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Graduated Driver Licensing Laws and Teen Abortion

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"Licencias de Conducir Intermedias y Aborto Adolescente"

Resumen

Aprovecho la introducción de licencias de conducir intermedias en Estados Unidos para estudiar el impacto de mayores restricciones sobre la tasa de aborto adolescente. La leyes de "Graduated Driver Licensing" (GDL) introducen una fase intermedia en la que conductores principiantes de entre 15 y 17 años se ven expuestos a mayor supervisión de sus padres, y deben cumplir con restricciones nocturas y de pasajeros al manejar. Usando una estrategia de doble diferencias-en-diferencias, encuentro una caída en la tasa de aborto adolescente de 3% luego de la implementación de las leyes GDL. El efecto es más fuerte en los estados en los que las restricciones nocturnas comienzan antes de las 11 pm. La caída en este caso es de 14% respecto a aquellos estados en los que las restricciones nocturnas comienzan más tarde. Finalmente, no encuentro un efecto diferencial en los estados donde la etapa intermedia dura más tiempo.

Palabras Clave: Aborto adolescente; Leyes GDL; Restricciones nocturnas de manejo; Supervisión parental

"Graduated Driver Licensing Laws and Teen Abortion"

Abstract

I exploit the implementation of state Graduated Driver Licensing (GDL) laws in the U.S. to study the impact of increased restrictions on teen abortion rates. GDL laws introduce an intermediate phase in which first-time drivers between 15 and 17 years of age are subjected to increased parental supervision, nighttime curfews, and passenger restrictions prior to obtaining an unrestricted driver's license. Using a triple differences approach, this study finds that following the implementation of GDL, abortion rates among teenagers decreased by 3%. The effect is stronger in states where the nighttime curfew begins before 11 pm, with abortion rates dropping 14% relative to states with later curfews. I find no differential effect in states where the intermediate license phase lasts a longer period.

Keywords: Teen abortion; GDL laws; Driving curfews; Parental supervision.

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1 Introduction

Around 75% of all teenage pregnancies in the United States are unintended (Finer & Henshaw, 2006; Finer & Zolna, 2016), higher than in other developed countries (Darroch et al., 2001; Kearney & Levine, 2012). Becoming a teen mother has a negative impact on the mother's education, employment and earnings (Bissell, 2000), as well as the baby's cognitive development and academic achievement (Moore et al., 2018). The consequences for women who decide on abortion are not conclusive. Many studies show a low risk of psychological harm for aborters (Adler et al., 1992), but Coleman (2011) finds an 81% increase risk of mental health problems, with around 10% attributable to the abortion.

This paper studies a general equilibrium effect of state Graduated Driver Licensing (GDL) laws on teen abortion rates in the U.S. GDL laws introduce an intermediate phase in which first-time drivers between 15 and 17 years of age are subjected to increased parental supervision, nighttime curfews, and passenger restrictions prior to obtaining an unrestricted driver's license. In general, these teenage drivers could drive unrestricted prior to the implementation of GDL. Various studies find an effect of adult supervision on unprotected sex (DiClemente et al., 2001; Reynoso & Rossi, 2019). Given the increased restrictions, I expect a reduction in teen abortion rates as a result of GDL implementation.

GDL laws in the U.S. were implemented in all states, but in different years. This provides panel data variability that I can exploit in a difference-in-difference strategy. In addition, using the fact that GDL restrictions only apply to teenagers aged 15-17, and not to young adults aged 18-19, I can refine my estimation using a triple differences approach. Given that GDL policies were not implemented with the purpose of affecting teen abortion rates, this source of variability is exogenous to the outcome under study. This provides internal validity if the correct specification is implemented.

Using administrative data from the Centers for Disease Control and Prevention (CDC), I create a panel database for girls aged 15 to 19 that received an abortion at a legal provider. Abortion in the first three months of pregnancy was legalized in the U.S. nationwide after a landmark trial in 1973 (Levine et al., 1999). My database registers teen abortion rates at an annual frequency between 1992-2012 within 39 states. Finally, I combine this with GDL implementation dates in each state according to the Insurance Institute for Highway Safety (IIHS) to measure the impact of GDL on teen abortion rates.

