In School and Out of Trouble? The Minimum Dropout Age and Juvenile Crime*

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Abstract

Does increasing the minimum dropout age reduce juvenile crime rates? Despite popular accounts that link school attendance to keeping youth out of trouble, little systematic research has analyzed the contemporaneous relationship between schooling and juvenile crime. This paper examines the connection between the minimum age at which youth can legally drop out of high school and juvenile arrest rates by exploiting state-level variation in the minimum dropout age. Using county-level arrest data for the United States between 1980 and 2008, a difference-in-difference-in-difference-type empirical strategy compares the arrest behavior over time of various age groups within counties that differ by their state's minimum dropout age. The evidence suggests that minimum dropout age requirements have a significant and negative effect on property and violent crime arrest rates for individuals aged 16 to 18 years-old, and these estimates are robust to a range of specification checks. While other mechanisms cannot necessarily be ruled out, the results are consistent with an incapacitation effect; school attendance decreases the time available for criminal activity.

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"Dropout prevention is crime prevention."
Lee Baca, Los Angeles County Sheriff

I. Introduction

Does increasing the minimum age at which youth are legally permitted to leave school keep them off the streets and away from crime? Previous research illustrates a correlation between youth dropouts and juvenile criminal behavior (see, e.g., Thornberry et al. 1985; Fagan and Pabon 1990). In the state of California alone, dropouts are estimated to be responsible for 1.1 billion dollars in annual juvenile crime costs.[1] Because of crime's deleterious consequences, it is important to understand whether or not being in school has a causal influence on juvenile offending; evidence suggests that involvement in juvenile crime adversely impacts economic outcomes later in life. Incarceration during adolescence is associated with lower educational attainment and decreased future earnings (Waldfogel 1994a; Waldfogel 1994b; Hjalmarsson 2008). Furthermore, juvenile crime not only has an immediate impact on the delinquent and their victim(s), but can impose negative externalities on those not directly involved with criminal acts (see, e.g., Grogger 1997).

Previous studies have focused on a wide array of determinants of juvenile crime. In general, much of the literature has concentrated on deterrence and punishment as crime-reducing mechanisms.[2] Research has also documented the impact of wages (Grogger 1998), high school experience (Arum and Beattie 1999), youth employment (Apel et al. 2008), underage drinking (French and Maclean 2006), and curfew ordinances (Kline 2009) to name a few.

[1] This number reflects an estimate that includes criminal justice expenditures, incarceration costs, school disruption costs and victim costs (Belfield and Levin 2009).
[2] See, for example, Becker (1968), Freeman (1996), Levitt (1998), and Corman and Mocan (2000).

This paper joins the sparse, yet growing, literature on the effects of education on crime by investigating the relationship between the minimum dropout age (MDA) and juvenile arrest rates.[3] In general, the literature can be divided into two categories: the longer-run relationship between education and crime and the contemporaneous relationship between education and crime. Research on the longer-run has focused on the impact of educational attainment on subsequent criminal behavior. More specifically, these studies are interested in whether the accumulation of education as a youth has an impact on adult criminality. Empirical research in this area is not decisive. Tauchen et al. (1994) and Witte and Tauchen (1994) find that having a parochial school education is associated with lower criminal behavior, but a high school degree has no effect. Grogger's (1998) results indicate that wages have a negative effect on crime, but having additional years of education or a high school diploma do not influence criminal activity. However, Grogger's (1998) findings do not rule out education having an indirect impact on crime through the labor market. On the other hand, Lochner (2004), Lochner and Moretti (2004), and Buonanno and Leonida (2009) illustrate that education is negatively related to adult crime. In a similar vein, Deming's (2011) results suggest that school quality predicts subsequent criminal behavior.

To date, considerably fewer studies have investigated the contemporaneous relationship between schooling and crime. This paper fits within this area of research. Gottfredson (1985), Farrington et al. (1986), and Witte and Tauchen (1994) find that time spent at school is associated with lower levels of criminal behavior. These studies do not control, however, for the potential endogeneity of schooling. Jacob and Lefgren (2003) and Luallen (2006) estimate the impact of school attendance on crime by exploiting variation in teacher in-service days and

[3] For a more comprehensive review of the literature, see the excellent discussion by Lochner (2010).

teacher strike days, respectively. Both papers show that property crimes committed by juveniles decrease when school is in session, but violent juvenile crime rates increase on these days. The authors suggest that incapacitation effects likely explain the property crime results, while concentration effects may underlie the violent crime findings. An incapacitation effect of school is that it keeps juveniles occupied, leaving less time and opportunity to commit crimes. In contrast, keeping children in school increases the number of potential interactions that facilitate delinquency, especially physical altercations.

This paper exploits the spatial and temporal variation in minimum dropout age laws to find strong evidence that increases in the minimum dropout age reduce rates of property and violent crime among high school-aged individuals. Estimates for drug-related crimes are large in magnitude and negative in sign, but are generally not statistically significant. Though this paper presents robust evidence on the effect of MDA laws on property and violent crime arrest rates, it is not possible to precisely pin down the channels through which education impacts crime. Nevertheless, by studying effects across age groups and types of crimes, it is possible to provide suggestive evidence on the mechanisms that are relatively important. Specifically, the results are consistent with an incapacitation effect; however, it should be noted that other mechanisms cannot necessarily be ruled out (e.g. human capital effects). These findings suggest that policies designed to keep kids in school may be successful at decreasing delinquent behavior.

This paper makes at least four important contributions to the literature. First, previous research has not systematically analyzed the effects of minimum dropout age laws on juvenile crime. Second, Jacob and Lefgren (2003) and Luallen (2006) are only able to test for the existence of extremely short-run effects of school attendance. An increase in the minimum dropout age can result in students staying in school for up to two additional years. In-service and strike days consist of much shorter lengths of time. Consequently, the school attendance and crime dynamic is likely to differ considerably between these policies.

Third, by explicitly examining changes in MDA laws, this paper's focus is on the marginal juvenile who is legally obligated to stay in school longer. While Jacob and Lefgren (2003) and Luallen (2006) analyze mechanisms that release entire student bodies from school, this paper concentrates on a policy that affects a small portion of the high school-aged population. Arguably, students on the margin of dropping out are of the utmost importance from a policy and social perspective because they represent a group of high risk offenders.

Lastly, after establishing a strong and negative relationship between the MDA and juvenile crime, this paper discusses the potential for delinquency and other risky behaviors to be displaced from the streets to schools when the MDA is higher. Using the national Youth Risk Behavior Survey data, a brief analysis highlights that this is a potentially important issue that policy-makers should consider when deciding whether or not to increase their state's minimum dropout age.

II. Background and relevant literature

In 1852, Massachusetts was the first state to enact a compulsory schooling law. By 1918, all states had some form of a compulsory schooling law in place (Lleras-Muney 2002). In general, these laws specify a minimum and maximum age for which attendance is required. Historically, compulsory schooling laws have changed frequently. Table 1 illustrates there has been a strong movement towards increasing the minimum dropout age in recent years.[4]

[4] For example, Illinois and Indiana have recently increased their MDA from 16 to 17 and 16 to 18, respectively. Other states, however, have maintained a constant MDA over the past 50 years. Iowa, Michigan, and Montana have

[Table 1 about here.]

Not surprisingly, the legislation is more complex than simply specifying a minimum dropout age. Some states allow exemptions if the child is working or has obtained parental consent. States also vary by their punishment of truancy; it is not unusual for a state to punish the parents of a truant child.[5]

Previous work has generally focused on compulsory schooling laws to estimate the returns to education.[6] Mentioned above, Lochner and Moretti (2004) estimate the effect of educational attainment on adult criminal activity using variation in state compulsory schooling laws to instrument endogenous schooling decisions.[7] Other applications of compulsory schooling include mortality and teenage childbearing (Lleras-Muney 2005; Black et al. 2008).

This study is concerned with the reduced form relationship between the minimum dropout age and juvenile crime. Implicit to this relationship is that these laws are effective at impacting attendance rates. Perhaps the most seminal work on this relationship is by Angrist and Krueger (1991); they find that approximately 25 percent of potential dropouts in the United States remain in school because of compulsory schooling laws. Results from other research on the effectiveness of compulsory schooling are consistent with the conclusions drawn from

had a dropout age of 16 during this period, while Ohio, Oklahoma, and Utah have maintained a dropout age of 18. In addition, several states have raised and lowered their MDA during this time.

[5] Oreopoulos (2009) offers a more complete discussion of the legislation. In particular, Table 1 in Oreopoulos (2009) lists examples of exemptions and punishments for states with a minimum dropout age greater than 16.

[6] See, for example, Acemoglu and Angrist (2001) and Oreopoulos (2006a, 2006b).

[7] It is important to note that Lochner and Moretti (2004) focus on the number of years of mandatory schooling as opposed to the minimum dropout age. Though positively correlated, a higher minimum dropout age does not necessarily mean more years of compulsory schooling because states also differ in their mandatory starting age. For example, Oregon and Maryland both require 12 years of compulsory schooling; yet, the minimum dropout ages for Oregon and Maryland are 18 and 16, respectively. Because this paper's attention is on the contemporaneous relationship between being in school and crime, the minimum dropout age is the variable of interest.

