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Does the Minimum Legal Drinking Age Save Lives?

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Abstract

The minimum legal drinking age (MLDA) is widely believed to save lives by reducing traffic fatalities among underage drivers. Further, the Federal Uniform Drinking Age Act, which pressured all states to adopt an MLDA of 21, is regarded as having contributed enormously to this life saving effect. This paper challenges both claims. State-level panel data for the past 30 years show that any nationwide impact of the MLDA is driven by states that increased their MLDA prior to any inducement from the federal government. Even in early adopting states, the impact of the MLDA did not persist much past the year of adoption. The MLDA appears to have only a minor impact on teen drinking.

1. Introduction

The Federal Uniform Drinking Age Act (FUDAA), signed by President Ronald Reagan on July 17, 1984, threatened to withhold highway construction funds from states that failed to increase their minimum legal drinking age (MLDA) to 21 by October 1, 1986. Some states complied without protest, but many states balked and sued the federal government to prevent implementation of the Act. In *South Dakota v. Dole* (1987), however, the U.S. Supreme Court ruled the Act constitutional. The Court decided that the "relatively small financial inducement offered by Congress" was not so coercive "as to pass the point at which pressure turns into compulsion." The Court argued, in particular, that reducing traffic fatalities among 18-20 year olds was sufficient reason for the federal government to intervene in an arena traditionally reserved to states.[1]

Research subsequent to the Court's decision appears to confirm that raising the MLDA saves lives, and much of it points to the FUDAA in particular. Relying on this research, the National Highway Traffic Safety Administration (NHTSA) attributes substantial declines in motor vehicle fatalities to federal and state traffic-safety policies, particularly the MLDA21. For example, NHTSA estimates the cumulative number of lives saved by the MLDA21 at 21,887 through 2002 (U.S. Department of Transportation, March 2005).

We challenge the view that MLDAs reduce traffic fatalities, based on three findings. First, the overall impact estimated in earlier research is driven by states that increased their MLDA prior to any inducement from the federal government. Second, even in early adopting

[1] In her dissent, Justice Sandra Day O'Connor expressed skepticism that a uniform drinking age of 21 across the United States would have the "life-saving' effects that might justify federal encroachment on rights afforded to states under the 10th Amendment to the Constitution (*South Dakota v. Dole*, 1987). The 10th Amendment states, "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people. At least one of the authors believes that, even if the MLDA saves lives, the FUDAA is not constitutional.

states, the impact of the MLDA did not persist much past the year of adoption. Third, the MLDA has at most a minor impact on teen drinking.

The remainder of the paper is organized as follows. Section 2 outlines the history of the MLDA and reviews the pre-existing literature. Section 3 examines the aggregate trends in the key variables. Section 4 describes the state-level data set and presents panel estimates of the relation between the MLDA and traffic fatalities. Section 5 investigates the effects of the MLDA on teen drinking.

2. Historical Background and Prior Literature

When the United States repealed Alcohol Prohibition in 1933, the 21st Amendment left states free to legalize, regulate, or prohibit alcohol as they saw fit. Most legalized but also enacted substantial regulation. This new regulation typically included an MLDA.

Table 1 gives the MLDA set by each state after Prohibition ended.[2] State reactions to federal repeal varied, from Alabama maintaining state-level prohibition to Colorado legalizing alcohol without a minimum drinking age. In general states set an MLDA between 18 and 21. In 1933, 32 states had an MLDA of 21 and 16 had an MLDA between 18 and 20. With few exceptions, these MLDAs persisted through the late 1960s.

Between 1970 and 1976 thirty states lowered their MLDA from 21 to 18. These policy changes coincided with national efforts toward greater enfranchisement of youth, exemplified by the 26th Amendment giving 18-20 year olds the right to vote. The reasons for lowering the MLDA are not well understood and may have varied by state. Perhaps the changes reflected Vietnam-era logic that a person old enough to die for America is old enough to drink (Asch and Levy 1987, Mosher 1980). Whatever the reasons, the lower MLDAs "enfranchised" over five million 18-20 year olds to buy alcohol (Males 1986, p. 183).

[2] This table indicates the MLDA for beer with greater than 3.2% alcohol content. The previous literature has generally ignored that different alcohol types have different MLDAs. We consider this issue below.

Soon after the reductions in the MLDAs, empirical studies claimed that traffic collisions and fatalities were increasing in states that lowered their MLDA. Most prominently featured in congressional discussion were two comprehensive, multi-state studies on the "life-saving" effects of raising the MLDA—the Insurance Institute for Highway Safety (IIHS) study and the National Transportation Safety Board (NTSB) study. According to Males (1986), both studies were referred to more than 50 times in the House and Senate debates, "almost to the exclusion of other research on the question" (p. 182). [3] These research findings played a key role in reversing the trend toward lower MLDAs. The justification for the FUDAA, espoused by organizations like the Presidential Commission on Drunk Driving, the American Medical Association, and the National Safety Council, was that higher MLDAs resulted in fewer traffic fatalities among 18-20 year olds (Males, 1986).

After passage of the FUDAA, all states adopted an MLDA21 by the end of 1988. Table 2 gives the most recent date each state switched to an MLDA21. Several states were early adopters (Michigan, Illinois, Maryland, and New Jersey), increasing their MLDAs before passage of the FUDAA. Other states were less eager to change. Colorado, Iowa, Louisiana, Montana, South Dakota, Texas, and West Virginia passed MLDA21 legislation, for example, but each provided for repeal if the FUDAA were held unconstitutional (DISCUS, 1996). Texas and Kansas enacted "sunset provisions" allowing the MLDA to drop back to 18 once federal sanctions expired (DISCUS, 1996). When the Supreme Court upheld the legality of the FUDAA, states faced a strong incentive to maintain an MLDA21. Nevertheless, the differences in how states responded suggests a policy endogeneity that needs to be addressed.

Several authors have recently summarized the MLDA literature, so we do not review specific papers in detail (see Shults et al. 2001, Wagenaar and Toomey 2002). Overall the existing research finds a negative relationship between the MLDA and traffic fatalities, but most

[3] Males (1986) argues that the two studies suffered from methodological and data limitations and had undeserved influence over the federal decision to intervene in state drinking age laws.

studies omit key variables and mainly analyze either cross-sectional data from one year or time-series data in one state (Ruhm 1996).

The most important exception to this summary is Dee (1999), who uses state-level panel data and controls for state fixed-effects, state trends, year dummies, and other variables. Dee's estimates "suggest that the movement to [a] higher MLDA reduced … traffic fatalities by at least 9%" (Dee, 1999, p. 314). Dee's analysis forms the starting point for the empirical work below.

In addition to considering the impact of the MLDA on traffic fatalities, earlier literature also considers how the MLDA affects teen drinking.[4] Kaestner (2000) explains that most studies use cross-sectional data and fail to control for unmeasured state characteristics affecting both alcohol consumption and minimum drinking ages. Again, Dee (1999) is an exception. Using the same techniques just described, Dee concludes that moving away from an MLDA of 18 is associated with a reduction in heavy teen drinking of 8.4%. More recently, Carpenter et al. (2007) replicate Dee (1999) and extend his sample to include 11 more years of data.[5] They find that "exposure to an MLDA of 18 was associated with a statistically significant increase in drinking participation and heavy drinking of about 4 and 3 percentage points, respectively" (p. 21).[6] They acknowledge, however, that adoption of the MLDA21 might have increased underreporting.

3. An Overview of the Aggregate Data

Before examining state-level regressions that relate traffic fatality rates (TFR) to MLDAs, we examine aggregate plots of the key variables. The reason is that state-level data on traffic fatalities are not available until the mid-1970s, but aggregate data on total and 15-24 year

[4] These studies rely on self-report of alcohol consumption. Outlawing a behavior, however, might reduce the degree of self-reporting.

[5] We are grateful to Kitt Carpenter for granting permission to cite his working paper.

[6] An MLDA of 18 is the most permissive MLDA in the sample.

old fatalities exist back to 1913. The 18-20 year old population is most relevant for the issues in this paper, but data for this age range are not available until 1975. The 18-20 fatality rate and the 15-24 fatality rate are highly correlated, however, as shown in Figure 1, so examination of the 15-24 TFR is likely informative.

Figure 2 presents the TFR for the total population and for 15-24 year olds for the period 1913-2004. These two series follow similar patterns over the past ninety years. Both TFRs increased from 1913 to 1969 and then decreased thereafter. This similarity fails to suggest a major impact of the MLDA, which should have affected the 15-24 TFR more than the total TFR. The marked decline in the TFR during this period also contravenes claims of a rapid increase in traffic fatalities after several states decreased their MLDAs between 1970 and 1973. The declines in the total and 15-24 TFR that began around 1969 long precede the adoptions of an MLDA of 21 in the mid-1980s.