My results suggest that GDL implementation caused teen abortion rates to decline.

Based on the triple differences estimation, I find that GDL implementation caused a 3% reduction in abortion rates among teen girls aged 15-17. This coefficient is statistically significant at the 10% level. I also find evidence that this effect is stronger in states with early nighttime curfew restrictions (before 11 pm), where the reduction in teen abortion rates drops 14% relative to states with later curfews. This coefficient is statistically significant at the 5% level. Finally, extending the period of the intermediate phase of GDL does not, by itself, affect teen abortion rates.

This paper relates to the literature studying unwanted pregnancy prevention policies. The most common policies include contraception availability (Durrance, 2013; Bennett & Assefi, 2005; Kearney & Levine, 2009) and sex education (Kirby, 2001; Trenholm et al., 2008). Regarding abortion, Parental Involvement Laws that require parental consent before a minor has a legal abortion, are found to reduce abortions and raise the cost of risky sex for adolescents (Levine, 2003; Klick et al., 2008; Myers & Ladd, 2020). Specifically designed policies aiming at reducing teen fertility or abortion are not the only policies that might influence these outcomes. General equilibrium effects might be playing a role on teen unintended pregnancy. An interesting example is the slight negative impact of beer taxes on teen abortion rates (Sen, 2003).

My study is closest to Deza (2019), who finds that GDL laws caused a reduction in teen fertility rates using a similar identification strategy. However, my outcome variable is more related to the unwanted pregnancy literature since, by definition, women who choose to abort do not want to give birth. By contrast, when studying teen fertility it is difficult to isolate unwanted pregnancies. In addition, while Deza only explores differences in the duration of the GDL intermediate phase, I also study the impact of differences in nighttime curfew schedules.

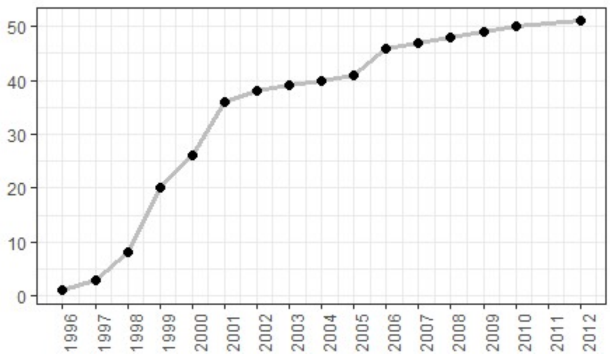
This paper also relates to the parental supervision literature. Reynoso & Rossi (2019) find that, due to lack of parental supervision, teenage girls attending school in the evening start having sexual intercourse earlier in life and show a higher probability of getting an abortion. DiClemente et al. (2001) find that teen girls perceiving less parental monitoring were more likely to report not using any contraception measure at their last sexual intercourse. Both of these results are consistent with the findings in this paper.

Finally, this paper relates to the literature studying general equilibrium effects of GDL laws. Besides reducing crash fatalities (Dee et al., 2005), GDL has additional effects, such as reducing teen participation in the labor force (Argys, Mroz & Pitts, 2019), teen participation in crime (Deza & Litwok, 2016), and teen fertility rates (Deza, 2019). These papers show that GDL restrictions explain around half of the decline in teen labor force participation since 1995, a 6% decline in teen arrests, and a 3-4% decrease in teen fertility among states that impose the restrictions for at least a year. The last two papers argue that GDL's mandatory implementation of nighttime curfews and passenger restrictions among teen drivers potentially limits their mobility freedom because of a raise in adult supervision. This reduces opportunities to commit a crime or become pregnant.

2 Graduated Driver Licensing

Graduated Driver Licensing (GDL) is a policy that was first introduced in 1996 in Florida to reduce high driving fatality rates caused by teenagers. According to numerous studies (Mayhew, et al. 2003; Chen, et al. 2000; Williams, 2003), teenager's crash rates are highest during the first months after obtaining their license, especially at night and when transporting other passengers. To address this issue, GDL laws add an intermediate stage before obtaining a full license in which teens are subjected to nighttime curfews and passenger restrictions. This allows young drivers to gain experience while being supervised by an adult. Five years after its implementation in Florida, most states had implemented GDL laws, with the last state implementing it in 2012. Figure 1 shows the evolution of states with GDL laws. The variation in the year of implementation across states provides panel data variability that I can exploit for my analysis.