Angrist and Krueger (1991).[8] Despite the existing evidence, this paper presents results on the relationship between the minimum dropout age and dropout status. These results, based on U.S. Census data, are discussed in the Appendix and are presented in Table A1. In short, the results confirm that increases in the MDA significantly decrease the likelihood of dropping out.

As pointed out by Angrist and Krueger (1991), the efficacy of compulsory schooling legislation is likely due to two enforcement mechanisms. In a majority of states, children are not permitted to work during school hours unless they are of an age at or above their state's compulsory schooling requirement. Additionally, young workers are required to obtain work permits that are often granted by school administrators. This, to an extent, allows schools to monitor the behavior of youth who are below the minimum dropout age. It is possible that dropouts who seek employment are less likely to commit crimes than those who leave school and have no interest in working. For the latter individuals, direct enforcement and policing may be more effective means of mandating attendance. More specifically, state legislation provides truancy officers to enforce the law; officers are given the authority to arrest truant youth without a warrant. Truancy regulations are also enforced by school officials and often implemented under the context of parental responsibility.

III. Data for county-level panel regressions

Dependent variables

[8] Li (2006) uses data from the High School and Beyond Survey to show that increasing the dropout age to 18 increases the probability of completing high school. Moreover, he shows the effects are much more pronounced for disadvantaged students. Wenger (2002) illustrates that increasing a state's dropout age is consistently predicted to decrease the probability that an individual will drop out of high school. More specifically, she finds the change in probability is equivalent to a decrease in the dropout rate of roughly 16 percent. The results in Oreopoulos (2009) also suggest that more restrictive compulsory schooling laws reduce dropout rates. Using less recent data, Lleras-Muney (2002) provides strong evidence that compulsory schooling laws were responsible for increased attendance during the period 1915 to 1939.

The juvenile arrest data come from the FBI's Uniform Crime Reports (UCR).[9] These data are aggregated by the age of the offender at the county-level for the period 1980 to 2008. Arrest rates are arrests per 1,000 of the specified age group population.[10] Arrests are reported for violent crimes (murder, rape, robbery, aggravated assault, and simple assault), property crimes (larceny, burglary, motor vehicle theft, and arson) and drug-related crimes (selling and possession).[11] The violent, property, and drug crime indices represent unweighted aggregations of their respective individual components. While this paper analyzes arrest rates for both sexes, the majority of the results focus on males because the male arrest rate is roughly four times higher than the female arrest rate.

Collection of the arrest data was completed through a cooperative effort of self-reporting by more than 16,000 city, county, and state law enforcement agencies. Of course, with a project of this magnitude, there are reasons to be cautious of the self-reported data. Gould et al. (2002) point out that arrest rates understate the true level of crime because not every crime committed is reported to the police. Moreover, underreporting can vary by crime type or county of jurisdiction. Data collection and reporting methods may vary by jurisdiction as well. Fortunately, county fixed effects eliminate the impact of time-invariant, cross-county differences in data collection and reporting techniques.

[9] U.S. Department of Justice, FBI, *Uniform Crime Reports: Arrests by Age, Sex, and Race*. Washington, DC: U.S. Department of Justice, FBI; Ann Arbor, MI: Inter-university Consortium for Political and Social Research (ICPSR, distributor).
[10] These rates are calculated using the National Cancer Institute, Surveillance Epidemiology and End Results, U.S. Population Data.
[11] It should be pointed out that "simple assaults" are actually referred to as "other assaults" in the UCR data codebook. However, because sexual and domestic offenses are given their own code, it is assumed that "other assaults" are mostly "simple assaults." This is likely a safe assumption given the age groups of interest.

The primary reason for using arrest rates is that detailed age data are not available in the UCR offense reports.[12] Although arrests are not a perfect measure of youth criminal behavior and understate the true level of crime, other research indicates that arrest data serve as an accurate representation of underlying criminal activity.[13] Furthermore, this type of measurement error is unlikely correlated with the minimum dropout age.[14] Using the UCR data, Lochner and Moretti (2004) report the correlations between arrests and crimes committed to be very high.[15]

In choosing the appropriate sample, counties with 10 or fewer years of arrest data reported are excluded from the analysis. In addition, age-specific county-year arrest counts that are greater than two standard deviations from the mean for the 29 year period are dropped from the sample. This is done because each county arrest count is an aggregation of police agency reports and not all agencies report every year. To further guard against this issue, this paper controls for the number of agencies reporting within a county for any given year.[16] Results from model specifications without these restrictions are presented in the sensitivity analysis below.

Independent variables

The state minimum dropout ages come from Oreopoulos (2009), the National Center for Education Statistics' *Digest of Education Statistics*, and various reports and policy briefs. Annual county-level demographic variables come from the U.S. Census Bureau. The regressions

[12] It would not be possible to include complete age data in the UCR offense reports because the ages of criminals who are not caught remain unknown.
[13] See, for example, Hindelang (1978, 1981).
[14] One worry is that a county might underreport arrests to suggest the MDA is bringing added benefits to the population. A benefit of the DDD approach is this issue is potentially addressed by differencing arrest rates across age groups. However, this concern is only quelled if a county underreports for both the 13 to 15 and 16 to 18 year-old age groups. If a county's underreporting specifically targets the 16 to 18 year-old population, then this remains a possible problem. The author would like to thank an anonymous referee for bringing this issue up.
[15] Lochner and Moretti (2004) report the following correlations: 0.96 for rape and robbery, 0.94 for murder, assault, and burglary, and 0.93 for auto theft.
[16] Following Gould et al. (2002), regressions were also considered where the sample was restricted to counties with an average population exceeding 25,000 between 1980 and 2008. This selection criterion is intended to capture a representative population and eliminate counties where arrest reports are more likely to be inaccurate. The results are similar when the sample is limited in this manner and are available upon request.

control for population density, the percentage black, the percentage male, and the percentages in the age ranges 13 to 15 and 16 to 18. Data on per capita personal income and the annual prevailing minimum wage are also included and come from the Bureau of Economic Analysis. These variables are deflated by the Consumer Price Index to convert to 2000 dollars. Data on each state's minimum legal drinking age come from Dee (2001). Table 2 presents descriptive statistics for all counties in the sample.

[Table 2 about here.]

IV. Empirical strategy

The empirical analysis is reduced form, based on the approach taken by a long line of researchers to evaluate the effects of county- and state-level variables on aggregate measures of crime.[17] As stated above, this study aims to evaluate the impact of the minimum dropout age on juvenile arrest rates by exploiting variation in state laws. The question that follows: Are students who would have otherwise dropped out less likely to commit crimes when forced to stay in school?

To estimate the impact of the minimum dropout age on juvenile arrest rates, this paper uses a difference-in-difference-in-difference-type (DDD) empirical strategy.[18] This approach relies on state-wide variation in compulsory schooling laws and on arrest data among age groups that are plausibly unaffected by the minimum dropout age as controls for unobserved state- and year-specific juvenile arrest shocks. The control group consists of individuals who are always

[17] For examples, see Ludwig (1998) on the effects of concealed-gun-carrying laws on crime; Levitt and Donahue (2001) and Joyce (2009) on the effects of abortion rates on crime; Grinols and Mustard (2006) on the effects of casinos on crime; Carpenter (2008) on the effects of underage drunk driving laws on crime; Mocan and Bali (2010) on the effects of unemployment on crime.

[18] Given the availability (or lack thereof) of yearly county-level high school dropout data, a two-stage estimation strategy was not possible.

below the minimum dropout age. Because all states have a minimum dropout age of at least 16, the control group is comprised of 13 to 15 year-olds.[19] The treatment group consists of youth who are subject to changes in the law (i.e. 16 to 18 year-olds).

The empirical framework relies on the assumption that criminal behavior among individuals who are below the minimum dropout age tracks the trend of those individuals aged 16 to 18 except that they are not subject to more or less restrictive dropout laws. By utilizing the control group, common confounding factors are subtracted out from the estimates and the effects of the policy are more precisely measured. The reference counties chosen for analysis are all counties in states with a minimum dropout age less than 18. In sum, this strategy compares the outcomes of youth who are affected by the minimum dropout age to the outcomes of youth who are not affected by the minimum dropout age (one "difference") in states with a minimum dropout age of 16 or 17 versus states with a minimum dropout age of 18 (a second "difference") over time (the third "difference"). This paper estimates the following equation:

$$\begin{aligned} ArrestRate_{ijst} = {} & \alpha + \beta_1 MDA18_{st} + \beta_2 age16to18_i + \beta_3(MDA18_{st} * age16to18_i) \\ & + \boldsymbol{X_{jst}\beta_4} + \boldsymbol{C_j\,\beta_5} + \boldsymbol{T_t\,\beta_6} + \boldsymbol{Trend_s\,\beta_7} + \varepsilon_{ijst}, \end{aligned} \tag{1}$$

where i indexes the age group, j indexes the county, s indexes the state, and t indexes the year.[20]

In equation (1), the dependent variable *ArrestRate* denotes the arrest rate per 1,000 of age group i in county j and state s at time t. On the right-hand side, *MDA18* is equal to one if the

[19] The one exception is Mississippi. From 1980 to 1993, Mississippi had a minimum dropout age of 14. The results are robust when Mississippi counties are excluded from the analysis.

