDA is strongest for BAC levels which induce reduced judgment and increased risk taking and thus, a higher crime propensity. Besides, crime increases under the influence appear mostly at the weekend, i.e. outside the structured school day that teenagers at age 16 usually attend during the week.

My findings shed light on the underlying working mechanisms but also improve the external validity of previous MLDA studies. Figure 4 summarizes cross-study evidence and compares the impact of different MLDA regulations on drinking and crime. Independent of the country and the age cutoff, there are substantial effects on the drinking prevalence (Panel A) which coincide with increases in violent and property crimes (Panel B). This comparison emphasizes the effectiveness of MLDA regulations in mitigating moderate but crime-inducing consumption patterns of teenagers and adolescents at very different stages of physical and mental maturity and in distinct settings around the world.

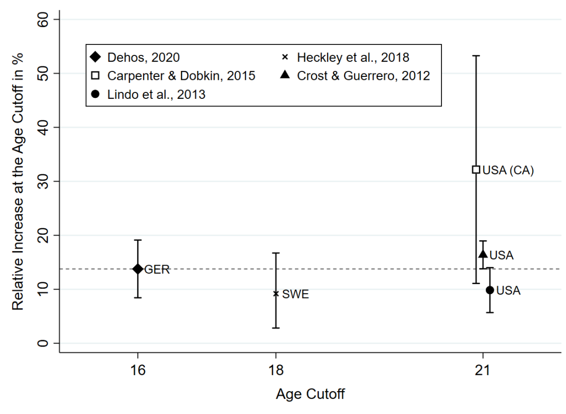
But the overall criminal implications of a MLDA are probably more far-reaching in light of consumption-induced victimization. A recent study by Chalfin et al. (2019), for instance, points to victimization increases at the US MLDA of 21. Due to data limitations, however, I cannot add estimates on intoxicated victims. Despite this limitation, my analysis provides policy-relevant insights on the mechanisms through which access regulations affect the different dimensions of teenage alcohol consumption and criminal engagement under the influence. In sum, higher costs of obtaining alcohol may thus substantially reduce drinking and crime.

Figure 4: Cross–Study/Country Comparison of Different MLDA Cutoff Regulations

Panel A: Prevalence of Alcohol Consumption



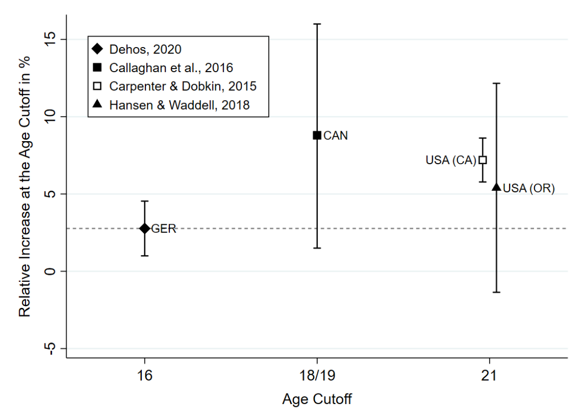
(a) Consumption Within last 7 Days



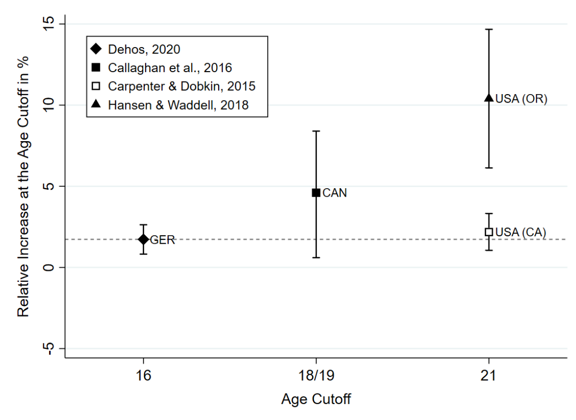
(b) Consumption Within last 30 Days

Notes: Figures (a) and (b) show the point estimates and the 95 percent confidence intervals of the relative increases in the prevalence of alcohol consumption at different age cutoffs for different countries using the results of the indicated studies.

Panel B: Criminal Engagement



(c) Violent Crimes



(d) Property Crimes

Notes: Figures (c) and (d) show the point estimates and the 95 percent confidence intervals of the relative increases in criminal engagement at different age cutoffs for different countries using the results of the indicated studies. To overcome compositional effects of different underlying crime categories, this figure compares violent and property crimes only. For both types of offenses a causal association with alcohol is possible but not mechanically apparent. Estimated crime increases of the present study are set into relation to the overall rate of violent and property crimes right below age 16, respectively.

References

Abboud, T., Bellou, A., Lewis, J., 2019. The Long-Run Impacts of Adolescent Drinking: Evidence from Zero Tolerance Laws. IZA Discussion Paper, 12833.

BKA, 2019. Catalogue of Criminal Offences. Federal Criminal Police Office.

Blecher, E., Liber, A., Van Walbeek, C., Rossouw, L., 2018. An International Analysis of the Price and Affordability of Beer. *PloS one*, 13 (12).

Callaghan, R.C., Gatley, J.M., Sanches, M., Benny, C., 2016. Do Drinking-Age Laws Have an Impact on Crime? Evidence From Canada, 2009–2013. *Drug and Alcohol Dependence*, 167, 67–74.

Carpenter, C., 2005. Heavy Alcohol Use and the Commission of Nuisance Crime: Evidence From Underage Drunk Driving Laws. *The American Economic Review*, 95 (2), 267–272.

Carpenter, C., Dobkin, C., 2009. The Effect of Alcohol Consumption on Mortality: Regression Discontinuity Evidence From the Minimum Drinking Age. *American Economic Journal: Applied Economics*, 1 (1), 164–182.

Carpenter, C., Dobkin, C., 2011. Alcohol Regulation and Crime. In: Cook, P.J., Ludwig, J., McCrary, J. (Eds.), Controlling Crime: Strategies and Tradeoffs. University of Chicago Press, pp. 291–329.

Carpenter, C., Dobkin, C., 2015. The Minimum Legal Drinking Age and Crime. *Review of Economics and Statistics*, 97 (2), 521–524.

Carpenter, C., Dobkin, C., 2017. The Minimum Legal Drinking Age and Morbidity in the United States. *Review of Economics and Statistics*, 99 (1), 95–104.

Carpenter, C., Dobkin, C., Warman, C., 2016. The Mechanisms of Alcohol Control. *Journal of Human Resources*, 51 (2), 328–356.

Carrell, S.E., Hoekstra, M., West, J.E., 2011. Does Drinking Impair College Performance? Evidence From a Regression Discontinuity Approach. *Journal of Public Economics*, 95 (1–2), 54–62.

Chalfin, A., Hansen, B., Ryley, R., 2019. The Minimum Legal Drinking Age and Crime Victimization. NBER Working Paper, 26051.

Crost, B., Guerrero, S., 2012. The Effect of Alcohol Availability on Marijuana Use: Evidence From the Minimum Legal Drinking Age. *Journal of Health Economics*, 31 (1), 112–121.