The data in Figure 2 do not control for the vehicle miles traveled (VMT) each year, which have increased enormously over the past century (National Safety Council, 2004). Figure 3 shows that fatalities per VMT exhibit a persistent downward trend over the entire sample period. The 15-24 TFR does seem to increase slightly beginning in the 1960s, even when controlling for VMT, but the decline returns around 1969, prior to passage of the FUDAA.

Figure 4 plots the average MLDA for all 50 states against the (VMT-based) TFR for the 15-24 year old age cohort.[7] While the average MLDA remained at approximately 20 between 1944 and 1970, traffic fatalities continued to decrease for years and then increased. Then in the early 1970s, several states lowered their MLDAs, reducing the average to below 19. Yet the brief increase in traffic fatality rates that occurred in the latter half of the 1970s looks modest in comparison to the larger, downward trend that preceded these changes to the MLDA. Previous studies that focused on the late 1970s and the early 1980s were unlikely to see this longstanding

[7] We obtain similar results with a population-weighted, average MLDA.

trend. Overall, the TFR has been decreasing steadily since 1969, but most of the variation in the MLDA occurred in the 1980s. The one major increase in traffic fatalities, from 1961-1967, occurred while the average MLDA remained constant.

The key fact about TFRs, therefore, is that they have been trending downward for decades and have been poorly correlated with the MLDAs. Moreover, several others factors likely played a role in this downward movement. These factors include advances in medical technology, advances in car design (air-bags, anti-lock brakes, seat belts, safety glass), and improved education about driving strategies and the risks associated with motor vehicles (Houston et al., 1995).[8]

The aggregate data thus provide little confirmation that MLDAs reduce traffic fatalities. These data also suggest the importance of controlling for pre-existing trends. We address this concern in the analysis that follows.

4. Data and Results

We next examine the relation between MLDAs and traffic fatalities using state-level panel data. This approach is better targeted than the aggregate approach considered above, since it allows us to compare fatalities within each state to changes in the MLDA in that state.

We measure traffic fatalities using the Fatality Analysis Reporting System (FARS). FARS contains the characteristics of vehicles, drivers, occupants, and non-occupants involved in all recorded fatal motor vehicle accidents in the United States. Dee (1999) uses the FARS to construct a panel data set for the 48 contiguous states over the period 1977-1992. [9] We reconstruct Dee's (1999) data set and extend it to include Alaska, Hawaii, and Washington DC

[8] Harris et al. (2002) find that "the downward trend in lethality [of criminal assault] involves parallel developments in medical technology and related medical support services." These appear to have brought down the homicide rate even as aggravated assault rates remained constant.

[9] We thank Thomas Dee for generously providing us with some of the data used to replicate his 1999 paper.

and the years 1976 and 1993-2005. We focus on 18-20 year–old fatalities because this group is most directly affected by changes in MLDA laws. Robustness checks reported later examine younger and older age groups.

We merge the FARS data with population information from the Census Bureau to construct age-specific vehicular fatality rates. We also include the unemployment rate, real per capita personal income, a binary indicator for whether a state has a mandatory seat belt law, the blood alcohol concentration (BAC) limit for legal driving, beer taxes, and total vehicle miles traveled. The last variable is a proxy for the vehicle miles traveled by 18-20 year olds, as mileage data are not age-specific. Table 3 presents summary statistics.

We omit several potentially relevant policies, in part to conform with Dee (1999), in part because of data availability, and in part because previous studies have found limited evidence of any impact on traffic fatality rates. These variables include dram shop liability laws, mandatory sentences for driving under the influence (DUI), sobriety check points, anti-plea bargaining statutes, changes in tort liability laws that place greater responsibility with intoxicated drivers, happy-hour regulations, and alcohol education programs.

Using this data set, we estimate

$$\ln(TFR_{st}/(1-TFR_{st})) = \beta_1 MLDA_{st} + \beta_2 Controls_{st} + \beta_3 (\text{state trend}) + u_s + v_t + e_{st} \qquad (1)$$

where β_1 is the point estimate of how MLDA laws influence traffic fatalities, β_2 is a vector of determinants of traffic fatalities, β_3 is the linear trend for each state, u_s is a state fixed-effect, v_t is a year-effect, and e_{st} is a mean-zero random error. We choose this form for the dependent variable to follow Dee (1999). We estimate this specification using weighted least squares. If TFR_{st} is the traffic fatality rate, and the regressand is $\ln(TFR_{st}/(1- TFR_{st}))$, then the error term is heteroscedastic, with variance $(TFR_{st}(1 - TFR_{st})n_{st})^{-1}$, where n_{st} is the age-specific population for the fatality rate (Ruhm 1996). In contrast to Dee, we cluster standard errors by state, although

this makes little difference to the results. As in Dee, we initially model the MLDA using separate variables for an MLDA of 19, 20, or 21 (all other states have 18).

Table 4 reports estimates of Equation (1).[10] Model (1) uses Dee's sample and replicates his results closely. In this specification an MLDA21 reduces traffic fatalities by 11.7%.[11] The insignificant coefficients on an MLDA19 and an MLDA20 are in accordance with Dee's findings. Model (2) extends the sample to include Alaska, Hawaii, and the District of Columbia, as well as the years 1976 and 1993-2005. This confirms Dee's findings that an MLDA21 reduces total traffic fatalities among 18-20 year olds by about 11%. Model (3) adds VMT, one variable that is available by state but that Dee did not include, and a dummy for whether the state has a BAC .08 per se law. This reduces the magnitude of the coefficient on MLDA21 to roughly 8%, but the significance remains. Models (2) and (3) report standard errors clustered by state. The significance of MLDA21 persists, though neither MLDA19 nor MLDA20 is significant.

The small and insignificant coefficients on MLDA19 and MLDA20 present a mild challenge to the claim that the MLDA reduces traffic fatalities. If restricting access to alcohol works as typically assumed, then though the MLDA21 should have the largest impact, the MLDA19 and MLDA20 should also reduce fatalities if restricting access works as typically assumed. This anomaly is not decisive because few states utilized an MLDA of 19 or 20, so the weak results might just reflect noise. Nevertheless, the coefficients are not always negative and never significant.

The results so far support two claims. Panel-data estimates suggest a substantial and statistically significant impact of the MLDA21. Aggregate data, however, make at most a weak

[10] The panel data set begins in 1976 because state unemployment rates are not available prior to that year.

[11] The slight difference between our findings and Dee's likely results from revised Census Bureau population data.

case, so the overall conclusion is not clear. To reconcile these different estimates, we conduct a state-by-state analysis of how the MLDA affects traffic fatalities.

Figure 5 graphs TFR18-20 in several states, along with an indicator for whether the state adopted an MLDA21. In South Carolina, TFR18-20 was increasing rapidly prior to adoption and then began a marked decline, consistent with an effect of the MLDA21 in reducing 18-20 year old fatalities. In California, however, TFR18-20 also declined dramatically even though the MLDA was 21 throughout. In South Dakota and Louisiana, TFR18-20 declined *prior* to the increase in the MLDA and seems to have decreased at a slower rate after MLDA21 adoption.[12] These four graphs, therefore, show a wide range of "impacts" of the MLDA. Plots for all 50 states confirm substantial heterogeneity in MLDA21's effect.

To examine this in more detail, Table 5 presents state-by-state estimates of the effects of the MLDA. Of the 38 states that increased their MLDA over the post 1975 time period, the MLDA21 reduced fatalities in six at the 5% level and in nine at the 10% level. At the same time, however, the MLDA21 increased fatalities in four states at the 5% level and in five at the 10% level. In eleven states the coefficient on MLDA is positive but insignificant while in thirteen it is negative but insignificant.

This heterogeneity suggests Dee's results are driven by a few states in which the impact is sufficiently negative to outweigh the positive or small impact in most states. The question is whether this heterogeneity is just sampling variation or something more systematic. We show below that the overall negative impact results from states that adopted the MLDA21 before 1984—that is, before the FUDAA.

Table 6 presents evidence for this claim. Model (1) repeats Model (1) from Table 4 for ease of comparison. Model (2) restricts the sample to those states that adopted the MLDA21 after 1979; this eliminates all states that had an MLDA21 prior to when FARS began collecting data.

[12] South Dakota and Louisiana were two states that challenged the constitutionality of the Federal Uniform Drinking Age Act.

The results are robust across this change in specification. Model (3) restricts the sample to those states that changed to an MLDA21 during or after 1983.[13] Again the MLDA 21 is significant, with a point estimate of -.07.