[20] In a previous version of this paper, an indicator and interaction terms for *MDA17* were also included on the right-hand-side of (1). Counties in MDA = 17 states are considered reference counties (along with counties in MDA = 16 states) in this version for the sake of brevity when discussing the results. More importantly, the trend among states has been to increase their MDA to 18. This paper highlights that point by focusing solely on indicators for MDA = 18 counties and provides results that are clearly interpretable in the context of the current policy environment. Results that include the *MDA17* variables are available upon request.

state has a minimum dropout age of 18 at time *t*, and is equal to zero otherwise. The variable *age16to18* is a dummy that controls for differences between 16 to 18 year-olds and 13 to 15 year-olds that are common across years. The variable ***X*** is a vector containing the county- and state-level controls described above. The variables ***C*** and ***T*** represent county fixed effects and year effects, respectively. The county fixed effects control for differences in counties that are common across years, while the year effects control for differences across time that are common to all counties and to individuals of all ages. Lastly, the variable ***Trend*** represents a vector of linear state-specific time trends that account for time-series variation within each state. In the Appendix, Table A2 shows results where equation (1) is altered to allow for differential treatment effects for 16, 17, and 18 year-olds.

The coefficient of interest is β_3. This interaction term coefficient represents the marginal effect of the policy on the treatment group relative to the control group. If increases in the MDA decrease crime among juveniles 16 to 18 years of age, then we expect β_3 to be negative.

This estimation approach addresses at least three important endogeneity problems. First, there is a strong association between age and crime rates. As a result, comparing the criminal behavior of 16-18 year-olds to 13-15 year-olds raises some concerns. This method, however, alleviates this issue because it also compares arrest rates of 16-18 year-olds in states with a minimum dropout age of 18 to arrest rates of 16-18 year-olds in states with a dropout age of 16 or 17. Second, expectations of when a student will be able to drop out may influence current criminal behavior. For example, a 16 year-old in a state with a minimum dropout age of 17 may behave differently than a 16 year-old in a state with a minimum dropout age of 18 because the former anticipates being able to drop out sooner. Again, this approach mitigates these concerns because it compares individuals of different ages within states that have similar minimum dropout ages. Lastly, this technique controls for the potential endogeneity of the minimum dropout age laws. This is accomplished by differencing over time. That is, changes in arrest rates are examined as opposed to differences in levels. As a result, permanent differences in the characteristics of states are taken into account.

All models are estimated with weighted least squares where mean county populations are used as weights. Following Bertrand et al. (2004), standard errors are corrected for clustering at the state level. This procedure accounts for the possibility that standard errors may be biased due to serial correlation of the policy variable over time within a state.

A caveat to mention is that the classification of states with respect to MDA laws is basic. The approach merely relies on the presence of a law in a state during a specific year and does not control for particular nuances in the laws. As noted previously, state laws vary along several dimensions, but a practical, parsimonious way to empirically consider all the differences is not clear. Besides an attempt made below to address major MDA exemptions, the empirical strategy simply estimates the average effects of these laws and the differences in outcomes across states by the general classification of each state's dropout age.

V. Results

Tables 3a and 3b provide a breakdown of the mean arrest rates by age group and the prevailing MDA law for males and females, respectively. It is immediately apparent the two age groups display different levels of criminal behavior. Fortunately, the empirical strategy relies only on the assumption that the rates of crime between the two groups trend with each other over time. Interestingly, for many crimes, the mean rate of arrest is highest in MDA = 18 counties.[21] However, it is imperative to note these are only simple means and a more rigorous approach is required to address causality. The means are calculated such that a county in a state that changes its MDA is recorded under both dropout age regimes. For example, if a county is in a state that changes from an MDA = 16 to an MDA = 18, the mean rates of arrest are classified under an MDA = 16 before the policy change and under an MDA = 18 after the policy change.

[Table 3a about here.]

[Table 3b about here.]

Before discussing the results based on estimation of equation (1), it is useful to consider a more explicit test for whether changes in criminal behavior take place after MDA laws change. Figure 1 presents point estimates (with 95 percent confidence intervals) from a simple regression designed to capture intertemporal effects.[22] Two lead dummies, five lag dummies, and an indicator for the year a state law changed are considered as independent variables in a regression that also includes county and year fixed effects.[23] The dependent variable is the arrest rate for 16 to 18 year-old males for all crimes (i.e. property + violent + drug crimes). The coefficient estimates for the lead dummies shown in Figure 1 strongly suggest that states that increase their MDA do not have different arrest rates for 16 to 18 year-olds during the two years prior to a policy change. However, all lag dummies have coefficient estimates that are negative and relatively large in magnitude.[24] This indicates that arrest rates among the population of interest

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[21] Arson is the only crime where 13 to 15 year-olds appear to participate at higher rates than 16 to 18 year-olds for both males and females.

[22] Grinols and Mustard (2006) use this approach to analyze the effects of casinos on crime.

[23] For example, the first of the two lead dummies takes on a value of one two years prior to a law change in a particular state, and is equal to zero otherwise. This variable is always equal to zero for counties in states that do not change their MDA during the sample time frame.

[24] The coefficient estimates (with p-values for the t-statistics) for the lags are as follows: lag 1 = -2.10 (p-value = 0.27); lag 2 = -3.34 (p-value = 0.16); lag 3 = -5.20 (p-value = 0.05); lag 4 = -3.21 (p-value = 0.14); lag 5 = -5.50 (p-

have fallen after increases in the MDA and motivates proceeding forward with a more careful empirical approach. In particular, this method does not account for important outside factors that may have occurred alongside MDA increases that also influenced arrest rates.[25]

[Figure 1 about here.]

Table 4 presents estimates for β_3 from equation (1) where each cell illustrates results from a separate regression. For males, the estimates are negative in sign and large in magnitude across all model specifications. With the exception of drug-related arrests, all estimates are statistically significant at the 10 percent level or better.[26] Though not reported for the sake of brevity, it is worth noting that β_1 from equation (1) is not statistically significant for any of the specifications for males in Table 4. This implies that 13 to 15 year-old males in MDA = 18 states do not have statistically significantly different arrest rates than males of the same age in MDA = 16 or MDA = 17 states. The results in the bottom panel of Table 4 illustrate a negative but statistically insignificant relationship between the MDA and the overall arrest rate among females. However, it does appear that a higher MDA reduces the rate of violent female offending.

[Table 4 about here.]

The estimate from the full specification for males in Column 3 of Table 4 indicates that exposure to an MDA = 18 reduces the overall arrest rate for 16 to 18 year-olds by 10.27 incidences per 1,000 of the age group population. To put this estimate into perspective, this represents a 17.2 percent decrease from the mean arrest rate for 16 to 18 year-olds in states with

value = 0.01). For example, the estimated coefficient of lag 5 indicates that the arrest rate was lower by 5.5 arrests per 1,000 of the 16 to 18 year-old population five years after an increase in the MDA.

[25] When this approach is applied to 13 to 15 year-old male arrest rates, the “control” rates, there is no evidence of a relatively discrete and persistent drop following MDA increases. This provides further confidence that the results in Figure 1 are illustrating a causal effect of changes in the dropout age.

[26] Because the county fixed effects explain most of the variation in crime, models without these were also considered in an even more basic specification. For males, the coefficient estimates remained negative and similar in magnitude to the results shown in Table 4.

an MDA = 16 or an MDA = 17. For male property crime arrests, an MDA = 18 is associated with a 9.9 percent reduction from the mean arrest rate for 16 to 18 year-olds in states with an MDA = 16 or an MDA = 17. For male violent crime arrests, an MDA = 18 is associated with a 22.5 percent reduction from the mean arrest rate for 16 to 18 year-olds in states with an MDA = 16 or an MDA = 17.

Because this paper relies on a reduced form approach, it is important to consider whether the magnitudes of these effects are plausible. The Census analysis in the Appendix indicates that a one year increase in the MDA is associated with roughly a 2 percentage point decrease in the dropout rate. According to the U.S. Department of Education, the status high school completion rate was nearly 90 percent in 2009 (Chapman et al. 2011). This implies that roughly 20 percent of those who drop out would stay in school with a one year increase in the MDA. Given that over 1.2 million youths drop out annually, this would mean that approximately 240,000 more students per year would stay in school with a higher MDA (Alliance for Excellent Education 2007).[27] Using property crimes as an example, the UCR data indicate that 16 to 18 year-old males were responsible for roughly 175,000 arrests in 2008. A decrease of 9.9 percent means that over 17,000 fewer property crimes are committed annually when the dropout age is higher. Taken together, these figures imply that for every 100 students kept from dropping out there would be over 7 fewer property crimes committed. Although these are simple back-of-the-envelope calculations, these numbers are perhaps useful for an economic interpretation of the results.

Male arrest rates by crime type

[27] This estimate is similar in magnitude to the results from Angrist and Krueger (1991). Li (2006) uses simulation to show that increasing the MDA to 18 will raise the percent who graduate high school from 89 to 94.1 percent. This implies that about half of those who drop out would stay in school with a higher MDA.