Destatis, 2019. Annual Population Statistics. Federal Statistical Office of Germany.

Dubowski, K.M., 1980. Alcohol Determination in the Clinical Laboratory. *American Journal of Clinical Pathology*, 74 (5), 747–750.

Eaton, D.K., Kann, L., Kinchen, S., Shanklin, S., Flint, K.H., Hawkins, J., Harris, W.A., Lowry, R., McManus, T., Chyen, D., et al., 2012. Youth Risk Behavior Surveillance–United States, 2011. *Morbidity and Mortality Weekly Report*, 61 (4), 1–162.

ESPAD, 2007. Europäische Schülerstudie zu Alkohol und anderen Drogen 2007. European School Survey Project on Alcohol and Other Drugs.

ESPAD, 2011. Europäische Schülerstudie zu Alkohol und anderen Drogen 2011. European School Survey Project on Alcohol and Other Drugs.

Eurostat, 2009. Comparative Price Levels for Food, Beverages and Tobacco.

FCHE, 2008. Die Drogenaffinität Jugendlicher in der Bundesrepublik Deutschland 2008. Federal Centre for Health Education.

FCHE, 2011. Die Drogenaffinität Jugendlicher in der Bundesrepublik Deutschland 2011. Federal Centre for Health Education.

FCHE, 2015. Die Drogenaffinität Jugendlicher in der Bundesrepublik Deutschland 2015. Federal Centre for Health Education.

GFHMS, 2017. Average Height and Weight of the Population. German Federal Health Monitoring System.

Hansen, B., Waddell, G.R., 2018. Legal Access to Alcohol and Criminality. *Journal of Health Economics*, 57, 277–289.

Harding, F.M., Hingson, R.W., Klitzner, M., Mosher, J.F., Brown, J., Vincent, R.M., Dahl, E., Cannon, C.L., 2016. Underage Drinking: A Review of Trends and Prevention Strategies. *American Journal of Preventive Medicine*, 51 (4), S148–S157.

Heckley, G., Gerdtham, U.G., Jarl, J., 2018. Too Young to Die: Regression Discontinuity of a Two-Part Minimum Legal Drinking Age Policy and the Causal Effect of Alcohol on Health. Lund University Working Paper.

Hibell, B., Guttormsson, U., Ahlström, S., Balakireva, O., Bjarnason, T., Kokkevi, A., Kraus, L., 2012. The 2011 ESPAD Report - Substance Use Among Students in 36 European Countries.

Hoffmann, J., Bronnmann, J., 2019. Bottle Size Matters: Heterogeneity in the German Carbonated Soft Drink Market. *Agribusiness*, 35 (4), 556–573.

Joksch, H.C., Jones, R.K., 1993. Changes in the Drinking Age and Crime. *Journal of Criminal Justice*, 21 (3), 209–221.

Kamalow, R., Siedler, T., 2019. The Effects of Stepwise Minimum Legal Drinking Age Legislation on Mortality: Evidence From Germany. IZA Discussion Paper, 12456.

Koppa, V., 2018. The Effect of Alcohol Access on Sexually Transmitted Diseases: Evidence From the Minimum Legal Drinking Age. *American Journal of Health Economics*, 4 (2), 164–184.

Kühne, M., Dombrowski, K., Funk, W., Schrauth, B., Roßnagel, T., 2019. Evaluation of the Pilot Project AM15: Part 1 - Traffic Probation Study.

Lindo, J.M., Siminski, P., Yerokhin, O., 2016. Breaking the Link Between Legal Access to Alcohol and Motor Vehicle Accidents: Evidence From New South Wales. *Health Economics*, 25 (7), 908–928.

Lindo, J.M., Swensen, I.D., Waddell, G.R., 2013. Alcohol and Student Performance: Estimating the Effect of Legal Access. *Journal of Health Economics*, 32 (1), 22–32.

Meng, Y., Brennan, A., Purshouse, R., Hill-McManus, D., Angus, C., Holmes, J., Meier, P.S., 2014. Estimation of Own and Cross Price Elasticities of Alcohol Demand in the UK–A Pseudo-Panel Approach Using the Living Costs and Food Survey 2001–2009. *Journal of Health Economics*, 34, 96–103.

Stockwell, T., Zhao, J., Chikritzhs, T., Greenfield, T.K., 2008. What Did You Drink Yesterday? Public Health Relevance of a Recent Recall Method Used in the 2004 Australian National Drug Strategy Household Survey. *Addiction*, 103 (6), 919–928.

Vonghia, L., Leggio, L., Ferrulli, A., Bertini, M., Gasbarrini, G., Addolorato, G., Group, A.T.S., et al., 2008. Acute Alcohol Intoxication. *European Journal of Internal Medicine*, 19 (8), 561–567.

Wen, H., Hockenberry, J.M., Cummings, J.R., 2015. The Effect of Medical Marijuana Laws on Adolescent and Adult Use of Marijuana, Alcohol, and Other Substances. *Journal of Health Economics*, 42, 64–80.

WHO, 2009. Evidence for the Effectiveness and Cost-Effectiveness of Interventions to Reduce Alcohol-Related Harm. World Health Organization.

WHO, 2010. Total Alcohol per Capita (15+) Consumption. WHO Global Information System on Alcohol and Health.

WHO, 2011. 15-Years Old Any Alcoholic Beverage in Past 12 Months by Country. WHO Global Information System on Alcohol and Health.

WHO, 2016a. Advertising Restrictions by Country. WHO Global Information System on Alcohol and Health.

WHO, 2016b. Age Limits - Alcohol Service/Sales by Country. WHO Global Information System on Alcohol and Health.

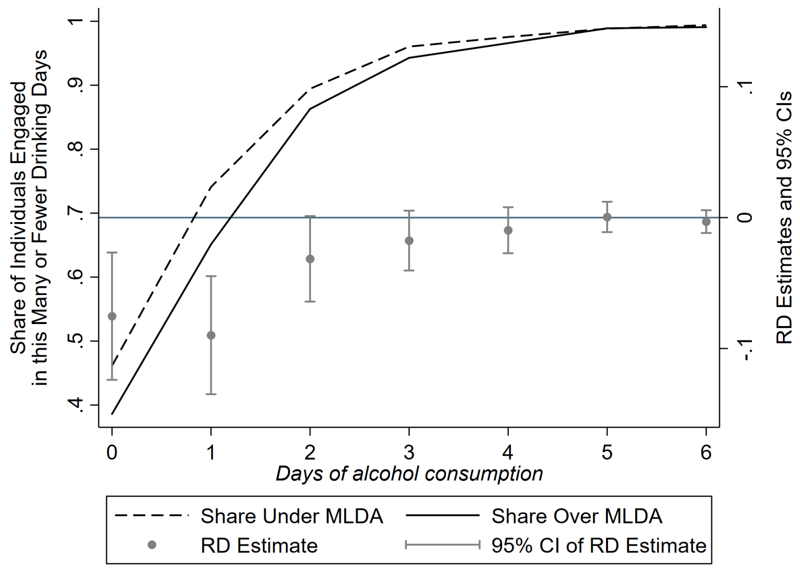
World Bank, 2011. International Comparison Program: Price Level Index. The World Bank Group.