Model (4), however, which restricts the sample to states that changed their MLDA to 21 during or after 1984, results in a lower point estimate (-.058) that is not significant at even the 10% level. Model (5), which restricts the sample to those states that changed the MLDA after 1984, produces a coefficient on MLDA21 near zero with a *t*-statistic of -.21.[14] Model (6) excludes Illinois, Maryland, Michigan, and New Jersey, the four earliest states to change their MLDA back to 21, each doing so on or before January 1983. When the sample excludes these states, the significance of MLDA21 disappears and its magnitude drops to -0.035.[15]

The year 1984 is when the federal government became directly involved in state-level MLDA legislation. The federal government's threat to withhold highway funding from states is arguably an exogenous shock to state-level MLDA policy. Thus if causality is to be attributed to the MLDA, inference should focus especially on states that increased their MLDAs in response to this (arguably) exogenous pressure. Yet the results for these states show virtually no effect of the MLDA21. Those states driving the relation between MLDA21 and TFR18-20 are the ones that proactively changed their MLDA legislation prior to federal involvement.

These results suggest that, at most, the MLDA21 reduced TFR18-20 in states that adopted on their own. This raises the question of endogeneity. The MLDA21 in these states may have been enacted in response to grassroots concern against drunk driving or implemented

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[13] No states changed their MLDA to 21 in 1981 or 1982.

[14] The MLDA laws were coded such that a year cell has an MLDA21 indicator of 1 if the MLDA of 21 was in effect for at least half that year. As the FUDAA was passed in July, Model (4) includes states that adopted an MLDA21 before its passage. Model (5) differs in including states that adopted an MLDA21 after 1984.

[15] These results are robust across specifications that allow for quadratic state trends.

alongside other efforts to reduce traffic fatalities. Relatedly, states that adopted on their own may have been states that devoted significant resources to enforcement.

To address the possible endogeneity of MLDA legislation, we modify the specification of the MLDA variable. Instead of a dummy for years in which it is in effect, we include several binary variables representing an interval of time in relation to the date a state enacted an MLDA21. For example, the binary variable "5-6 Before" is equal to 1 for every state-year that is 5-6 years before a state adopted an MLDA of 21. The other intervals included in the regressions are "3-4 Before," "1-2 Before," "Year of Enactment," "1-2 After," "3-4 After," "5-6 After," "7-8 After," and "9-10 After." This empirical strategy improves on the approach in Section 4 because the time pattern of policy effects informs both the extent of policy endogeneity and the persistence of the policy's effect.

Table 7 gives estimates of this alternative specification; figures 6-9 plot the coefficients and standard error bands on the MLDA21 variables. Model (1) supports the claim that the MLDA legislation was not a significant determinant of traffic fatality rates, as none of the coefficients is significant at even the 10% level. The pattern of coefficients mildly suggests that the MLDA reduces TFR18-20, but the pre-adoption coefficients are positive, and the effect approaches zero in the years following enactment.

In Model (2), which includes only the states that adopted their MLDA21 during or prior to 1983, there does seem to be a significant and large drop in fatalities during the year of MLDA increase. Though not significant, this decrease predates the adoption of the MLDA21 across states, as illustrated by the negative coefficients on the binary indicators dating back six years before policy enactment. In the year of adoption, fatalities declined 16.7% at the 5% significance level. Yet as early as 1-2 years after enactment, the MLDA is no longer significant and the point estimate increases from -16.7% to -5.4%. More interestingly, the MLDA21 seems to increase fatalities from three to six years after enactment, although the result is not significant. This suggests the fatality-reductions due to MLDA21 policies were transient or even perverse.

Model (3) restricts the sample to those states that enacted an MLDA21 during or after 1984. Those states experienced increases in 18-20 year old fatalities leading up to enactment of an MLDA21; upon the adoption, there was no significant decrease in fatalities, and as soon as 1-2 years after adoption the increase in traffic fatalities became significant at the 10% level. As with the early adopters, the coefficient on MLDA21 approaches zero five years beyond adoption.

Model (4) restricts the sample to states that adopted the MLDA21 after 1984. The estimates suggest that 1 to 2 years after adoption, states experienced a 10% increase in 18-20 traffic fatalities, significant at the 1% level. The effect persists at the 10% significance level 3-4 years after the adoption. In these states the traffic fatality rate of 18-20 year olds seems to have been increasing prior to the adoption of the MLDA 21. In states that were pressured to change their MLDAs, the changes were likely inconsequential or even counterproductive.[16]

Several additional findings are also inconsistent with the claim that the minimum legal drinking age reduces traffic fatalities. Table 8 presents regressions analogous to those in Table 6, but using the 17 year old driver fatalities as the dependent variable, find that MLDA19, MLDA20, and MLDA21 all *increase* traffic fatalities at the 5% level of significance. One explanation is that when the MLDA is 18, more high school students have access to alcohol through peer networks, including 18 year olds. When the MLDA is higher, these peer networks are less effective at obtaining alcohol, so individuals younger than 18 feel pressure to drink intensely at each drinking occasion. Alternatively, when the MLDA is 18, law enforcement monitors the drinking behavior of individuals aged 17 and younger. When the MLDA is 21, this monitoring is spread more thinly, resulting in more drinking among 17 year olds.

A final result concerns construction of the MLDA variable. Many states employ different MLDAs for different categories of alcoholic beverages. For example, as of October 1983, North Carolina had an MLDA of 19 for beer and table wine but an MLDA of 21 for fortified wine and distilled spirits. Historically, states have been most willing to lower their MLDAs for beer. When

[16] These results are robust across specifications that allow for quadratic state trends.

it happens that only one alcohol category has an MLDA below 21, the MLDA variable used in earlier literature and our regressions has been set to that value. This might provide a misleading picture of the MLDA's impact.

To address this we estimate models that include an MLDA variable for strong beer, weak beer, fortified wine, table wine, and spirits. Table 9 presents results. In this specification none of the coefficients on an MLDA variable is significant, and no single coefficient has an absolute value greater than .03. The coefficients on the MLDA for strong beer and fortified wine are positive, while the coefficients on the MLDA for weak beer, table wine, and spirits are negative. This lack of consistency reaffirms the tenuous relationship between the MLDA and traffic fatalities.

5. The MLDA and Teen Alcohol Consumption

The final question we address is why the MLDA does not appear to have had much effect on traffic fatalities. One possibility is that although the MLDA reduces 18-20 year old drinking, it does so mainly for those who drink responsibly. Another possibility is that the MLDA does not reduce drinking to a substantial degree. The previous literature has suggested that the MLDA does reduce teen drinking. We revisit that question here.

We utilize data from Monitoring the Future, an annual survey of high school seniors that contains measures of drinking habits. We employ the two specific measures common in the literature, "drinker" (having any drink of alcohol in the last month), and "heavy episodic drinker" (having five or more drinks in a row at some point in the last two weeks). We also examine the number of motor vehicle accidents that respondents report as occurring after consuming alcohol. We estimate regressions similar to those considered above but with these dependent variables. The measure of the MLDA is identical to that used in previous literature, a dummy for having a drinking age of 18.

Tables 10 and Table 11 give results. Though we use slightly different data than Carpenter et al. (2007), we approximate their findings. Models (1) and (2) in Tables 10 and 11 show an MLDA18 is associated with an almost 4% increase in drinking participation rates, and approximately a 3% increase in heavy episodic drinking rates, both significant at the 1% level.

Model (3) and (4), however, suggest that these reductions derive mainly from states that adopted the MLDA21 before enactment of the FUDAA.[17] Model (3) shows that in the early-adopting states, the MLDA 18 is associated with a 5% increase in drinking participation and a 3.7% increase in heavy drinking, both significant at the 1% level. In later-adopting states, exposure to an MLDA of 18 has a weaker and insignificant effect on alcohol consumption.

Two interpretations of these results are possible. The absence of any effect of MLDA18 in reducing drinking in the coerced adopters is consistent with the absence of any effect of MLDA21 on traffic fatalities. The negative effects found for early adopters might reflect a true reduction in alcohol consumption and also explain a reduction in fatalities in these states. Yet these negative effects might also reflect an increase in underreporting in the MTF data due to enactment of MLDA21.

One mechanism for resolving this is to examine the number of alcohol-related traffic accidents reported by MTF respondents. If the MLDA works as predicted and underage persons are deterred from drinking, the number of accidents post-alcohol consumption should decline when a state adopts an MLDA21. The results in Table 12 are telling. The panel estimates reveal that movement away from an MLDA of 18 is associated with a statistically insignificant -.0007 change in reporting of alcohol-related traffic accidents. Given these findings, it is not surprising that Higson et al. found that "although the modes of procuring alcohol changed, no significant changes were observed in Massachusetts relative to New York in the proportion of surveyed teenagers who reported that they drank or in the volume of their consumption" (p. 163).