Figure 1: Number of states implementing GDL



Source: dates from IIHS

The program is composed of three stages. New drivers under 18 start with the learner stage, in which they are fully supervised. Once a driver's test is passed and the minimum age requirement is fulfilled, drivers enter the intermediate stage in which they are subjected to nighttime curfews and passenger restrictions. This is the stage I analyze in this paper. Once a 6 to 12 months period has passed, or the driver turns 18, he or she can enter the full privilege stage which is a standard driver's license.

Each state specifies its own rules, differing in minimum age required to enter each stage, nighttime curfew schedule, and the number of passengers allowed (see Table A1 in the Appendix for a full description). In all cases, GDL restrictions only apply to drivers below age 18, but each state mandates a period from 6 to 12 months since obtaining the intermediate license before they are eligible to obtain an unrestricted one. In most states, a teenager can enter the intermediate phase of GDL as early as age 16. This means they can generally leave the intermediate phase by age 17. Table 1 shows the distribution of states by minimum age of entry and departure from the intermediate phase of GDL.

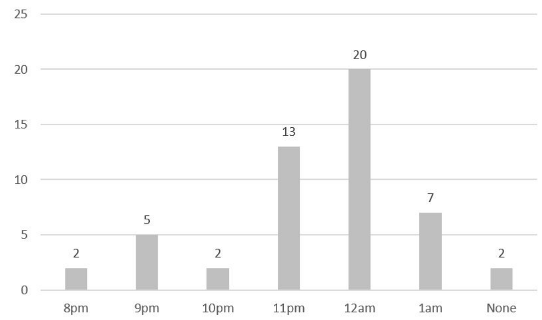
Table 1: Distribution of states by age of entry and departure from the intermediate phase

Min. Age	To enter Intermediate Phase	To leave Intermediate Phase
<16	5	-
16	36	5
16.5	9	10
17	1	21
17.5	-	1
18	-	13

Source: Governors Highway Safety Association

Drivers who are subjected to the intermediate phase of the GDL are either forbidden to drive or must be accompanied by an adult when driving at nighttime hours. The characteristics of the nighttime curfew also vary by state. Figure 2 shows the distribution of states by curfew schedule. The nighttime curfew begins before 11 pm in 22 states and after 11 pm in 27 states.

Figure 2: Number of states per curfew schedule



Source: Insurance Institute for Highway Safety (IIHS)

While most states implemented both restrictions simultaneously, 5 states already included nighttime curfews before GDL implementation, 13 states implemented the restrictions on different years, and 5 states implemented only one restriction.

Because GDL was not designed nor implemented to reduce abortions nor unwanted pregnancies, the source of variability it provides is exogenous to the outcome under study. This means that neither the order, time, or context in which the states become treated are related to abortion rate trends. This variability provides internal validity to the study if the correct specification is used. The external validity of the results depends on the characteristics present in the U.S. teen driving population and their parents' supervision behavior. Minimum driving age, sexual behavior among teenagers, and family income distribution could plausibly affect the impact of GDL restrictions on abortion rates within a different context.

3 Data Description

I use two main databases to identify whether Graduated Driver Licensing (GDL) had an effect on teen abortion rates. The first shows the GDL implementation date by state and comes from the Insurance Institute for Highway Safety (IIHS). The second registers annual legal abortions by age and state of occurrence in the U.S. and comes from the Abortion Surveillance reports published by the Centers for Disease Control and Prevention (CDC)[1].