Yörük, B.K., Yörük, C.E., 2013. The Impact of Minimum Legal Drinking Age Laws on Alcohol Consumption, Smoking, and Marijuana Use Revisited. *Journal of Health Economics*, 32 (2), 477–479.

Yörük, B.K., Yörük, C.E., 2015. Alcohol Consumption and Risky Sexual Behavior Among Young Adults: Evidence From Minimum Legal Drinking Age Laws. *Journal of Population Economics*, 28 (1), 133–157.

Appendix A. Appendix

Figure A.4: Drinking Frequency Distribution at Age 16
Days of Alcohol Consumption Within the Last 7 Days



Notes: The dashed (solid) line shows the share of individuals right below (above) the 16^{th} birthday who drunk this many or fewer days within the last 7 days. The gray dots represent the estimated difference between dashed and solid line and the vertical bars the respective 95 percent confidence intervals. Each point estimate, i.e. gray dot, and confidence interval are obtained from a regression on the full sample (N=15,725) using a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month.

Table A.7: Change in Violent and Property Crimes Under the Influence (UI) at Age 16

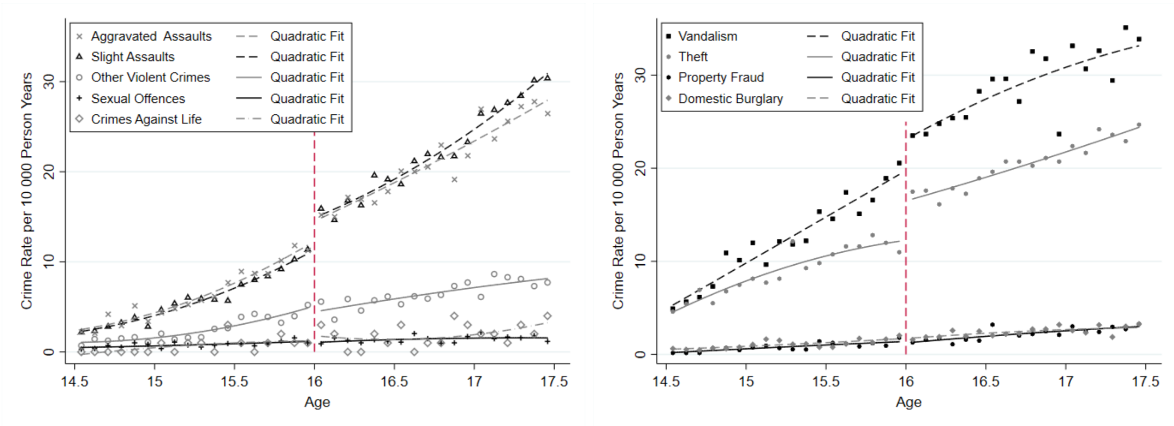
	(1)	(2)	(3)	(4)	(5)
Panel A: Violent Crimes UI	Crimes Against Life	Sexual Offenses	Aggravated Assaults	Slight Assaults	Other Violent Crimes
Increase at 16	0.046	-0.180	2.403**	3.255***	-0.598
	(0.095)	(0.288)	(1.000)	(0.997)	(0.586)
Mean under 16	0.092	1.173	12.010	11.131	4.982
Panel B: Property Crimes UI	Theft	Domestic Burglary	Property Fraud	Vandalism	
Increase at 16	3.911***	0.057	-0.102	3.220**	
	(1.131)	(0.367)	(0.327)	(1.368)	
Mean under 16	12.069	1.641	1.376	19.452	

Notes: See notes from Table 4. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure A.5: Age Profiles of Violent and Property Crimes Under the Influence of Alcohol (UI) Around Age 16

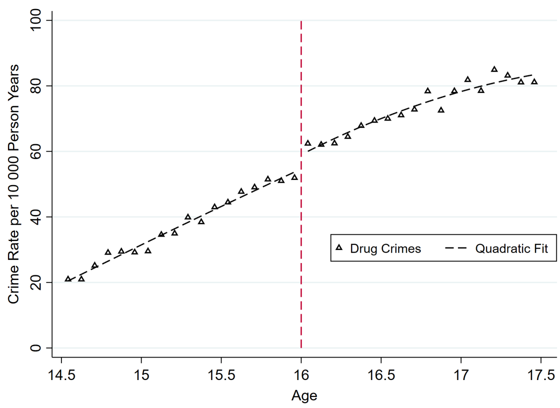
(a) Violent Crimes UI

(b) Property Crimes UI



Notes: Figures (a) to (b) show for property and violent crimes UI at each age cell the respective crime rate per 10,000 person years. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. For further details on the sample, see notes from Table 2.

Figure A.6: Age Profile of Drug Crimes Without Mention of Alcohol Around Age 16



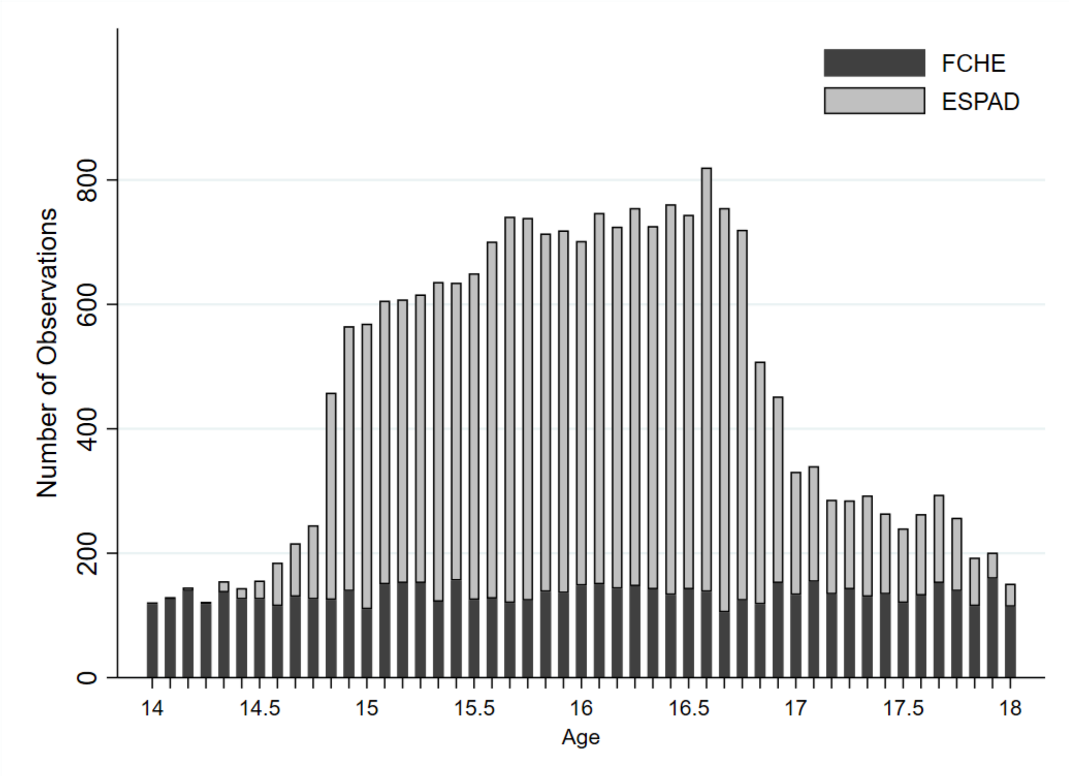
Notes: This Figure shows for drug crimes without mention of alcohol at each age cell the respective crime rate per 10,000 person years. Second order polynomials indicate on each side of the age 16 cutoff the respective age profiles. For further details on the sample, see notes from Table 2.