[17] The relevance of the MLDA of 21 to consumption patterns among high school seniors is that in a large number of states, movement away from a drinking age of 18 was brought about by the adoption of an MLDA of 21.

6. Conclusion

The MLDA21 is predicated on the belief that it reduces alcohol-related teen traffic-fatalities. We challenge that claim, showing that the MLDA fails to have the fatality-reducing effects that previous papers have reported.

If not the MLDA, then what might explain the drastic reductions in traffic fatalities over the past half century? Figure 2 suggests that the decline began in the year 1969, the year in which several landmark improvements were made in the accident avoidance and crash protection features of passenger cars. Table 13, taken from Crandall et al. (1986) shows just how many federal safety standards were introduced in the 1968 model year. They explain that "most of these standards for new automobiles were in place by 1970," which allowed for improvements in over three dozen safety measures not previously found in automobiles (Crandall et all, 1986, p. 47). Further research might operationalize these advancements in vehicle safety as they are likely to be major determinants of the declining traffic fatality trends.

The same effort should be made to measure and control for advances in medical technology. In this way, researchers can ascertain whether traffic fatalities are declining because traffic crashes are becoming less frequent or becoming less lethal. Future studies estimating the relationship between the MLDA and traffic fatality rates might use as control variables the number of blood banks, the number of hospital admissions, the number of hospitals that provide open-heart surgery, the number of hospital affiliated physicians, or the number of hospital beds in the state (Harris et al., 2002).

In arguing against an MLDA of 21, this paper also challenges the desirability of coercive federalism. The case of the drinking age informs several other public policy debates, including the appropriateness of the No Child Left Behind Act (NCLB). When the governor of Utah attempted to ignore NCLB's provisions that conflicted with Utah's own education policy, the Department of Education threatened to withhold federal education funding (Fusarelli, 2005). Fusarelli (2005) argues that such actions demonstrate that in just "a few short years, federal

education policy had shifted from minimal federal involvement (President Reagan wanted to abolish the U.S. Department of Education) to the development of voluntary national standards (under President Clinton) to the new law mandating testing of all students in Grades 3–8" (p. 121). Whether Congress has violated the 10th amendment with NCLB is a question left for the Supreme Court. Nevertheless, the empirical strategy employed in this paper might tease out whether the successes attributed to the NCLB are similarly driven by states that proactively adopted its standards of education reform prior to the federal mandate.

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APPENDIX A: DATA SOURCES

The sources of all the variables used in the reported regressions are listed below.

Fatalities

Data obtained from the Fatality Analysis Reporting System (FARS).

Consumption

Data obtained from private-use extract from the Monitoring the Future Surveys, contractually granted by the Institute for Social Research at the University of Michigan

Population

Data obtained from the United States Census Bureau.

Fatality Rates 1913-2005

Data obtained from the National Safety Council, 2005 Publication of *Injury Facts*.

Vehicles Miles Traveled

Data obtained from thirty issues of the Federal Highway Administration's annual publication, *Highway Statistics*.

Per Capita Personal Income Rates

Data obtained from the Bureau of Labor Statistics (BLS).

Beer Tax

Data obtained from the United States Brewers' Association, *Brewers Almanac*, published annually, 1941-present.

Unemployment Rates

Data obtained from the Bureau of Labor Statistics (BLS).

BAC .08 Laws

Data obtained from several issues of *The Insurance Fact Book,* published annually by the Insurance Information Institute.

MLDA Laws

Data obtained from Distilled Spirits Council of United States.

Mandatory Seat Belt Laws

Data obtained from several issues of *The Insurance Fact Book,* published annually by the Insurance Information Institute.

TABLES

Table 1: Minimum Legal Drinking Age Levels in States After Repeal of Prohibition, 1933

AL	Alcohol Prohibited	**KY**	21	**ND**	21
AK	18	**LA**	21	**OH**	16
AZ	21	**ME**	18	**OK**	21
AR	21	**MD**	21	**OR**	21
CA	21	**MA**	21	**PA**	21
CO	None	**MI**	18	**RI**	21
CT	21	**MN**	21	**SC**	18
DE	21	**MS**	18	**SD**	18
DC	18	**MO**	21	**TN**	21
FL	21	**MT**	21	**TX**	21
GA	21	**NE**	20	**UT**	21
HI	20	**NV**	21	**VT**	18
ID	20	**NH**	21	**VA**	18
IL	21	**NJ**	21	**WA**	21
IN	21	**NM**	21	**WV**	18
IA	21	**NY**	21	**WI**	18
KS	18	**NC**	18	**WY**	21

Table 2: States' Most Recent Date of Adopting an MLDA of 21

AL	10/85	**KY**	05/38	**ND**	12/36
AK	10/83	**LA**	03/87	**OH**	08/87
AZ	01/85	**ME**	07/85	**OK**	09/83
AR	03/35	**MD**	07/82	**OR**	12/33
CA	12/33	**MA**	06/85	**PA**	07/35
CO	07/87	**MI**	12/78	**RI**	07/84
CT	09/85	**MN**	09/86	**SC**	09/86
DE	01/84	**MS**	10/86	**SD**	04/88
DC	10/86	**MO**	05/45	**TN**	08/84
FL	07/85	**MT**	05/87	**TX**	09/86
GA	09/86	**NE**	01/85	**UT**	03/35
HI	10/86	**NV**	12/33	**VT**	07/86
ID	04/87	**NH**	06/85	**VA**	07/85
IL	01/80	**NJ**	01/83	**WA**	01/34
IN	01/34	**NM**	12/34	**WV**	07/86
IA	07/86	**NY**	12/85	**WI**	09/86
KS	07/85	**NC**	09/86	**WY**	07/88

Table 3: Summary Statistics for Variables Used in the Construction of the Dependent Variables and Endogenous Regressors, 1976-2005.

Variable	Obs	Mean	Std. Dev.	Min	Max
MLDA	1530	20.39	1.11	18	21
Total fatality rate	1530	19.39	7.12	5.52	59.51
18-20 fatality rate	1530	43.36	18.53	0	168.41
17 & under fatality rate	1530	9.87	3.98	.79	31.28
21-23 fatality rate	1530	38.55	15.92	0	161.72
25-29 fatality rate	1530	26.83	11.41	1.50	95.28
Per capita personal income	1530	19165.38	8603.89	4744	54985
State unemployment rate	1530	5.96	2.00	2.30	17.4
Total vehicle miles traveled	1530	42410.23	46065.99	2527	329267
BAC08 Limit?	1530	.20	.40	0	1
Seat Belt Law?	1530	.57	.49	0	1
Beer Tax	1520	.52	.18	.24	1.86

Fatality rates are per hundred thousand members of the age-specific state population.

Table 4

WLS Estimates of Teen Traffic Fatality Equation, 18-20 Year Olds

Specification		Model (1)	Model (2)	Model (3)
	Dee (1999) published results	Replication of Dee (1999)	Dee (1999) extended 13 years, plus HI, AK, & D.C.	Model (2) controlling for VMT and BAC .08
MLDA 19	-0.022	-0.028	-0.021	-0.014
	(1.06)	(0.022)	(0.023)	(0.021)
MLDA 20	-0.009	0.007	-0.012	-0.004

The dependent variable is the natural logarithm of TFR_{st} /(1-TFR_{st}) where TFR_{st} is the 18-20 year old total fatality rate for state s at time t. The estimations are weighted by $n(TFR_{st})(1-TFR_{st})$ where n is 18-20 year old population in state s at time t. Dee's results, as well as Models (1) and (2) include variables controlling for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, and a binary indicator for any mandatory seat belt law. Additionally, Model (3) controls for whether the state has a BAC .08 law and vehicle miles traveled within the state. Robust standard errors are reported below point estimates for Models (1) – (3). Standard errors clustered by state are reported for Model (2) and Model (3). Dee's original results were reported with t-statistics instead of standard errors, and are reproduced as such.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 5

State by State OLS Estimates with Newey-West HAC Standard Errors of MLDA Regressed on Total Traffic Fatalities among 18-20 Year Olds 1976-2005