Table 5 focuses on male arrest rates and breaks down property, violent, and drug crimes by their respective components. For the individual property crime arrests, all coefficient estimates are negative in sign. Furthermore, with the exception of motor vehicle theft arrests, all estimates are statistically significant at the 10 percent level or better. Similarly, all coefficient estimates from the individual violent crime arrest models are negative in sign. Estimates for murder, rape, and simple assault are statistically significant at the 10 percent level or better, while estimates for robbery and aggravated assault are statistically insignificant. The decrease in the violent crime arrest rate appears to be driven in large part by simple assaults. This perhaps should come as no surprise because this particular crime is relatively common among juveniles.

[Table 5 about here.]

Table 5 also reports results separately for the selling of drugs and the possession of drugs. Though not statistically significant at conventional levels, the coefficient estimate for selling-related arrests is relatively large in magnitude. There is no evidence that possession-related arrests are influenced by the MDA.

Lastly, although not reported, it is worth noting that an MDA = 18 shares a negative and statistically significant relationship with simple assaults for females. There is no evidence that other individual female offenses are influenced by the MDA.

Less serious offenses

In addition to the crimes reported in Table 5, it is also informative to consider less serious offenses that may be more relevant for these age groups. Table 6 displays results for disorderly conduct, vandalism, and curfew violation arrests for both sexes. Arrests for prostitution are also considered for females. An MDA = 18 is associated with roughly 5.4 and 1.2 fewer disorderly conduct arrests per 1,000 of the relevant age group population for males and females, respectively. Rates of female vandalism also share a negative and statistically significant relationship with the MDA. Male vandalism, male and female curfew violation, and female prostitution arrest rates do not share statistically significant relationships with the MDA.

[Table 6 about here.]

Interaction terms with subsamples of the population

When considering a policy change, it is vital to know whether the law has a homogeneous influence across different types of populations. In general, this information is of interest to policy-makers whose goal is to impact specific populations or areas where the policy may be most effective. Table 7 reports estimates for male arrest rates based on interaction terms with potentially important subsamples of the population.[28] In the upper panel of Table 7, the variable of interest is interacted with a dummy variable indicating whether the percentage of the county's population that is African-American is below the sample median.[29] The most striking result is for property crimes where it appears that a higher MDA may be more effective at reducing crime in areas with relatively large African-American populations. This result is of interest because dropout and arrest rates are historically higher among blacks than whites.

[Table 7 about here.]

In the bottom panel of Table 7, the variable of interest is interacted with a dummy variable indicating whether the county's income per capita is below the sample median. While three of the four estimates are negative in sign, none are statistically significant at conventional levels.

Sensitivity of results to alternative specifications

[28] Results for females are available from the author upon request.
[29] Unfortunately, it is not possible to observe race for the age-specific UCR arrest data.

Table 8 investigates the sensitivity of the results to a range of alternative specifications. Column 1 reports the estimate from Column 3 in Table 4 to serve as a baseline reference for the impact of an MDA = 18 on overall male arrest rates.

[Table 8 about here.]

In Column 2, the estimate from a standard difference-in-difference (DD) regression is reported. This model is similar to equation (1) but does not utilize the arrest rates for 13 to 15 year-olds as control trends. While this estimate is smaller in magnitude than the baseline estimate, it is relatively large in size and statistically significant at the 10 percent level. Table A3 in the Appendix illustrates DD results for more sparse specifications for both sexes.

In Column 3, the sensitivity of the results to using the log transformation of the arrest rate is assessed. While other papers use this as their dependent variable (e.g., Lochner and Moretti (2004)), it comes with the drawback that zero values must be discarded. The estimate in Column 3 indicates the results are robust to this transformation.

In Column 4, linear age-specific time trends are added to the baseline specification. Age-specific trends are designed to account for time series variation particular to each age group. The DDD coefficient estimate is slightly larger in magnitude and more precisely measured under this alternative specification.

Column 5 adds age-by-year and age-by-state fixed effects to the baseline model.[30] The age-by-year fixed effects serve a similar purpose as the age-specific trends in that they allow each age group to have their own time trend. The age-by-year effects are, however, less restrictive because they do not impose linearity. The age-by-state fixed effects are included to allow for separate shifts in the arrest rates for 16 to 18 year-olds in different states. When adding

[30] This amounts to adding 80 new variables to the baseline specification that already contains county fixed effects, year effects, and state-specific trends.

these terms the coefficient estimate of interest remains negative in sign and statistically significant at the 10 percent level. The magnitude of the estimate decreases, but still implies a relatively large effect. In this case, an MDA = 18 leads to roughly 5.36 fewer arrests per 1,000. This represents an approximate 9 percent decrease from the mean rate of arrests for 16 to 18 year-olds in states with an MDA = 16 or an MDA = 17.

Column 6 illustrates results where 19 year-olds serve as the control group. Regardless of the state, 19 year-olds are not legally obligated to attend school. One may argue that 19 year-olds serve as a better control group because they are more similar to 16-18 year-olds than are 13-15 year-olds. However, a potential issue with this specification is that 19 year-olds in MDA = 18 states may have been less likely to commit crime when younger and, as a result, may be less likely to commit crime at age 19. If this is the case, then the impact of MDA laws on 16-18 year-olds will be understated. While the result in Column 6 is negative in sign, it is smaller in magnitude than the baseline estimate and is measured imprecisely.

In Column 7, the sample is not restricted by the criteria described in Section III above. In this case, the estimate is only slightly smaller in magnitude than the baseline result and remains statistically significant at the 10 percent level.

Column 8 illustrates results where only counties in states that have an MDA = 16 throughout the entire period or that offer a major exemption to their dropout age law are included in the sample.[31] This exercise is performed because it is important to know from a policy perspective if the results are driven primarily by states with the least flexible legislation.[32] The coefficient estimate under this specification is slightly larger in magnitude and more precisely

[31] As an example, individuals in New Mexico can drop out one year before reaching their state's MDA of 18 if they have obtained a work permit. In Arkansas, youth can drop out a year early if they attend an adult education program at least 10 hours per week. Counties in states that always have an MDA = 16 are kept as "control" counties.
[32] Counties from 10 states plus D.C. are dropped from observation under this sample restriction.

estimated than the baseline result. This implies the minimum dropout age set by law is itself an important factor in determining juvenile arrest rates.

Lastly, the sensitivity of the results to large populations is examined in Column 9 of Table 8. This is an important consideration because the regressions are population weighted. California, Florida, New York, and Texas contribute over 20,000 observations to the full sample.[33] Additionally, California and Texas both increased their dropout age to 18 during the sample time period. When counties from these states are dropped the main result holds; increases in the MDA reduce arrest rates among 16 to 18 year-olds.

Investigating the potential mechanisms through which education reduces crime

Education may reduce crime because schooling has an incapacitating effect on youth. The incapacitation mechanism is inherent to a time allocation problem where youth choose between investing in education, participating in the labor force, and committing crime (Lochner 2010).[34] If increasing the minimum dropout age has an incapacitating effect on youth only, then these laws should have no impact on individuals of ages above which the law binds. However, if human capital effects are an important channel through which education impacts crime, then MDA laws should have a lasting influence on criminal behavior that goes beyond high school. More schooling increases future wage rates and, as a result, increases the opportunity costs of crime. Furthermore, punishment is likely to be more costly for individuals with additional years of schooling.[35]

[33] Eight out of the top 10 and 40 out of the top 100 most populous counties are in these four states.

[34] It is possible that criminal behavior is merely "pent up" after an increase in the minimum dropout age and the result is an increase in offending when individuals leave school at a later date. This paper finds no evidence, however, to support this hypothesis. The author would like to thank Lan Shi for conversations regarding this point.

[35] Arrow (1997) suggests youth may also learn important values in school that alter their tastes for crime. For example, schooling may decrease criminal behavior by affecting the psychic costs of breaking the law. Schooling may also generate important social interaction effects. Keeping youth in school longer may promote physical

To investigate this further, Table 9 includes 19 to 21 year-olds in the sample.[36] The regression model follows the baseline DDD specification, but the policy indicator is defined as the minimum dropout age that was in place 3 years prior. This is done so as to more correctly match the 19 to 21 year-old age group with the MDA regime that was in place when they were in high school. The control group consists of males aged 13 to 18 years-old. Arrest rates for 16 to 18 year-olds are included as control rates because, in principle, the MDA in place when these individuals were three years younger should have no impact on their current offending behavior.

[Table 9 about here.]

The results shown in Table 9 are negative in sign for three of the four specifications, but none are statistically significant. Although imprecisely measured, the coefficient estimate for the violent crime equation is relatively large in magnitude.[37] Taken together, the estimates in this paper indicate that the effects of MDA laws are relatively large at ages where the law binds (i.e. 16 to 18 year-olds). Though this does not rule out other mechanisms, these results are consistent with the notion that incapacitation effects are important to the relationship between the MDA and juvenile crime.[38] Unfortunately, due to limitations of the data, further interpretation of these results should be made with caution.[39]

MDA laws and measures of police enforcement

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altercations and facilitate the coordination of crime (Jacob and Lefgren 2003). On the other hand, youth that stay in school may be less likely to form peer groups that promote delinquency.

[36] Again, results for females are available upon request.

[37] The sensitivity of these results to alternative control groups was examined. This paper considered 13 to 15 year-olds and 16 to 18 year-olds separately as controls. Estimates where only 16 to 18 year-olds served as controls were always insignificant. When 13 to 15 year-olds were the controls, the violent crime equation returned a negative and statistically significant coefficient estimate on the interaction term of interest. The implied magnitude of this effect was smaller than that for 16 to 18 year-olds in the baseline violent crime specification shown in Table 4.