Online Appendix (not intended for publication)

Appendix B. Data

Appendix B.1. Consumption Data

Figure B.7: Consumption Data – Age Distribution



Source: ESPAD & FCHE.
Notes: This figure presents for the consumption data the distribution of the running variable, i.e. the individual's age in months.

Appendix B.1.1. Age Calculation

ESPAD and FCHE data include for each individual the year and month of birth which I use to calculate someones age in month. Since ESPAD interviews were conducted within two weeks of a single month, I can draw on the precise information of survey year and month for the age calculation. The collection of FCHE interviews (wave 2005 to 2011) took place within one or up to one and a half months. Since this results in an overlap of months, I use the intermediate month of each survey period for the age calculation. Drawing on the question of completed years, I can further adjust miscalculations of the monthly age at the cutoff within the FCHE sample. For the 2015 wave, FECH provides the actual month of each interview.

Appendix B.1.2. BAC calculation

The blood alcohol content (BAC) specifies the amount of alcohol present in the bloodstream. A BAC of 1‰ indicates that an individual's bloodstream contains one part of alcohol for every 1000 parts of blood. In this study, I draw on a simplified version of the Widmark formula which is commonly used to convert the amount of consumed alcohol to the respective BAC level:

$$BAC_{Widmark} \text{ in ‰} = \frac{\text{g of pure alcohol consumed}}{r\,W}$$

with r being the gender-specific Widmark factor which amounts 0.55 for females and 0.68 for males and W being the body weight in kg. Since the consumption surveys do not collect physical characteristics of the respondents, I use data of the German Federal Health Monitoring System (GFHMS, 2017) on teenagers aged 15 to 17 to include an average body weight of $58.1\,kg$ for females and $68\,kg$ for males.

To strengthen the robustness of this conversion, I also apply the Watson formula which accounts for the total body water (Q) of females and males using their age in years (G), weight (W) in kg, and height (H) in cm . The Watson formula reads:

$$BAC_{Watson} \text{ in ‰} = \frac{(\text{g of pure alcohol consumed})\;\; 0.8}{Q_{gender}}$$

with 0.8 being the average weight/volume ratio of water in blood and Q_{gender} defined as:
$Q_{female} = 0.2466\,W + 10.69\,H - 2.097$, and
$Q_{male} \quad = 0.3362\,W + 10.74\,H - 0.09516\,G + 2.447$.
As previously outlined, I use the gender-specific body weight of an average teenager aged 15 to 17 and a respective body height of $166.5\,cm$ for females and $177\,cm$ for males (GFHMS, 2017).

Appendix B.2. Crime Data

Table B.8: Coding of Offenses

Crime Category	Key Components	Offense Codes
All Crimes	all crimes w/o Asylum Act offenses#	0** - 74*, excl. 725
Violent Crimes		
Crimes Against Life	murder and manslaughter	0**
Sexual Offenses	crimes against sexual self-determination	1**
Aggravated Assaults	dangerous and serious bodily injury	221 - 223
Slight Assaults	simple bodily injury	224 - 225
Other Violent Crimes	rape and non-physical violence (e.g. threat, kidnapping, or stalking)	21*, 23*
Property Crimes		
Theft	all thefts excluding domestic burglary	3**- 4**, excl. domestic burglary
Domestic Burglary	burglaries in dwellings and attached buildings (basement etc.) and respective thefts	335, 340, 345, 435, 436, 440, 445
Property Fraud	fraud, breache of trust, misappropriation	51*-53*
Vandalism	property and environmental destruction, arson, breach of the peace	620, 623, 623, 640, 674, 675, 676
Drug Crimes	violations against the narcotics law	73*
Other Crimes		all remaining codes

Notes: This table outlines for each crime category the key components and the underlying offense codes. Following previous studies on the impact of alcohol on crime (CM; HW, 2015; 2018), I group the data into comparable categories using the first three digits of the offense codes set out by the German Federal Police Office (BKA, 2019).

#Asylum Act offenses consist of unauthorized entry or illegal residence, which are clearly unrelated to the MLDA. Compared to other types of incidents in the crime statistics, these violations cannot be committed by natives or officially registered foreigners. The sometimes incomplete paperwork of newly arriving asylum seekers gives further scope for potential bunching at the birthday cutoffs to benefit from a lower age. For the sake of comparability and a potentially confounding impact, I thus exclude this category from the analysis.

Appendix B.2.1. Calculation of the Crime Rate

In a first step, I sum up the total number of offenders at each day of age over the entire sample period. In a second step, I divide each of these counts by the total number of years used in the analysis (11 years) and the total number of 16-year-old teenagers living in the federal states of Baden-Wuerttemberg and Schleswig-Holstein as of December 31, 2011 (Destatis, 2019). Finally, I multiply every adjusted count by $365 * 10{,}000$ to obtain for each day-of-age cell the crime rate per 10,000 person-years.

Appendix C. Background Information on Baden-Wuerttemberg and Schleswig-Holstein

Around 13.7 million people live in the two West-German states of Baden-Wuerttemberg and Schleswig-Holstein, which corresponds to 17% of the overall population in Germany (Destatis, 2019). Since both states cover approximately 14.5% of the German territory, their population density is slightly above the national average. The overall demographic structure in both states is similar to the national average. The share of teenagers aged 14 to 18, for instance, amounts 4.2% in Baden-Wuerttemberg and Schleswig-Holstein and 3.9% at the national level.

Following aggregate statistics of the Federal Criminal Police Office (BKA), 528 out of 10,000 teenagers aged 14 to 18 committed a crime in Germany during the year 2015.[31] For the states of Baden-Wuerttemberg and Schleswig-Holstein, BKA statistics document an overall crime rate of 503 for the same age group in 2015. The crime rate under the influence of alcohol among 14- to 18-year-old teenagers amounts 45.7 all over Germany in 2015, and 50.1 within the states of Baden-Wuerttemberg and Schleswig-Holstein. Overall there are thus no structural differences in teenage criminal engagement within the two states under consideration.

Following previous US MLDA studies on the impact of crime, the underlying population of the present study is of comparable size. HW (2018) draw their analysis on the state of Oregon where 3.8 million people live. The study by CM (2015) investigates the criminal engagement in California where more than 39.5 million people live. With an underlying population of 13.7 million, the present analysis thus ranges between HW (2018) and CM (2015).