State	MLDA	SE	State	MLDA	SE
AL	0.065	(0.054)	**MT**	0.168	(0.054)***
AK	-0.406	(0.206)*	**NE**	-0.034	(0.127)
AZ	-0.065	(0.054)	**NV**		
AR			**NH**	-0.153	(0.146)
CA			**NJ**	-0.176	(0.032)***
CO	0.063	(0.031)*	**NM**		
CT	-0.244	(0.071)***	**NY**	0.007	(0.053)
DE	0.092	(0.158)	**NC**	-0.124	(0.024)***
FL	0.076	(0.07)	**ND**		
GA	-0.018	(0.028)	**OH**	-0.012	(0.028)
HI	0.356	(0.144)**	**OK**	-0.055	(0.024)**
ID	-0.023	(0.093)	**OR**		
IL	-0.066	(0.059)	**PA**		
IN			**RI**	-0.31	(0.123)**
IA	-0.102	(0.068)	**SC**	0.166	(0.052)***
KS	0.102	(0.034)***	**SD**	0.092	(0.11)
KY			**TN**	0.015	(0.086)
LA	-0.05	(0.029)*	**TX**	-0.056	(0.035)
ME	0.078	(0.091)	**UT**		
MD	-0.104	(0.025)***	**VT**	0.038	(0.031)
MA	0.04	(0.129)	**VA**	0.097	(0.075)

MI	-0.1	(0.053)*	**WA**		
MN	-0.116	(0.128)	**WV**	-0.176	(0.126)
MS	0.013	(0.033)	**WI**	-0.055	(0.034)
MO			**WY**	-0.142	(0.089)

The dependent variable is the natural logarithm of TFR_t /(1-TFR_t) where TFR_t is the 18-20 year old total fatality rate at time *t*. **States with black cells are ones that had already had in place an MLDA of 21 before 1976, and thus had no variation in MLDA over the last 30 years. Red indicates a coefficient is negative and significant at least at the 10% level. Blue indicates a coefficient is positive and significant at least at the 10% level.** The regressions include controls for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, total vehicle miles traveled in the state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. Newey-West HAC standard errors are reported.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 6

WLS Estimates of Total Traffic Fatality Equation 18-20 Year Olds, 1976-2005
Samples Restricted by Year States Adopted an MLDA of 21

Specification	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	Not Restricted	States that changed MLDA to 21 before 1980	States that changed MLDA to 21 before 1983	States that changed MLDA to 21 between 1984-2005	States that changed MLDA to 21 between 1985-2005	All states 1975-2005, w/o IL, MI, MD, NJ
MLDA 19	-0.014	-0.01	-0.011	-0.01	-0.008	-0.013
	(0.021)	(0.019)	(0.021)	(0.021)	(0.022)	(0.022)
MLDA 20	-0.004	0.001	0.003	0.004	0.014	0.004
	(.034)	(0.036)	(0.036)	(0.036)	(0.039)	(0.035)
MLDA 21	-0.08	-0.087	-0.069	-0.058	-0.008	-0.035
	(0.032)**	(0.030)***	(0.034)**	(0.037)	(0.037)	(0.037)
Constant	75.177	67.985	71.45	74.904	73.781	79.8
	(19.260)***	(24.944)***	(25.074)***	(25.271)***	(28.895)**	(20.110)***
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State Trends	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1519	1129	1099	1069	949	1399
R-squared	0.87	0.87	0.86	0.86	0.86	0.86

The dependent variable is the natural logarithm of TFR_{st} /(1-TFR_{st}) where TFR_{st} is the 18-20 year old total fatality rate for state *s* at time *t*. The estimations are weighted by $n(TFR_{st})(1-$

TFR_{st}) where *n* is 18-20 year old population in state *s* at time *t*. All models include variables controlling for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, vehicle miles traveled within state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. They also allow for linear state trends. Robust standard errors are reported below point estimates.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 7

WLS Estimates of Total Traffic Fatality Rate 18-20 Year Olds, 1976-2005
Samples Restricted by Year States Adopted an MLDA of 21

Specification	Model (1)	Model (2)	Model (3)	Model (4)
	Not restricted	States that changed MLDA to 21 before 1983	States that changed MLDA to 21 between 1984-2005	States that changed MLDA to 21 between 1985-2005
5-6 Years Before	0.022	-0.061	0.023	0.023
	(0.026)	(0.059)	(0.034)	(0.044)
3-4 Years Before	0.014	-0.019	0.039	0.004
	(0.02)	(0.059)	(0.046)	(0.054)
1-2 Years Before	0.022	-0.014	0.073	0.029
	(0.023)	(0.059)	(0.041)*	(0.045)
Year of Enactment	-0.042	-0.167	0.055	0.045
	(0.033)	(0.054)***	(0.044)	(0.051)
1-2 Years After	-0.016	-0.054	0.08	0.102
	(0.024)	(0.038)	(0.041)*	(0.036)***
3-4 Years After	-0.012	0.017	0.061	0.094
	(0.026)	(0.053)	(0.059)	(0.049)*
5-6 Years After	-0.006	0.025	0.016	0.038
	(0.026)	(0.041)	(0.046)	(0.042)
7-8 Years After	-0.027	0.06	-0.04	-0.043
	(0.032)	(0.031)*	(0.042)	(0.052)
9-10 Years After	0.002	0.042	0.006	0.005
	(0.022)	(0.037)	(0.027)	(0.036)
Constant	81.07	77.964	87.804	74.012
	(19.929)***	(38.567)*	(27.225)***	(28.653)**
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
State Trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Observations	1519	459	1060	949

The dependent variable is the natural logarithm of TFR_{st} /(1-TFR_{st}) where TFR_{st} is the 18-20 year old total fatality rate for state *s* at time *t*. The estimations are weighted by $n(TFR_{st})(1-TFR_{st})$ where *n* is 18-20 year old population in state *s* at time *t*. All models include variables controlling for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, vehicle miles traveled within state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. They also allow for linear state trends. Robust standard errors are reported below point estimates.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 8

WLS Estimates of Total Driver Fatality Rate, Selected Age Groups 1976-2005

Specification	Model (1)	Model (2)	Model (3)
Dependent Variable:	Driver Fatality Rate, persons aged 17 and under	Driver Fatality Rate, persons aged 18 to 20 years old	Driver Fatality Rate, persons aged 21 to 23 years old
MLDA 19	0.073	-0.007	0.015
	(0.032)**	(0.023)	(0.027)
MLDA 20	0.102	0.007	0.026
	(0.036)***	(0.04)	(0.052)
MLDA 21	0.092	-0.08	-0.029
	(0.035)**	(0.034)**	(0.031)
Constant	71.496	72.571	83.494
	(35.141)**	(25.698)***	(21.259)***
State Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
State Trends	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes
Observations	1501	1516	1517
R-squared	0.85	0.85	0.82

The dependent variable is the natural logarithm of TFR_{st} /(1-TFR_{st}) where TFR_{st} is the age-specific fatality rate for drivers in state *s* at time *t*. The estimations are weighted by $n(TFR_{st})(1-TFR_{st})$ where *n* is age-specific population in state *s* at time *t*. All models include variables controlling for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, vehicle miles traveled within state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. They also allow for linear state trends. Robust standard errors are reported below point estimates.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 9

WLS Estimates of Fatality Rates of 18-20 Year Olds by Various MLDA Laws, 1977-2005

Dependent Variable:	Total Traffic Fatality rate 18-20 year olds
MLDA Near Beer	-0.017
	(0.02)
MLDA Strong Beer	0.028
	(0.019)
MLDA Table Wine	-0.031
	(0.018)
MLDA Fortified Wine	0.009
	(0.047)
MLDA Spirits	-0.028
	(0.046)
Constant	71.503
	(17.921)***
State Fixed Effects	Yes
Year Fixed Effects	Yes
State Trends	Yes
Controls	Yes
Clustered SE	Yes
Observations	1519
R-squared	0.87

The dependent variable is the natural logarithm of TFR_{st} /(1-TFR_{st}) where TFR_{st} is the 18-20 year old total fatality rate for state s at time t. The estimations are weighted by $n(TFR_{st})(1-TFR_{st})$ where n is 18-20 year old population in state s at time t. All models include variables controlling for the state unemployment rate, state average per capita personal income, the beer tax rate in the state, vehicle miles traveled within state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. They also allow for linear state trends. Robust standard errors are reported below point estimates.