[38] Table A4 in the Appendix shows results for white collar crimes for 19 to 21 year-olds.

[39] Other results considered specifications for 19 to 21 year-olds with a series of lagged indicators for the timing of policy changes. These estimates provided similar evidence as to the results reported in Table 9.

A final concern is that increases in the minimum dropout age are made alongside increases in police effort. If police officers exert more effort towards reducing juvenile crime when MDA laws are made more restrictive, then one might incorrectly attribute decreases in crime rates to the MDA policy. To examine this further, observable measures of police enforcement are regressed on MDA law indicators where states with an MDA = 16 serve as the reference category.[40] The dependent variables are annual state-level measures of police expenditures per capita and the number of sworn officers per capita. These data cover the period 1982 to 2005 and come from the Bureau of Justice Statistics.

[Table 10 about here.]

If effects are spurious due to increased policing, then measures of police enforcement should be positively associated with more restrictive MDA legislation. Table 10 provides no evidence that higher MDA laws coincide with increases in police effort.[41] Estimates in Column 2 actually suggest that police expenditures per capita are lower in states with an MDA = 18. As pointed out by Lochner and Moretti (2004), this is consistent with trade-offs related to strict state-level budget constraints. Overall, the results in Table 10 support the notion that observed decreases in juvenile arrest rates can be attributed to MDA laws and not stricter police enforcement.

VI. Do MDA laws displace problems to schools?

[40] Both regression models control for the fraction of the population aged 15 to 19, the fraction of the population that is black, the minimum legal drinking age, state fixed effects, year fixed effects, and state-specific time trends. The models are estimated with weighted least squares where state populations are used as weights.

[41] Carpenter (2007) finds similar results for zero-tolerance drunk-driving laws and police enforcement. Using data for earlier years, Lochner and Moretti (2004) show results similar to those presented here for the relationship between compulsory schooling laws and police expenditures and employment.

The above results provide strong evidence that increasing the minimum dropout age has a negative effect on juvenile arrest rates. Yet, it is important to bear in mind these estimates do not fully consider the potential displacement of delinquency from the streets to schools. If a youth commits a crime within school that is punished by arrest, then this is reflected in the results above. Nevertheless, these results do not account for possible increases of within-school delinquency that do not end in arrest. It is possible that by increasing the minimum dropout age more delinquents are kept in school and, as a result, other students suffer costs due to their presence. Such consequences could be increased bullying, threats, gang activity or simply a decrease in the perception of school safety. Evidence suggests that students who fear victimization at school are more likely to stay at home (Pearson and Toby 1992).

The goal here is to provide a brief treatment along this line of inquiry. This section employs restricted use state-identified versions of the 1993-2007 National Youth Risk Behavior Surveys (YRBS). The YRBS data have been used by economists to study a wide range of topics concerning policy evaluations and youth behavior.[42] The national surveys are conducted every other year by the Centers for Disease Control and Prevention and provide a nationally representative sample of U.S. high school students.[43] The primary purpose of the YRBS is to gather information on youth activities that influence health.[44] The YRBS also asks students questions pertaining to in-school safety. In the top panel of Table 11, the dependent variable of interest is a dummy for whether the respondent has missed school in the past month for fear of his or her own safety.

[42] For other studies that use the YRBS data, see Gruber and Zinman (2001) on trends in youth smoking; Carpenter and Stehr (2008) on the effects of mandatory seatbelt laws on seatbelt use, motor vehicle fatalities, and crash-related injuries; Anderson (2010) on the effect of an anti-methamphetamine campaign on teen meth use.

[43] Though intended to be nationally representative, not all 50 states are represented in any given year the survey has been conducted.

[44] See Anderson (2010) for a more thorough discussion of the YRBS data.

[Table 11 about here.]

Standard two-way fixed effects models are estimated to gauge the extent to which student responses differ by their state's MDA law.[45] Table 11 illustrates that females in MDA = 18 states are more likely to report missing school for fear of their own safety than females attending schools in MDA = 16 or MDA = 17 states. Not only do these results highlight the potential for negative peer effects due to stricter dropout laws, but they suggest that female students may be more susceptible to these effects than male students. To explore asymmetric effects further, the second panel presents estimates on the relationship between MDA laws and whether the respondent reports having had sexual intercourse during the past month. These results suggest that females attending schools with an MDA = 18 are statistically significantly more likely to report have had recent sex. Lastly, the bottom panel shows results for teenage pregnancy. While the coefficient estimate is positive in sign and large in magnitude, it is not statistically significant at conventional levels.[46]

Though intended to be brief, these results emphasize important potential unintended consequences of increases in the minimum dropout age. Future research should explore these issues further. Due to negative peer effects that displaced delinquents might generate, future

[45] More specifically, the following equation is estimated:

$$Y_{ist} = \alpha + \beta_1 MDA18_{st} + \boldsymbol{X_{ist}\beta_2} + \boldsymbol{S_s\beta_3} + \boldsymbol{T_t\beta_4} + \boldsymbol{Trend_s\beta_5} + \varepsilon_{ist}$$

where i indexes the individual, s indexes the state, and t indexes the year. On the right-hand side, *MDA18* is the same as described above and $\boldsymbol{X}$ is a vector of individual-level controls. $\boldsymbol{S}$ and $\boldsymbol{T}$ represent state and time fixed effects, respectively. Lastly, ***Trend*** is a vector of linear state-specific time trends. All regressions are estimated with linear probability models and are weighted by the sample weights provided with the YRBS data. Standard errors are clustered at the state-level.

[46] Of course, because these surveys are conducted in school, these estimates could be picking up the fact that females who are kept in school due to stricter dropout laws may be more likely to report staying home for fear of their own safety or having had recent sexual intercourse. To check against these possibilities, the regressions were run on the subsample of females under the age of 16. Under this specification, the estimate for the missing school outcome becomes larger in magnitude and more precisely estimated. On the other hand, the estimate for recent sexual intercourse becomes statistically insignificant.

research will also want to consider the impact that stricter MDA laws might have on the academic outcomes of students who stay in school regardless of the minimum dropout age. This could be important for the short- and long-run outcomes of these individuals.

VII. Conclusion

Juvenile crime in the United States is widespread and a major concern for policy-makers. To date, much attention has been paid to identifying key determinants of juvenile crime. Little is known, however, about the contemporaneous link between schooling and delinquent behavior. This paper examines the effect of school attendance on juvenile arrest rates by exploiting state-level variation in minimum dropout age laws in the United States.

Using a difference-in-difference-in-difference-type empirical strategy and age-specific county arrest data, this paper finds that minimum dropout age requirements have a significant and negative effect on juvenile crime. Results from the preferred specification suggest that a minimum dropout age of 18 decreases arrest rates among 16 to 18 year-olds by approximately 17 percent. The negative effect holds and is sizeable for property crime, violent crime, and drug crime arrests; however, the estimated effects are usually not statistically significant for drug-related arrests. In addition, the magnitude of the property crime effect is greater for counties with proportionally large African-American populations. This indicates that MDA laws may be more relevant for at-risk subsamples of the general population. Lastly, while other mechanisms cannot necessarily be ruled out, the results are consistent with an incapacitation effect; keeping teenagers in school decreases the time and opportunity available to commit crimes.

Not only do these findings provide support for the efficacy of programs intended to keep juveniles in school and out of trouble, but they also identify a potential benefit of minimum dropout age laws. Back-of-the-envelope calculations imply that roughly $190 million dollars could be saved annually on the nation's average value of lost property if all states were to set an MDA = 18.[47, 48] Though this figure does not reflect the social cost of property crime, it is nevertheless useful in describing the effect of MDA laws. Furthermore, these cost savings likely pale in comparison to potential benefits reaped from more difficult-to-measure variables associated with keeping kids in school. Cohen (1998) estimates that a high school dropout causes roughly $300,000 in external costs during his or her lifetime. To put this number into further perspective, consider that roughly 1.2 million youths drop out of high school every year and that the average public expenditures per pupil enrolled in elementary and secondary schools is approximately $10,000 (Alliance for Excellent Education 2007; National Center for Education Statistics 2008). High school graduation incentive programs have been estimated to cost around $12,000 per student (Greenwood et al. 1996).

Despite the benefits, it is important to bear in mind these estimates do not fully consider the potential displacement of delinquency and other risky behaviors from the streets to schools. As Section VI highlights, this is an important area for future research. It is possible that other students bear costs when an increase in the minimum dropout age forces more delinquents to remain in school. Furthermore, it is also important to consider that these laws may have asymmetric effects between male and female students. Policy-makers should take these potential consequences into consideration when weighing the costs and benefits associated with an

[47] From this paper's analysis, an MDA = 18 is associated with an approximate 10 percent decrease in property crime arrests for 16 to 18 year-old males. According to the UCR data, this group is responsible for nearly 17 percent of all male property crimes. Taken together, these estimates imply that if all states had an MDA = 18, then property crime arrests for the entire male population would decrease by roughly 1.7 percent. Given that the Federal Bureau of Investigation estimates the nation's cost of lost physical property due to property crimes to be $17.2 billion per year and that males are arrested for roughly 65 percent of all property crimes, this implies an annual cost savings of approximately $190 million. This calculation is based off of estimates for 2008.