[31] In line with the present study, the overall crime rate does not include migrant specific violations such as offenses against the asylum act. Also note that annual BKA-statistics include each offender just once irrespective of repeat offenses. This restricts a comparison with Table 2, which also includes repeat offenders.

Appendix D. Robustness and Falsification Checks

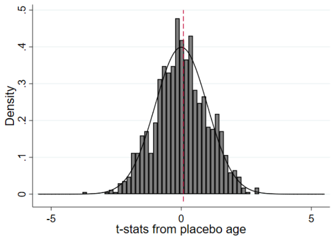
Appendix D.1. Permutation Tests

As a first permutation test, I randomly substitute the running variable. In the consumption data, I shuffle around the individual age of each survey participant. In the crime data, I randomly interchange the day-of-age information of each aggregated crime rate. Using the placebo age, I restimate the preferred specifications of the consumption and the crime analysis. For every outcome, I repeat this check 1 000 times to obtain a distribution of placebo t-statistics. Following the idea of randomization inference, I can compare this distribution with the t-statistic from the baseline regression that draws on the the true age. Ideally, the placebo distribution follows an asymptotic Student's t probability density function with the t-statistic of the baseline specification located in the tail (in the center) in case of a significant (insignificant) treatment effect. As outlined in Figures D.8 and D.9, the results prove robust to this check.

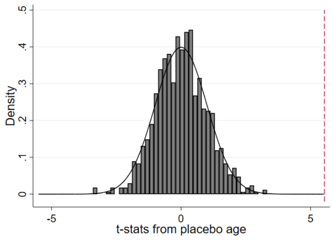
In a second and related falsification test, I stress the robustness of the crime analysis using a randomly defined age cutoff. I draw the placebo cutoffs separately from the left and from the right side of the true threshold at age 16 and conduct 1,000 replications on each side. Each placebo estimation includes only observations from that same side in order to avoid potential misspecification due to assuming continuity at the true threshold. As a further condition, each placebo regression requires at least 30 observations, i.e. one month on each side of the newly specified placebo cutoff. Once again, I plot the distribution of placebo t-statistics and the actual t-statistic for each specification as outlined in Table D.10. Overall, this falsification check confirms the robustness of the crime analysis. Note that I cannot conduct this specification test with the consumption data. Since the age information is only available on a monthly basis, there are just 16 other potential cutoffs on each side of the true age threshold if I consider the preferred specification of the consumption analysis. For a simulation, this limited number of placebo cutoffs is insufficient to trace out a distribution of t-statistics.

Figure D.8: Placebo Age – Consumption Behavior

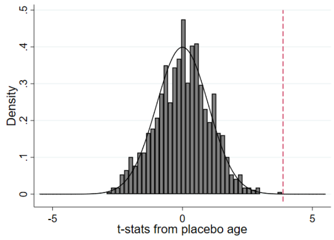
Panel A: Drinking Participation



(a) Lifetime Consumption

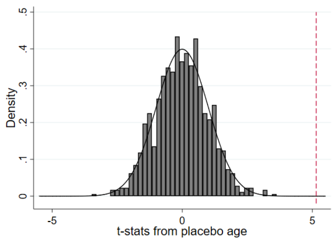


(b) Consumption Within Last 30 days

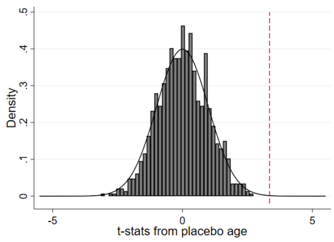


(c) Consumption Within Last 7 days

Panel B: Drinking Frequency

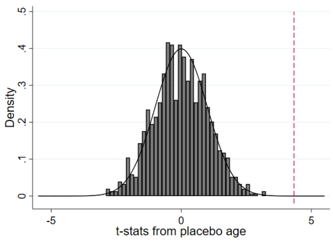


(d) Number of Drinking Occasions Within Last 30 Days

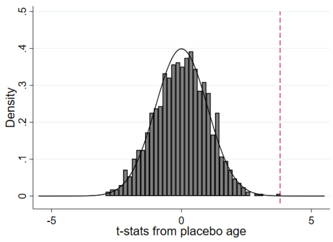


(e) Number of Drinking Days Within Last 7 Days

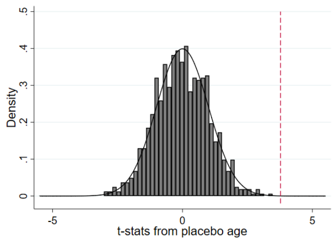
Panel C: Drinking Intensity



(f) Overall Amount on Last Occasion Within Last 7 Days



(g) Undistilled Alcohol on Last Occasion Within Last 7 Days

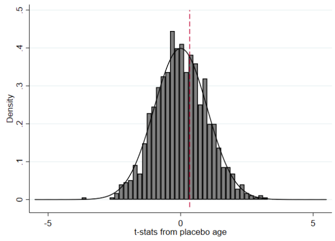


(h) Distilled Alcohol on Last Occasion Within Last 7 Days

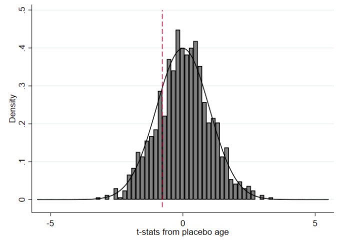
Notes: Each figure shows the empirical distribution of t-statistics for the regression discontinuity (RD) estimates at age 16 that are obtained from a Monte Carlo Simulation based on 1,000 replications. Using the indicated outcome variable and the baseline RD specification, each replication randomly substitutes the age of an individual with the age of another individual in the sample. Each regression includes a quadratic polynomial in placebo age fully interacted with an indicator variable for placebo age over 16 and a full set of covariates. The vertical red dashed line of a figure represents the t-statistics from the baseline regression using the true age.

Figure D.9: Placebo Age – Criminal Engagement

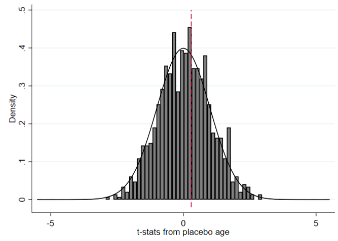
Panel A: Criminal Engagement Without the Influence (w/oI) of Alcohol