*significant at 10%; ** significant at 5%; *** significant at 1%

Table 10

WLS Estimates of MLDA 18 Effects on Drinking Participation Rates in High School Seniors, 1976-2004 MTF

		Model (1)	Model (2)	Model (3)	Model (4)
	Carpenter et al. (2007) estimates: 1976-2003	Replicating Carpenter et al. (2007) estimates: 1976-2003	Adding control variables to Carpenter et al. (2007), extending to include 2004	Modified specification, limited to states that changed MLDA to 21 before 1984	Modified specification, limited to states that changed MLDA to 21 between 1985-2004
MLDA 18	.039 (3.9)***	.038 (0.015)***	.037 (.014)***	.05 (.013)***	.028 (.018)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
State Trends	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes
R-squared	.086	.080	.081	.084	.80
Observations	394,547	451,747	466,969	207,036	259,933

Table 11

WLS Estimates of MLDA 18 Effects on Heavy Episodic Drinking Participation Rates in High School Seniors, 1976-2004 MTF

		Model (1)	Model (2)	Model (3)	Model (4)
	Carpenter et al. (2007) estimates: 1976-2003	Replicating Carpenter et al. (2007) estimates: 1976-2003	Adding control variables to Carpenter et al. (2007), extending to include 2004	Modified specification, limited to states that changed MLDA to 21 before 1984	Modified specification, limited to states that changed MLDA to 21 between 1985-2004
MLDA 18	.031 (4.0)***	.034 (0.011)***	.033 (.011)***	.037 (.013)***	.025 (.016)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
State Trends	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes
R-squared	.075	.068	.068	.70	.69
Observations	394,547	451,747	466,969	207,036	259,933

Carpenter et al. (2007) includes controls for demographic covariates, including: age, a male indicator, an indicator for Hispanic ethnicity, an indicator for African American race, and an indicator for "other race," as well as levels of the beer tax and presence of Zero Tolerance laws in a state-year. My controls include presence of BAC .08 per se law, state unemployment rates, per capita personal income rates, beer tax rates, and age of respondent. Robust standard errors are reported below point estimates for Models (1)-(4). The results in Carpenter et al. (2007) were reported with t-statistics instead of standard errors, and are reproduced as such.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12	
WLS Estimates of MLDA 18 Effects on Alcohol-Related Accidents in High School Seniors, 1976-2004 MTF	
	Dependent Variable: # of traffic-related accidents after alcohol consumption
MLDA 18	-.0007 (0.02)
State Fixed Effects Year Fixed Effects State Trends Controls Clustered SE	Yes Yes Yes Yes Yes
R-squared Observations	.18 457,145

The model includes variables controlling for the age of the respondent, the state unemployment rate, state average per capita personal income, the beer tax rate in the state, vehicle miles traveled within state, the BAC limit for driving in a state, and a binary indicator for any mandatory seat belt law. They also allow for linear state trends. Robust standard errors are reported below point estimates.