[48] Interestingly, this estimate is similar to the cost savings associated with introducing zero-tolerance drunk-driving laws (see Carpenter 2007).

increase in the minimum dropout age. Future research should also evaluate whether an increase in the minimum dropout age has an adverse impact on the academic outcomes of students who stay in school regardless of their state's law.

Appendix

Appendix Section I: The minimum dropout age and dropout status

To examine the relationship between the MDA and high school dropout status, this paper calls upon data from the 1980, 1990, and 2000 U.S. Censuses and considers a specification similar to that used by Lochner and Moretti (2004).[49] Following previous authors, the relevant minimum dropout age is assigned to individuals based on their state of birth and the year the individual was 14 years-old (Lochner and Moretti 2004; Oreopoulos 2007).[50] Table A1 illustrates results on the relationship between MDA laws and dropout status. All models control for age, race and ethnicity, cohort of birth, state of birth, and state of residence. The estimate in Column 1 indicates that a one year increase in the MDA decreases the likelihood the respondent is a high school dropout by 2.2 percentage points. This represents a 15 percent decrease from the mean dropout rate for states with an MDA = 16 and a 16 percent decrease from the mean dropout rate for states with an MDA = 17. A one year increase in the MDA decreases the likelihood of dropping out by 1.8 percentage points and 2.5 percentage points for males and females, respectively.

[Table A1 about here.]

[49] Census data from 2010 are not yet publicly available. The results presented here, however, are more up-to-date than those from Lochner and Moretti (2004) as they relied on Census data from 1960, 1970, and 1980.
[50] Migration across states between birth and age 14 will diminish the precision of the estimates.

Appendix Section II: Arrests by single ages

Table A2 reports results from models similar to the baseline specifications for all crimes, property crime, violent crime, and drug crime with the exception that arrest rates are not pooled by age group. Instead, arrest rates are observed for single ages and estimates are reported for interaction terms of the *MDA18* indicator with three separate age dummies.[51] A benefit of these specifications is that it allows for differential treatment effects for 16, 17, and 18 year-olds.

These results are interesting because they show that large effects exist for 18 year-olds in MDA = 18 states. If individuals drop out as soon as the law permits and incapacitation effects dominate, then we might expect 18 year-olds to be uninfluenced by an MDA = 18. [52] Empirical findings from the compulsory schooling literature offer two possible reasons for this observation.

First, and perhaps most likely, individuals required to go to school longer because of a higher minimum dropout age may also be more likely to graduate, since the time to complete high school declines once they can legally leave school. If this results in a decrease in the perceived costs of graduating, students who would have left school under more lenient laws may choose to stay enrolled (Oreopoulos 2006a). Second, youth may also delay dropping out after an increase in the dropout age in order to signal to employers they are better potential workers than those who elect to drop out as soon as the law permits (Lang and Kropp 1986).

[Table A2 about here.]

Appendix Section III: Difference-in-difference results

[Table A3 about here.]

[51] Specifications were considered where an *age15* dummy was interacted with *MDA18* to serve as a robustness check for the control group. This term was statistically indistinguishable from zero, providing confidence that the control group's criminal behavior is uninfluenced by an MDA = 18.
[52] Arkansas has an MDA = 17 and actually requires their students to finish the school year in which they turn 17.

Appendix Section IV: White collar crimes

Table A4 illustrates white collar crime results for males aged 19 to 21 years-old. The estimates are from a DDD specification that is similar to the model used to generate the results in Table 9. While the Table 9 estimates show that MDA laws have no statistically significant effect on property, violent, and drug crimes for older individuals, the results in Table A4 suggest a negative and statistically significant relationship between an MDA = 18 and arrests for fraud. This result is interesting because it is consistent with human capital effects playing an important role in the link between education and crime. White collar crimes, as opposed to property or violent crimes, are perhaps more appropriate for testing the human capital hypothesis because these offenses are much more commonly committed by young adults than teenagers. While arrests rates for property and violent crimes peak at ages 16 to 18, arrest rates for white collar crimes peak around ages 20 to 21 (Lochner 2004).

[Table A4 about here.]

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Figure 1. Male arrest rate for all crimes

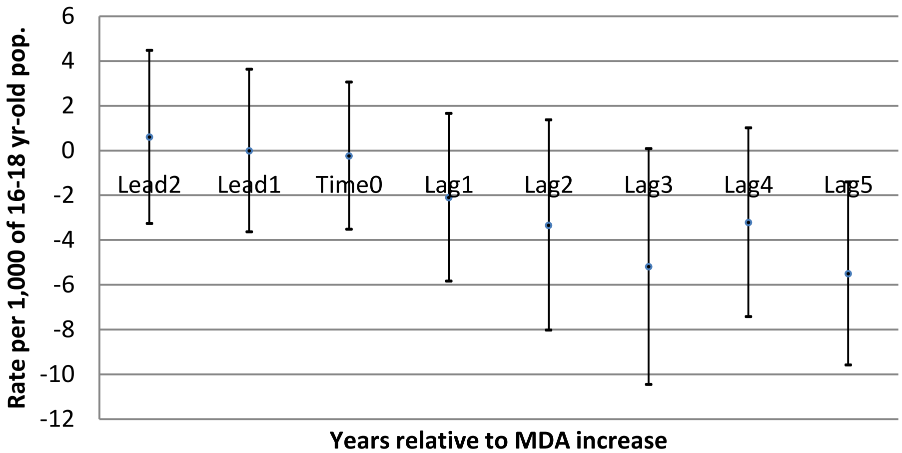

Table 1. Number of states by mandatory minimum dropout age, 1950-2008

	1950	1960	1970	1980	1990	2000	2008
MDA ≤ 16	42	43	40	39	33	30	25
MDA = 17	5	4	6	6	10	8	8
MDA = 18	4	4	5	6	8	13	18

Notes: Washington D.C. is included.

Table 2. Descriptive statistics for county panel data, 1980-2008

Variable	Mean	Std. Dev.
Total crime arrest rate 13 to 15 year-old males	31.59	33.28
Total crime arrest rate 16 to 18 year-old males	61.70	49.06
Total crime arrest rate 13 to 15 year-old females	10.40	13.46
Total crime arrest rate 16 to 18 year-old females	14.78	14.93
Minimum dropout age = 18	0.239	0.427
Population density (thousands)	0.174	0.970
Percent black	0.088	0.140
Percent male	0.493	0.017
Percent aged 13 to 15	0.048	0.008
Percent aged 16 to 18	0.049	0.008
Real income per capita (2000 dollars)	21849	5779
Real minimum wage (2000 dollars)	5.157	0.535
Minimum legal drinking age = 19	0.089	0.285
Minimum legal drinking age = 20	0.009	0.097
Minimum legal drinking age = 21	0.845	0.362
Number of reporting agencies	4.621	7.877

Notes: (1) The sample is based on the selection criteria described in the text. (2) Unweighted means are presented. (3) Arrest rates are arrests per 1,000 of the relevant age group population.

Table 3a. Descriptive statistics for male arrest rates

	MDA ≤ 16			MDA = 17			MDA = 18		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
16-18 year-olds									
Larceny arrest rate	17.92	16.75	39,323	17.40	15.07	11,560	19.57	19.31	16,149
Burglary arrest rate	9.692	9.903	39,014	10.84	10.04	11,504	9.648	9.748	16,163
Auto theft arrest rate	2.468	3.951	38,928	2.903	5.493	11,413	3.162	4.945	16,066
Arson arrest rate	0.133	0.451	39,430	0.153	0.443	11,513	0.166	0.478	15,978
Property crime arrest rate	31.66	25.86	39,306	32.75	25.41	11,588	33.82	28.84	16,189
Murder arrest rate	0.071	0.297	39,773	0.122	0.543	11,515	0.063	0.273	16,177
Rape arrest rate	0.248	0.626	39,248	0.331	0.750	11,515	0.307	0.736	15,857
Robbery arrest rate	1.009	2.237	39,368	1.669	10.02	11,491	0.978	1.973	15,975
Aggravated assault arrest rate	3.072	4.290	39,314	3.631	6.056	11,458	3.195	4.023	15,944
Simple assault arrest rate	8.076	9.731	39,547	9.333	9.578	11,620	9.850	9.912	15,863
Violent crime arrest rate	13.36	14.51	39,662	16.12	21.97	11,673	15.38	13.67	15,986
Drug sale arrest rate	1.821	4.560	39,187	2.353	9.120	11,483	1.723	3.168	15,769
Drug possession arrest rate	9.287	13.59	39,500	10.20	14.35	11,679	13.78	16.10	15,828
Total drug arrest rate	11.67	16.10	39,545	13.50	22.82	11,727	16.21	17.40	15,855
Total crime arrest rate	58.61	46.52	39,528	64.03	59.91	11,665	67.62	45.66	16,089
13-15 year-olds									
Larceny arrest rate	12.17	14.91	39,290	11.30	13.39	11,512	15.19	17.83	16,095
Burglary arrest rate	4.956	6.902	38,995	5.811	7.493	11,493	6.124	7.617	16,084
Auto theft arrest rate	1.403	2.825	38,898	1.481	3.272	11,387	2.019	3.552	16,035
Arson arrest rate	0.167	0.517	39,608	0.163	0.508	11,574	0.272	0.671	15,920
Property crime arrest rate	19.77	21.87	39,260	19.87	21.33	11,533	24.76	25.75	16,161
Murder arrest rate	0.007	0.072	40,469	0.015	0.120	11,859	0.007	0.057	16,468
Rape arrest rate	0.085	0.315	39,765	0.138	0.414	11,600	0.144	0.438	15,929
Robbery arrest rate	0.306	1.079	39,886	0.630	6.717	11,560	0.352	1.014	16,086
Aggravated assault arrest rate	1.072	2.100	39,287	1.325	2.879	11,456	1.413	2.225	15,796
Simple assault arrest rate	4.065	7.017	39,447	5.022	8.042	11,557	6.619	8.862	15,754
Violent crime arrest rate	5.956	9.192	39,420	7.674	15.21	11,552	9.204	10.94	15,823
Drug sale arrest rate	0.305	1.366	39,604	0.392	2.454	11,575	0.327	0.873	15,870
Drug possession arrest rate	1.592	3.052	39,400	1.767	3.190	11,578	3.011	4.283	15,765
Total drug arrest rate	2.052	3.977	39,375	2.368	5.071	11,595	3.576	4.798	15,763
Total crime arrest rate	28.79	30.81	39,393	31.06	36.97	11,573	38.84	35.19	16,048