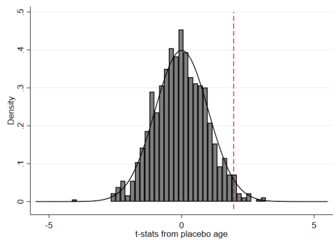
(a) All Crimes w/oI



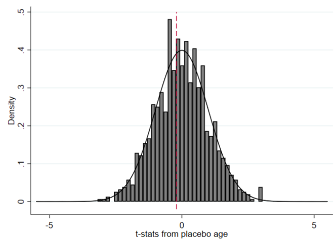
(b) Violent Crimes w/oI



(c) Property Crimes w/oI

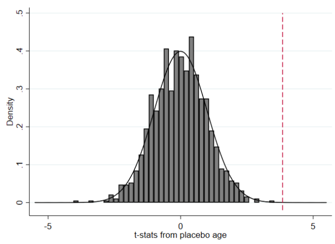


(d) Drug Crimes w/o

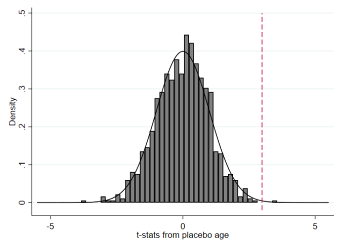


(e) Other Crimes w/oI

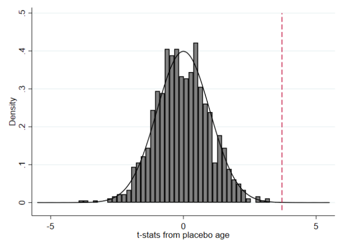
Panel B: Criminal Engagement Under the Influence (UI) of Alcohol



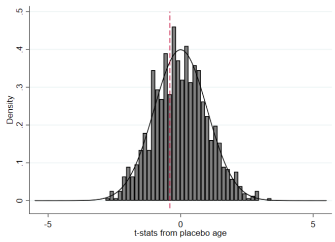
(f) All Crimes UI



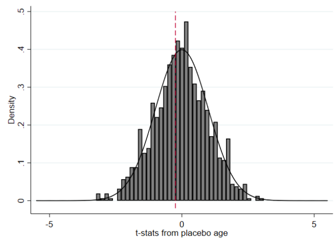
(g) Violent Crimes UI



(h) Property Crimes UI



(i) Drug Crimes UI

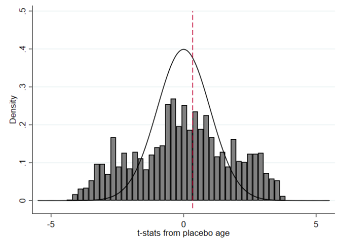


(j) Other Crimes UI

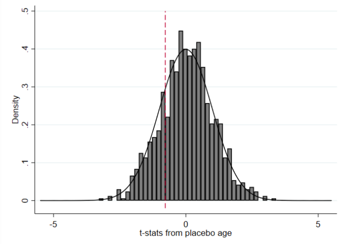
Notes: Each figure shows the empirical distribution of t-statistics for the regression discontinuity (RD) estimates at age 16 that are obtained from a Monte Carlo Simulation based on 1,000 replications. Using the indicated outcome variable and the baseline RD specification, every replication randomly interchanges the day-of-age information of the aggregated crime rates. Each regression includes a quadratic polynomial in placebo age fully interacted with an indicator variable for placebo age over 16 and a set of birthday dummies. The vertical red dashed line of a figure represents the t-statistics from the baseline regression using the true day-of-age information.

Figure D.10: Placebo Cutoff – Criminal Engagement

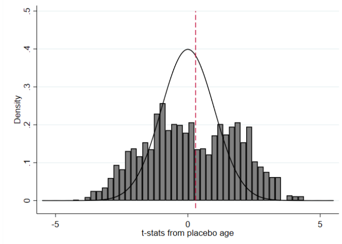
Panel A: Criminal Engagement Without the Influence (w/oI) of Alcohol



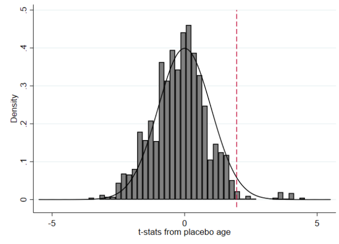
(a) All Crimes w/oI



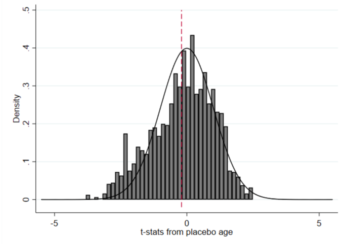
(b) Violent Crimes w/oI



(c) Property Crimes w/oI

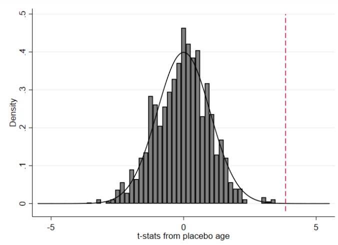


(d) Drug Crimes w/o

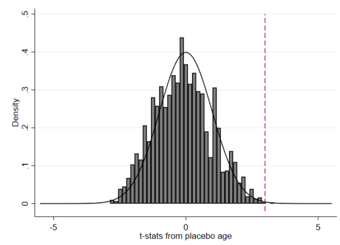


(e) Other Crimes w/oI

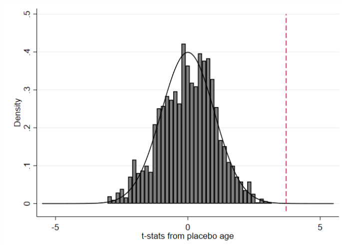
Panel B: Criminal Engagement Under the Influence (UI) of Alcohol



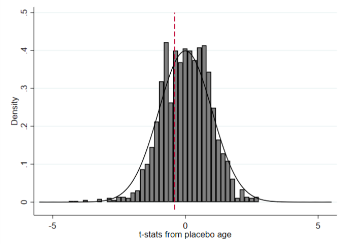
(f) All Crimes UI



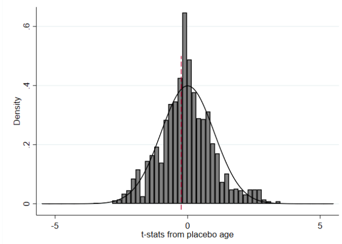
(g) Violent Crimes UI



(h) Property Crimes UI



(i) Drug Crimes UI



(j) Other Crimes UI

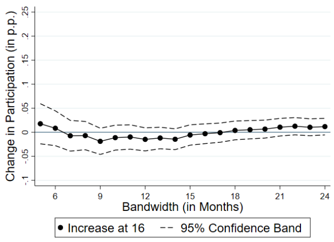
Notes: Each figure shows the empirical distribution of t-statistics that are obtained from regression discontinuity (RD) estimates based on placebo cutoffs. The placebo cutoffs are drawn separately from the left and from the right side of the true threshold, i.e. age 16 (1000 reps on each side). Each placebo estimation includes only observations from that same side in order to avoid potential mis-specification due to assuming continuity at the true threshold. As a further condition, each placebo regression requires at least 30 observations, i.e. one month on each side of the newly specified placebo cutoff.