*significant at 10%; ** significant at 5%; *** significant at 1%

FIGURES

FIGURE 1

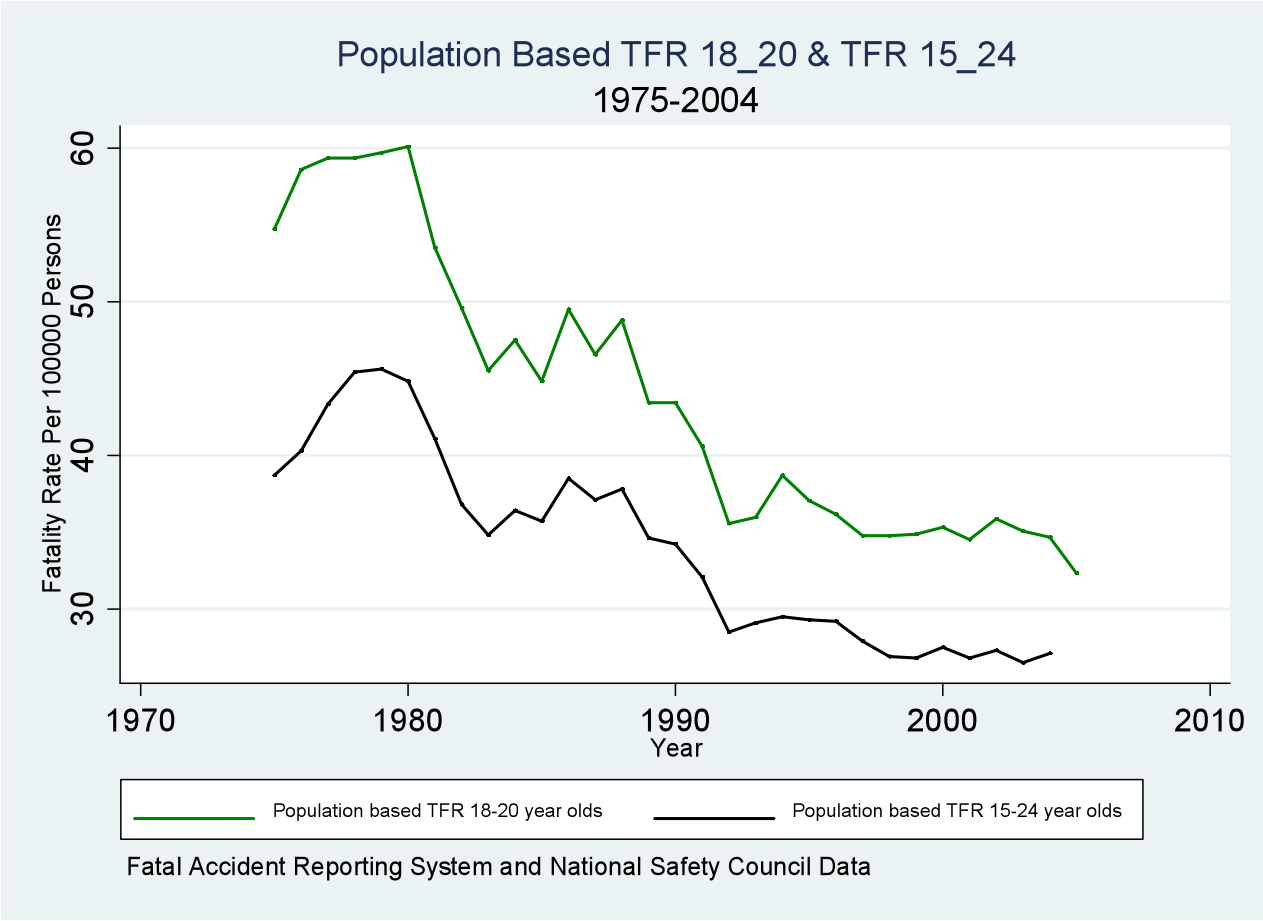


FIGURE 2

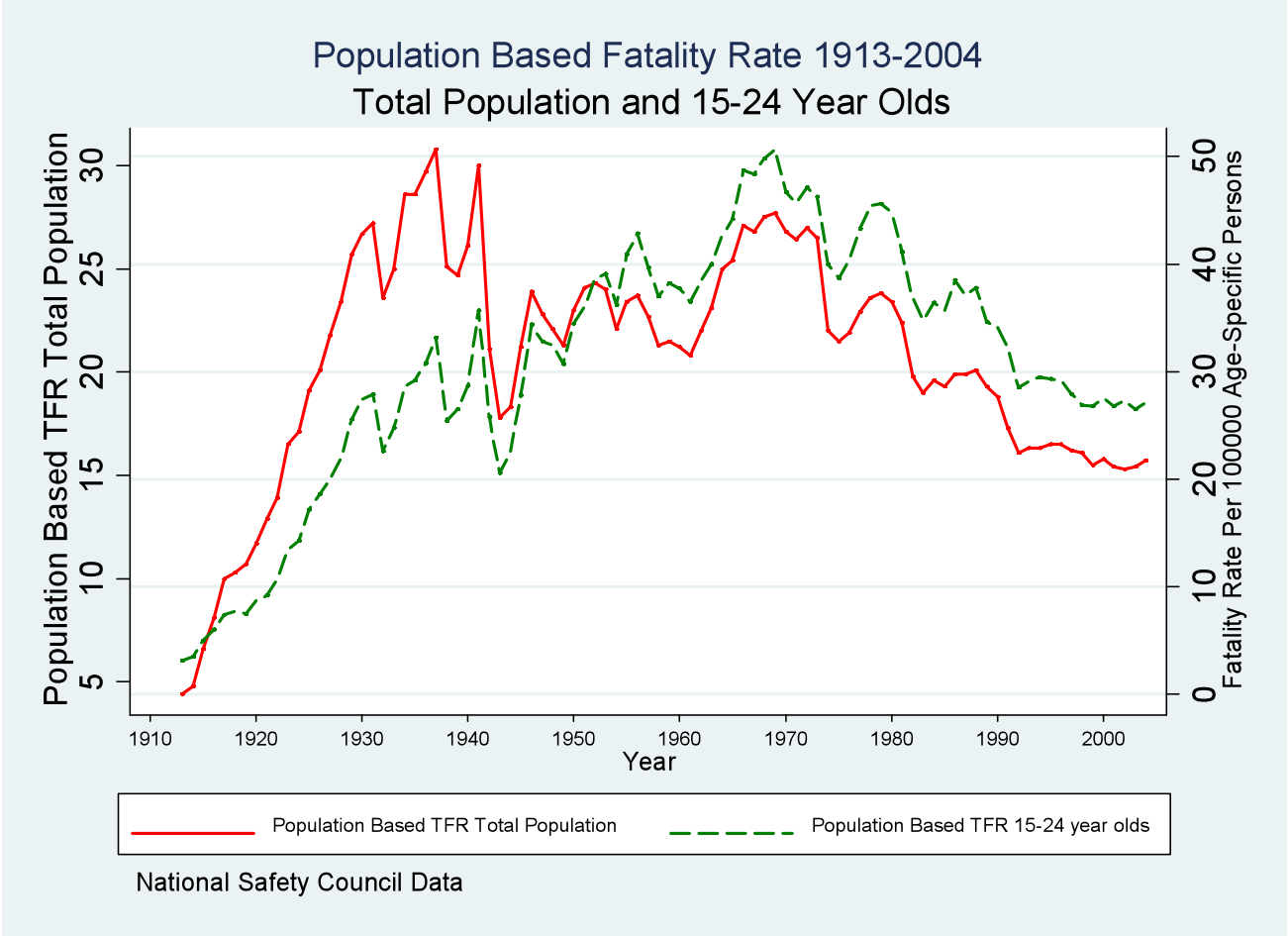

Population Based Fatality Rate 1913-2004
Total Population and 15-24 Year Olds
Population Based TFR Total Population
5
10
15
20
25
30
Fatality Rate Per 100000 Age-Specific Persons
0
10
20
30
40
50
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
Population Based TFR Total Population
Population Based TFR 15-24 year olds
National Safety Council Data

FIGURE 3

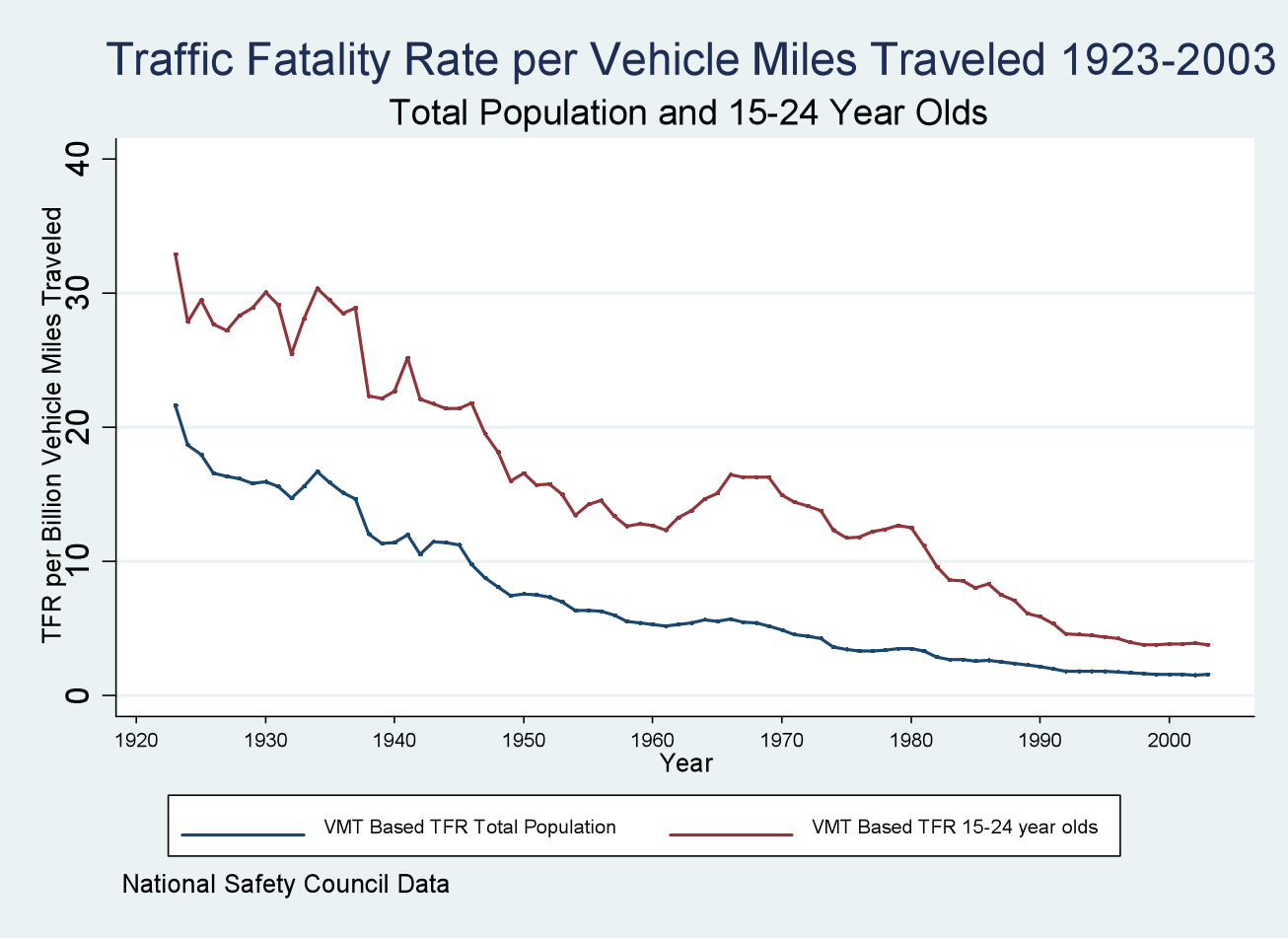

Traffic Fatality Rate per Vehicle Miles Traveled 1923-2003
Total Population and 15-24 Year Olds
TFR per Billion Vehicle Miles Traveled
0
10
20
30
40
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
VMT Based TFR Total Population
VMT Based TFR 15-24 year olds
National Safety Council Data