Notes: (1) The sample is based on the selection criteria described in the text. (2) Unweighted means are presented. (3) Arrest rates are arrests per 1,000 of the relevant age group population.

Table 3b. Descriptive statistics for female arrest rates

	MDA ≤ 16			MDA = 17			MDA = 18		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
16-18 year-olds									
Larceny arrest rate	6.520	8.443	39,293	6.284	7.776	11,681	7.614	9.385	15,913
Burglary arrest rate	0.490	1.071	39,096	0.478	1.099	11,649	0.632	1.312	15,899
Auto theft arrest rate	0.224	0.676	39,194	0.223	0.686	11,671	0.437	1.063	15,923
Arson arrest rate	0.005	0.052	40,387	0.006	0.048	12,035	0.008	0.067	16,343
Property crime arrest rate	7.641	9.147	39,248	7.387	8.403	11,705	9.168	10.30	15,938
Murder arrest rate	0.002	0.023	40,622	0.003	0.033	12,139	0.002	0.022	16,534
Rape arrest rate	0.000	0.012	40,964	0.000	0.004	12,242	0.000	0.015	16,665
Robbery arrest rate	0.047	0.186	40,095	0.081	0.716	11,927	0.059	0.217	16,190
Aggravated assault arrest rate	0.531	1.168	39,271	0.622	1.442	11,713	0.565	1.186	15,782
Simple assault arrest rate	2.740	4.479	39,410	3.118	4.226	11,802	3.790	5.460	15,652
Violent crime arrest rate	3.570	5.293	39,467	4.090	5.468	11,804	4.709	6.095	15,733
Drug sale arrest rate	0.211	0.704	39,322	0.227	0.794	11,732	0.212	0.754	15,790
Drug possession arrest rate	1.482	3.139	39,221	1.401	2.562	11,725	2.498	4.238	15,612
Total drug arrest rate	1.845	3.499	39,227	1.807	3.105	11,727	2.885	4.486	15,579
Total crime arrest rate	13.77	14.57	39,570	14.03	13.96	11,876	17.86	16.07	15,850
13-15 year-olds									
Larceny arrest rate	5.053	7.853	39,269	4.271	6.334	11,702	6.936	9.514	15,949
Burglary arrest rate	0.348	0.931	39,339	0.331	0.891	11,662	0.551	1.246	15,945
Auto theft arrest rate	0.268	0.854	39,331	0.234	0.847	11,681	0.545	1.300	15,923
Arson arrest rate	0.015	0.106	40,394	0.012	0.091	12,044	0.025	0.141	16,281
Property crime arrest rate	6.029	8.775	39,199	5.194	7.101	11,691	8.576	10.92	15,946
Murder arrest rate	0.000	0.003	41,002	0.000	0.008	12,251	0.000	0.005	16,649
Rape arrest rate	0.001	0.024	40,979	0.000	0.003	12,245	0.001	0.041	16,637
Robbery arrest rate	0.022	0.123	40,570	0.058	0.951	12,067	0.036	0.190	16,363
Aggravated assault arrest rate	0.273	0.789	39,542	0.348	0.984	11,717	0.351	0.862	15,842
Simple assault arrest rate	1.818	3.756	39,491	2.160	4.032	11,745	3.327	5.415	15,673
Violent crime arrest rate	2.240	4.274	39,411	2.752	5.210	11,735	3.950	6.011	15,710
Drug sale arrest rate	0.043	0.232	40,016	0.042	0.247	11,899	0.061	0.296	16,077
Drug possession arrest rate	0.380	1.016	39,410	0.356	0.978	11,738	0.827	1.559	15,736
Total drug arrest rate	0.470	1.171	39,351	0.457	1.142	11,765	0.962	1.736	15,703
Total crime arrest rate	9.282	12.59	39,382	8.941	11.86	11,752	14.26	15.76	15,877

Notes: (1) The sample is based on the selection criteria described in the text. (2) Unweighted means are presented. (3) Arrest rates are arrests per 1,000 of the relevant age group population.

Table 4. Teen arrest rates and the minimum dropout age, 1980-2008

	All crimes			Property crime			Violent crime			Drug crime		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Males												
MDA18	-10.20*	-10.20*	-10.27*	-3.270**	-3.232**	-3.241**	-3.262**	-3.268**	-3.264**	-3.287	-3.275	-3.309
**age16to18*	(5.331)	(5.321)	(5.323)	(1.303)	(1.296)	(1.295)	(1.468)	(1.466)	(1.468)	(3.431)	(3.426)	(3.436)
N	134,296	134,293	134,293	134,037	134,034	134,034	134,116	134,114	134,114	133,860	133,857	133,857
R^2	0.830	0.835	0.841	0.742	0.762	0.779	0.868	0.872	0.877	0.619	0.634	0.643
Females												
MDA18	-1.419	-1.448	-1.553	-0.739	-0.740	-0.749	-0.634**	-0.643**	-0.656**	0.029	0.030	0.027
**age16to18*	(1.227)	(1.203)	(1.192)	(0.837)	(0.835)	(0.833)	(0.303)	(0.304)	(0.304)	(0.439)	(0.438)	(0.439)
N	134,307	134,304	134,304	133,727	133,725	133,725	133,860	133,857	133,857	133,352	133,349	133,349
R^2	0.747	0.756	0.773	0.709	0.718	0.733	0.717	0.727	0.746	0.586	0.599	0.611
County FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Covariates	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES
State trends	NO	NO	YES	NO	NO	YES	NO	NO	YES	NO	NO	YES

Notes: (1) Each cell represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (3) Control group consists of individuals 13 to 15 years of age. (4) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. (5) County mean populations are used as weights. (6) Standard errors are corrected for clustering at the state level. (7) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 5. Male teen arrest rates by crime type, 1980-2008

DDD estimates (coefficient on *MDA18*age16to18*)	(1)		(2)		(3)
Individual property crimes		***Individual violent crimes***		***Individual drug crimes***	
Larceny	-1.574* (0.806) N = 133,926	Murder	-0.102* (0.055) N = 136,258	Selling	-1.731 (1.151) N = 133,485
Burglary	-1.057* (0.570) N = 133,250	Rape	-0.068* (0.034) N = 133,912	Possession	-0.057 (2.368) N = 133,747
Motor vehicle theft	-0.399 (0.470) N = 132,724	Robbery	-0.633 (0.571) N = 134,363		
Arson	-0.100** (0.040) N = 134,020	Aggravated assault	-0.687 (0.738) N = 133,252		
		Simple assault	-1.655*** (0.512) N = 133,785		

Notes: (1) Each cell represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (3) Control group consists of individuals 13 to 15 years of age. (4) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (5) County mean populations are used as weights. (6) Standard errors are corrected for clustering at the state level. (7) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 6. Teen arrest rates for petty delinquency, 1980-2008

DDD estimates (coefficient on *MDA18*age16to18*)	(1)		(2)
Males		***Females***	
Disorderly conduct	-5.368*** (1.986) N = 133,364 Mean = 8.022	Disorderly conduct	-1.200*** (0.363) N = 133,713 Mean = 2.134
Vandalism	-0.247 (0.325) N = 133,067 Mean = 5.611	Vandalism	-0.162** (0.061) N = 133,910 Mean = 0.572
Curfew	0.184 (0.729) N = 134,473 Mean = 2.061	Curfew	-0.338 (0.320) N = 135,392 Mean = 0.749
		Prostitution	0.020 (0.102) N = 139,229 Mean = 0.046

Notes: (1) Each cell represents a separate regression. (2) For context, each cell reports the mean arrest rate for 16 to 18 year-olds in states with an MDA lower than 18. (3) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (4) Control group consists of individuals 13 to 15 years of age. (5) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (6) County mean populations are used as weights. (7) Standard errors are corrected for clustering at the state level. (8) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 7. Interaction terms and male arrest rates, 1980-2008