Appendix D.2. RD Specific Robustness Checks

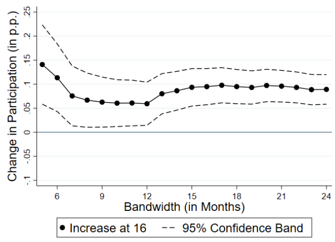
Figure D.11: Robustness to Bandwidth Choice – Consumption Behavior

Panel A: Change in Drinking Participation at Age 16

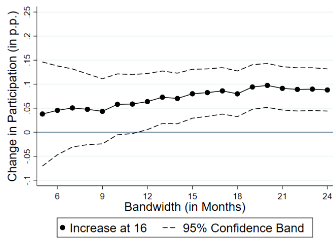
(a) Lifetime Consumption



(b) Consumption Within Last 30 days

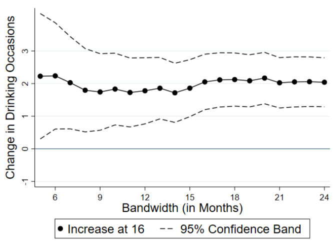


(c) Consumption Within Last 7 days

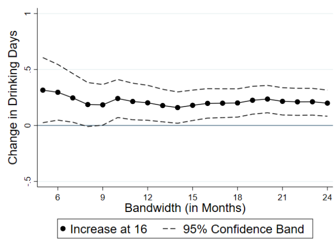


Panel B: Change in Drinking Frequency at Age 16

(d) Number of Drinking Occasions Within Last 30 Days

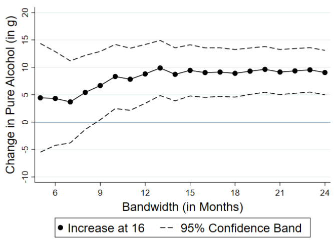


(e) Number of Drinking Days Within Last 7 Days

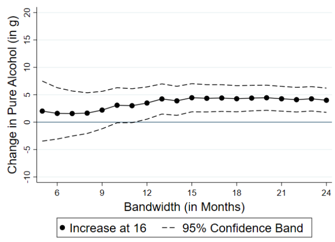


Panel C: Change in Drinking Intensity at Age 16

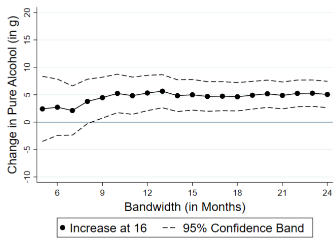
(f) Overall Amount on Last Occasion Within Last 7 Days



(g) Undistilled Alcohol on Last Occasion Within Last 7 Days



(h) Distilled Alcohol on Last Occasion Within Last 7 Days

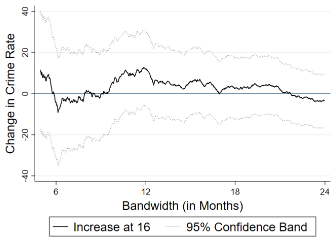


Notes: Figures a-h show for different bandwidth choices the estimates of a discrete change in the consumption behavior at age 16 and the respective 95% confidence bands. Each regression includes a quadratic polynomial in age fully interacted with an indicator variable for age over 16 and a full set of covariates.

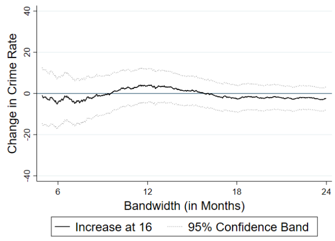
Figure D.12: Robustness to Bandwidth Choice – Criminal Engagement

Panel A: Criminal Engagement Without the Influence (w/oI) of Alcohol

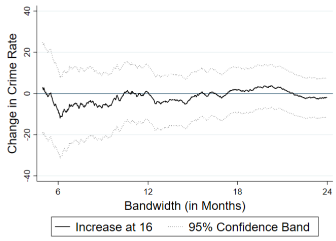
(a) All Crimes w/oI



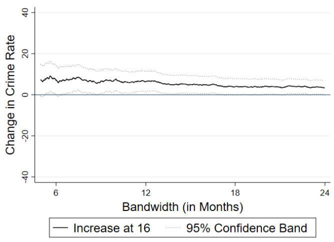
(b) Violent Crimes w/oI



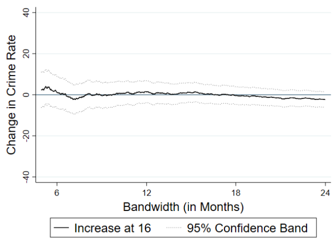
(c) Property Crimes w/oI



(d) Drug Crimes w/oI

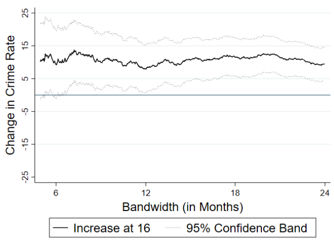


(e) Other Crimes w/oI

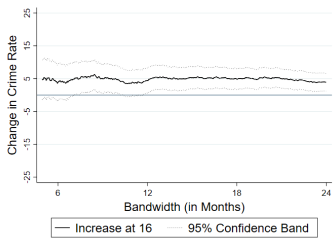


Panel B: Criminal Engagement Under the Influence (UI) of Alcohol

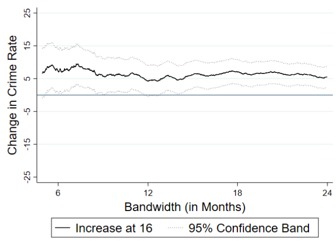
(f) All Crimes UI



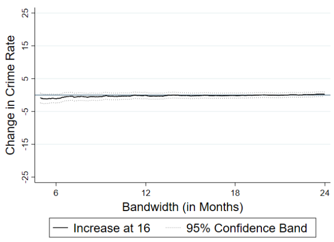
(g) Violent Crimes UI



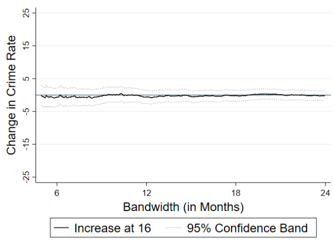
(h) Property Crimes UI



(i) Drug Crimes UI



(j) Other Crimes UI



Notes: Figures a-j show for different bandwidth choices the estimates of a discrete change in criminal engagement at age 16 and the respective 95% confidence bands. Each regression includes a quadratic polynomial in age fully interacted with an indicator variable for being older than 16 and dummy variables indicating whether the crime was conducted at the birthday or at a subsequent day.

Table D.9: Robustness to Functional Form Adjustments – Change in Consumption Behavior at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Drinking Participation	Lifetime Consumption		Consumption Within Last 30 days		Consumption Within Last 7 days	
Increase at 16	-0.021	-0.002	0.058**	0.095***	0.045	0.089***
	(0.015)	(0.011)	(0.028)	(0.022)	(0.037)	(0.027)
Mean just under 16	0.952		0.715		0.456	
Panel B: Drinking Frequency	Number of Drinking Occasions Within Last 30 Days		Number of Drinking Days Within Last 7 Days			
Increase at 16	1.367**	1.594***	0.189*	0.256***		
	(0.637)	(0.467)	(0.098)	(0.074)		
Mean just under 16	5.870		0.970			
Panel C: Drinking Intensity (in g of Pure Alcohol)	Overall Amount on Last Occasion Within Last 7 Days		Undistilled Alcohol on Last Occasion Within Last 7 Days		Distilled Alcohol on Last Occasion Within Last 7 Days	
Increase at 16	7.678**	8.718***	2.604	4.519***	5.074**	4.079**
	(3.377)	(2.891)	(1.852)	(1.499)	(2.026)	(1.679)
Mean just under 16	25.758		15.008		10.751	
Specification	cubic	LLR	cubic	LLR	cubic	LLR