FIGURE 4

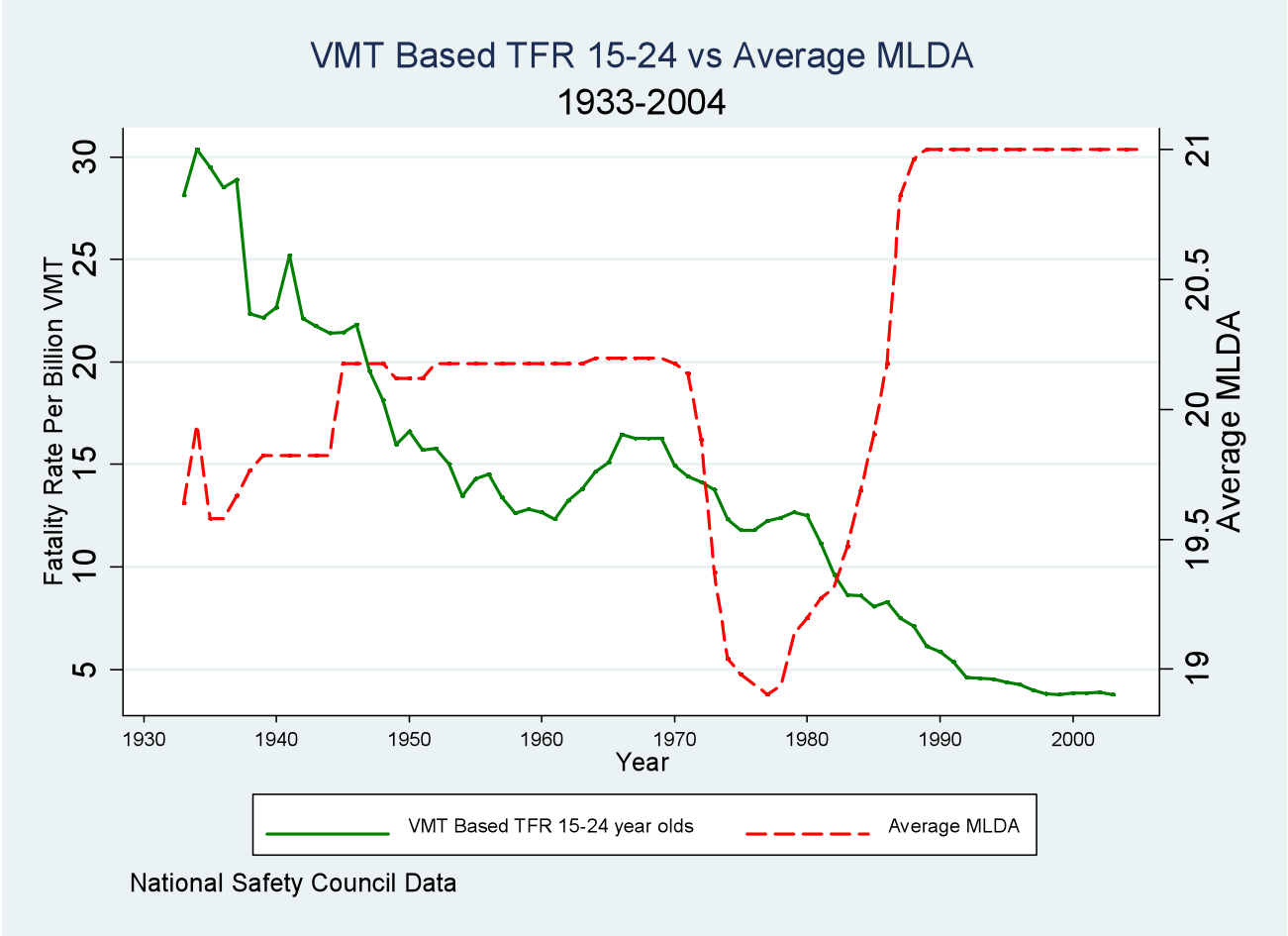

VMT Based TFR 15-24 vs Average MLDA
1933-2004
Fatality Rate Per Billion VMT
5
10
15
20
25
30
Average MLDA
19
19.5
20
20.5
21
1930
1940
1950
1960
1970
1980
1990
2000
Year
VMT Based TFR 15-24 year olds
Average MLDA
National Safety Council Data

FIGURE 5: AVERAGE TOTAL FATALITY RATE PER 100,000 18-20 YEAR OLDS 1976-2005



FIGURE 6

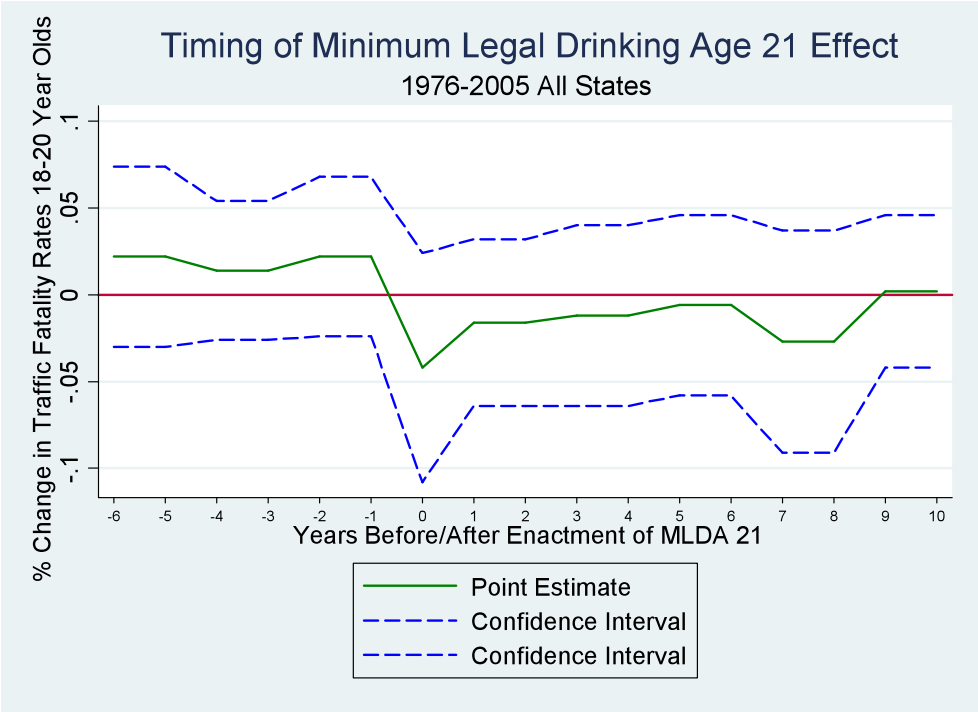


FIGURE 7

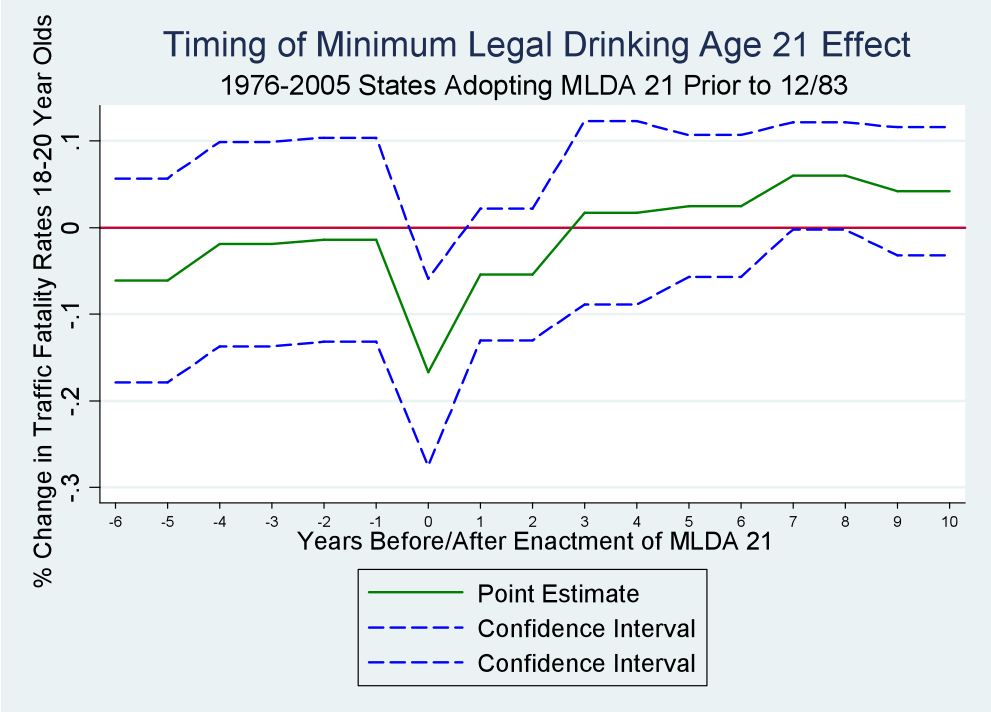


FIGURE 8

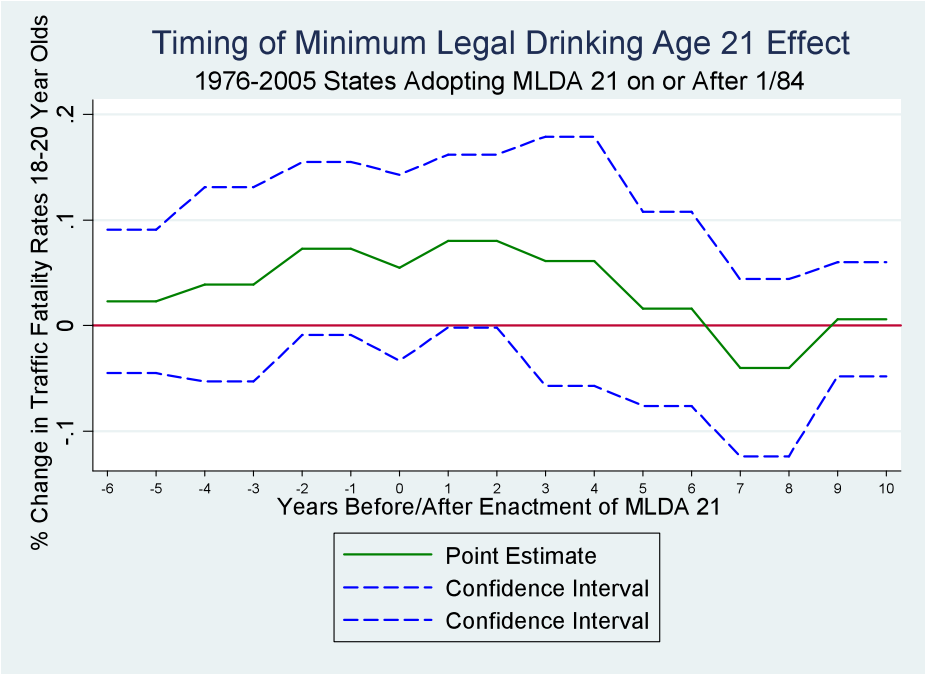


FIGURE 9