	(1) All crimes	(2) Property crime	(3) Violent crime	(4) Drug crime
*MDA18*age16to18 **	1.350	5.206***	0.468	-3.469
% black below median	(3.794)	(1.109)	(1.986)	(2.862)
	N = 134,293	N = 134,034	N = 134,114	N = 133,857
*MDA18*age16to18**	-1.403	1.256	-0.298	-2.396
income below median	(3.362)	(1.289)	(1.060)	(1.652)
	N = 134,293	N = 134,034	N = 134,114	N = 133,857

Notes: (1) Each column represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (3) Control group consists of individuals 13 to 15 years of age. (4) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include an MDA18 indicator, an age16to18 indicator, county fixed effects, year fixed effects, and state-specific time trends. Lastly, the regressions in the top panel include an indicator for whether the percentage of the county's black population is below the sample median, while the regressions in the bottom panel include an indicator for whether the county's real income per capita is below the sample median. (5) County mean populations are used as weights. (6) Standard errors are clustered at the state-level. (7) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 8. Sensitivity of male arrest results to alternative specifications, 1980-2008

(1) Baseline estimate from Column in 3 Table 4	(2) DD estimate	(3) log(arrest rate)	(4) Add age-specific trends	(5) Add age-by-year and age-by-state fixed effects	(6) 19 year-olds as controls	(7) No sample restrictions	(8) Only counties in states with major exemptions	(9) Exclude CA, FL, NY, and TX counties counties
-10.27*	-7.32*	-0.132*	-13.00**	-5.364*	-3.400	-8.367*	-14.65**	-11.12***
(5.323)	(3.88)	(0.070)	(5.061)	(3.172)	(3.953)	(4.526)	(6.716)	(3.793)
N = 134,293	N = 71,841	N = 120,749	N = 134,293	N = 134,293	N = 134,477	N = 145,750	N = 93,034	N = 113,149

Notes: (1) Each cell represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population for all crimes (i.e. property + violent + drug). (3) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (4) County mean populations are used as weights. (5) Standard errors are corrected for clustering at the state level. (6) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 9. 19-21 year-old male arrest rates, 1980-2008

	(1) All crimes	(2) Property crime	(3) Violent crime	(4) Drug crime
*MDA18*age19to21*	-1.545	0.263	-1.503	-0.074
	(5.476)	(3.401)	(0.987)	(2.556)
	N = 201,399	N = 200,795	N = 201,188	N = 200,711

Notes: (1) Each cell represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (3) The MDA18 variable represents a three year lagged indicator. This is done so as to represent the dropout age regime that was in place when the 19 to 21 year-old age group was in high school. (4) Control group is 13 to 18 year-olds. (5) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (5) County mean populations are used as weights. (6) Standard errors are clustered at the state-level. (7) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 10. MDA laws and police enforcement, 1982-2005

	(1) Policemen per capita	(2) Police expenditures per capita
MDA17	0.073	-0.299
	(0.061)	(1.816)
MDA18	-0.014	-10.400***
	(0.048)	(2.151)
N	1,152	1,058
R^2	0.971	0.981
State FE	YES	YES
Year FE	YES	YES
State trends	YES	YES

Notes: (1) Each column is a separate state-level regression. (2) The dependent variable in the first column is the number of sworn police officers per capita. The dependent variable in the second column is police protection expenditures per capita in 2000 dollars. (3) All regression models control for the fraction of the population aged 15-19, the fraction of the population that is black, the minimum legal drinking age, state fixed effects, year fixed effects, and state-specific time trends. (4) State populations are used as weights. (5) Standard errors are corrected for clustering at the state level. (6) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table 11. Do MDA laws displace problems to schools? Evidence from YRBS data

Coefficients on *MDA18*	(1) Everyone	(2) Males	(3) Females
Missed school out of fear for own safety during past month	0.032***	0.019	0.044**
	(0.008)	(0.018)	(0.017)
N	113,727	55,927	57,800
Mean of dependent variable	0.062	0.061	0.063
Had sexual intercourse during past month	0.025	-0.009	0.061**
	(0.016)	(0.040)	(0.025)
N	106,441	51,699	54,742
Mean of dependent variable	0.412	0.419	0.406
Ever been pregnant	…	…	0.026
			(0.018)
N	…	…	42,303
Mean of dependent variable	…	…	0.093

Notes: (1) Each cell represents a separate regression. (2) The dependent variable in the top panel is equal to one if the respondent missed school out of fear for his or her own safety during the past month, and is equal to zero otherwise. The dependent variable in the middle panel is equal to one if the respondent had sexual intercourse during the past month, and is equal to zero otherwise. The dependent variable in the bottom panel is equal to one if the respondent has ever been pregnant, and is equal to zero otherwise. (3) For context, each cell reports the mean rate for individuals in states with an MDA lower than 18. (4) At the individual-level, all regression models control for age, grade, and race. All regression models also include state fixed effects, year fixed effects, and state-specific time trends. (5) Standard errors are clustered at the state-level. (6) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table A1: MDA laws and high school dropout status: Evidence from Census data

	(1) All	(2) Males	(3) Females
Minimum dropout age	-0.022**	-0.018**	-0.025**
	(0.010)	(0.009)	(0.011)
N	3,623,526	1,777,128	1,846,398
R^2	0.091	0.089	0.094

Notes: (1) Sample is based on IPUMS data (1 percent samples) from the 1980, 1990, and 2000 Censuses. (2) Each column represents a separate regression. (3) The dependent variable is a dummy equal to 1 if the respondent is a high school dropout. All regression models control for age, race, ethnicity, cohort of birth, state of birth, and state of residence. Age effects are 14 dummy variables (20-22, 23-25, 26-28, etc.). Cohort of birth effects are 7 dummy variables for decade of birth (1913-1922, 1923-1932, 1933-1942, etc.). State of birth effects are 51 dummies for state of birth (District of Columbia included). State of residence effects are 51 dummies for state of residence (District of Columbia included). (4) Standard errors are clustered at the state level. (5) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table A2: Teen arrest rates by single ages, 1980-2008

	(1) All crimes	(2) Property crime	(3) Violent crime	(4) Drug crime
Males				
*MDA18*age16*	-7.431*	-2.393*	-1.980	-2.584
	(4.098)	(1.361)	(1.358)	(2.196)
*MDA18*age17*	-11.69**	-3.564**	-3.034**	-4.549
	(5.273)	(1.450)	(1.435)	(3.317)
*MDA18*age18*	-10.87*	-3.399	-4.204***	-2.528
	(6.364)	(2.107)	(1.334)	(4.339)
N	334,861	334,149	334,128	333,862
R^2	0.813	0.702	0.849	0.663
Females				
*MDA18*age16*	-0.471	-0.054	-0.246	-0.123
	(0.711)	(0.456)	(0.223)	(0.223)
*MDA18*age17*	-2.072	-1.009	-0.691*	-0.257
	(1.261)	(0.924)	(0.345)	(0.373)
*MDA18*age18*	-2.530	-1.597	-1.105**	0.371
	(1.734)	(1.297)	(0.496)	(0.672)
N	334,673	334,246	334,109	334,345
R^2	0.694	0.646	0.670	0.546

Notes: (1) Each cell represents a separate regression. (2) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (3) Control group consists of individuals 13 to 15 years of age. (4) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (5) County mean populations are used as weights. (6) Standard errors are clustered at the state-level. (7) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table A3. Difference-in-difference results, 1980-2008

	All crimes		
	(1)	(2)	(3)
Males			
MDA18	-15.23**	-15.01*	-13.65**
	(5.882)	(8.170)	(5.832)
N	67,282	67,282	67,282
R^2	0.898	0.912	0.917
Females			
MDA18	4.818**	-2.534	-3.092
	(2.349)	(2.634)	(2.061)
N	67,296	67,296	67,296
R^2	0.702	0.760	0.772
County FE	YES	YES	YES
Year FE	NO	YES	YES
Other covariates	NO	NO	YES

Notes: (1) Each cell represents a separate regression. (2) The dependent is the arrest rate per 1,000 of the 16 to 18 year-old age group for all crimes (i.e. property + violent + drug). (3) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. (4) County mean populations are used as weights. (5) Standard errors are clustered at the state-level. (6) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.

Table A4. 19-21 year-old male arrest rates for white collar crimes, 1980-2008

	(1) Forgery	(2) Fraud	(3) Embezzlement
*MDA18*age19to21*	0.009	-0.876**	0.008
	(0.109)	(0.389)	(0.020)
	N = 132,828	N = 132,872	N = 136,612
	Mean = 1.229	Mean = 3.816	Mean = 0.067

Notes: (1) Each cell represents a separate regression. (2) For context, each cell reports the mean arrest rate for 19 to 21 year-olds in states that had an MDA lower than 18. (3) The dependent variable is the arrest rate per 1,000 of the relevant age group population. (4) The MDA18 variable represents a three year lagged indicator. This is done so as to represent the dropout age regime that was in place when the 19 to 21 year-old age group was in high school. (5) Control group is 16 to 18 year-olds. (6) Other covariates control for county demographic variables, population density, the minimum wage, the minimum legal drinking age, and the count of agencies reporting each year. All regressions also include county fixed effects, year fixed effects, and state-specific time trends. (7) County mean populations are used as weights. (8) Standard errors are clustered at the state-level. (9) *, significant at 10% level; **, significant at 5% level; ***, significant at 1% level.