Notes: See notes from Table 1 for a description of the sample and the respective data sources. Using a bandwidth of one and a half years, odd columns include a third order polynomial in age fully interacted with a treatment dummy for being older than 16 and a full set of controls. Even columns show the results of a local linear regression using a MSE-optimal bandwidth selector and a triangular kernel. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D.10: Robustness to Functional Form Adjustments – Change in Criminal Engagement at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Criminal Engagement w/oI	All Crimes		Violent Crimes		Property Crimes		Drug Crimes		Other Crimes	
Increase at 16	6.744	-1.505	4.088	-1.028	-5.990	-6.786	7.019**	7.173***	1.627	0.197
	(10.027)	(10.372)	(4.590)	(3.520)	(7.403)	(7.689)	(2.721)	(2.620)	(2.982)	(2.612)
Mean under 16	625.063		144.463		367.593		52.395		60.611	
Panel B: Criminal Engagement UI	All Crimes		Violent Crimes		Property Crimes		Drug Crimes		Other Crimes	
Increase at 16	9.224**	12.375***	5.175**	5.555***	4.775*	7.244***	-0.326	-0.039	-0.399	0.255
	(4.022)	(3.319)	(2.115)	(1.651)	(2.615)	(2.233)	(0.520)	(0.467)	(1.127)	(0.835)
Mean under 16	76.156		29.893		35.487		1.936		8.840	
Specification	cubic	LLR	cubic	LLR	cubic	LLR	cubic	LLR	cubic	LLR

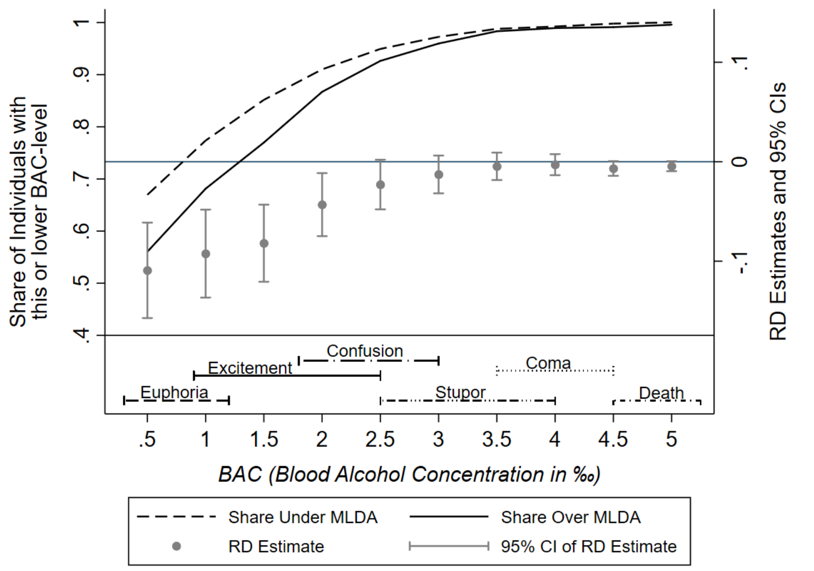
Notes: See notes from Table 2 for a description of the sample and the respective data sources. Each observation is the crime rate per 10,000 person-years at a specific day-of-age cell. Using a bandwidth of one and a half years, odd columns include a third order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday and the day immediately after. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Even columns show the results of a local linear regression using a MSE-optimal bandwidth selector and a triangular kernel. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D.11: Change in Sample Characteristics at Age 16

	Preparatory High School	Comprehensive School	Technical / Vocational School	Apprenticeship, Job, Other	Male	College Degree Parent	Number of Survey Participants
Panel A: Overall Sample							
Increase at 16	0.023	-0.002	-0.021	-0.001	0.001	0.018	70.910
	(0.037)	(0.024)	(0.017)	(0.007)	(0.019)	(0.015)	(50.317)
Mean just under 16	0.393	0.437	0.150	0.020	0.486	0.282	713
Panel B: ESPAD Sample							
Increase at 16	-0.015	0.036	-0.022		-0.004	-0.024	47.250
	(0.046)	(0.030)	(0.021)		(0.021)	(0.024)	(52.660)
Mean just under 16	0.410	0.431	0.159		0.479	0.280	585

Notes: Individual characteristics are included in the consumption data which stem from the Federal Centre for Health Education (FCHE) and the European School Survey Project on Alcohol and Other Drugs (ESPAD) covering the years 2005 to 2015. Age is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. For the number number of survey participants, the dependent variable is the number of individuals interviewed at a monthly age cell. All regressions use a bandwidth of one and a half years and include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. Since ESPAD interviews students only, there is no information on those who do not stay in school. However, this is a minority in Germany at this age. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure D.13: Robustness to Alternative BAC Conversion
Drinking-Intensity Distribution: BAC level at Last Drinking Occasion within Last 7 Days



Notes: The dashed (solid) line shows the share of individuals right below (above) the 16^{th} birthday who reached a certain BAC level or stayed below it during the last drinking occasion within the last 7 days. The gray dots represent the estimated BAC difference between dashed and solid line and the vertical bars the respective 95 percent confidence intervals. Each point estimate, i.e. gray dot, and confidence interval are obtained from a regression on the full sample (N=15,725) using a second order polynomial in age fully interacted with a treatment dummy for being older than 16, and dummy variables indicating the birthday if the interview was conducted within the same month. The BAC conversion draws on the Widmark formula (see Appendix B.1.2).

Table D.12: Supplementary Consumption Analysis - Changes at Age 16

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Purchase of Alcohol Within Last 30 days		Prevalence of Alcohol Consumption Within Last 30 Days by Regional Type			Joint Consumption (in g) of Undistilled and Distilled Alcohol on Last Occasion Within Last 7 Days	Prevalence of Marijuana Use Within Last 30 Days
	Off-Premise	On-Premise	Rural & Urban	Rural	Urban		
Increase at 16	0.152^{***}	0.081^{***}	0.114^{*}	0.084	0.122	7.822^{***}	0.023^{**}
	(0.024)	(0.024)	(0.058)	(0.079)	(0.086)	(2.315)	(0.010)
Mean just under 16	0.405	0.537	0.569	0.497	0.683	19.864	0.048
Observations	15,725	15,725	2,826	1,626	1,200	15,725	20,789
Full Set of Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source	ESPAD	ESPAD	FCHE	FCHE	FCHE	ESPAD	ESPAD & FCHE

Notes: All regressions include a second order polynomial in age fully interacted with a treatment dummy for being older than 16, dummy variables indicating the birthday if the interview was conducted within the same month and a full set of control variables. The age variable is centered on 16 such that the treatment coefficient interprets as the discontinuous increase at this age. Columns 1, 2, 6, and 7 use a bandwidth of one and a half years around age 16. The regional information is only included in the FCHE waves 2008, 2011, and 2015. To increase the sample size, column 3-5 thus draw on a bandwidth of two years. Robust standard errors of the estimates are reported underneath in parentheses: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.