I am interested in the differences in GDL restrictions across states. To study this, I use the IIHS database to define two measures that identify those states in which GDL restrictions are particularly tough (Tough GDL states). The first measure is in line with Deza (2019). In this case, I define Tough GDL states as those in which the intermediate phase lasts at least 12 months. Non-Tough GDL states are those in which the intermediate phase lasts a shorter period (typically 6 months). I name this measure *Tough IPD (Intermediate Phase Duration).*

For the second measure I define Tough GDL states as those in which nighttime restrictions begin before 11 pm (inclusive), and Non-Tough GDL states as those where the nighttime restriction begins after 11 pm. I name this measure *Tough NCS (Nighttime Curfew Schedule).* This measure is relevant because of the sexual behavior of adolescents. According to the National Longitudinal Survey of Youth from 1997 (Table A2), 40% of

[1] https://www.cdc.gov/reproductivehealth/data_stats/index.htm

females aged 16-17 had their first sexual relation between 10 pm and 7 am, only 17% did it in their family home, and the average age of their couple was 17. The most usual place for them to have their first intercourse was in their partner's family home (35%). This implies that teen girls having sex are away from their family home at nighttime hours. Therefore, I expect a stronger impact on teen abortion rates in states with curfews that start earlier.

The abortion data is voluntarily supplied by abortion providers in 46 reporting areas[2] and compiled and offered publicly by the CDC. To construct my database, I collect the data on the number of abortions by women of the same age by state of occurrence displayed in Table 5 in the Abortion Surveillance annual reports. For each year and state, I group the abortions of girls aged 15 to 17 and 18 to 19 and calculate the rate of abortions per 1,000 women using female population data from the CDC.

The composition of these age groups takes into account that the maximum age to lift GDL restrictions is 18 years in all states. In addition, we take advantage of the fact that women tend to date older men, which means that the partners of women aged 18 or older are not subject to GDL restrictions either. Therefore, if there is an effect of GDL on teen abortions, there should be an impact on abortion rates in the 15-17 teenage population. On the other hand, young adults of 18 and 19 years will not be under GDL restrictions. Thus the abortion rates in young adults should not be affected.

In some states, GDL restrictions can be lifted at age 17. To account for this, I generated an alternative database excluding 17-year-old's. The results in this paper are robust to excluding 17 year old's from the sample (see Table A4 & Table A6 in the Appendix).

As it is not mandatory to report abortion data to the CDC, the organism acknowledges that the number of abortions is incomplete and under-reported. Figure A1 in the Appendix shows the evolution of abortion rates by age group and state. A few states present discontinuities or behave erratically (e.g. District of Columbia). This behavior is likely a consequence of a low number of or fluctuations in reporting abortion providers.

To resolve this issue I take advantage of an alternative source, which is a more accurate reflection of abortion rates according to the CDC[3]: the Guttmacher Institute survey. This survey is done periodically, with continuous annual data only available as of 2005. Before

[2] 44 states, District of Columbia and New York City; data was not provided by California, Florida, Illinois, New Hampshire, and Wyoming

[3] According to the CDC's 2016 report, the total annual abortion figures reported by the CDC during the period 2007-2016 were 68-71% of the numbers reported by the Guttmacher Institute.

that, the database includes abortion figures for 1992, 1996, and 2000[4]. If there are large discontinuities in the CDC figures, then this will be reflected in a poor correlation with the Guttmacher survey. I measure the correlation between the two series for the available years and drop 5 states which have a correlation under 90% (see Table A3 in the Appendix). As a result, I obtain a panel structure with the abortions rates of adolescents in two age groups, 15-17 and 18-19, for 20 years, and 39 states.[5]

I also compile data on other measures that might affect abortion levels of teenagers during the period under study and serve as control variables to my analysis. (1) Number of abortion providers by state, percentage of counties with no providers and percentage of women in counties with no providers, [6] (2) Parental Involvement laws,[7] (3) Medicaid Family Planning waivers, [8] (4) AFDC waivers and (5) TANF waivers.[9] I use (6) unemployment rates from the U.S. Bureau of Labor Statistics. For the demographic data, I use Bridged-Race Population Estimates from CDC WONDER On-line Database. I include (7) the natural logarithm of population, (8) percentage of females, shares of (9) Hispanics, (10) Blacks non-Hispanic, (11) Whites non-Hispanic, and (12) people aged 15-19.

Table 2: Summary statistics

	All States	Tough NCS	Non-Tough NCS
Abortion rate (per 1,000 women)	16.7	16.5	16.9
Age 15-17	9.6	9.8	9.4
Age 18-19	23.9	23.2	24.4
Abortion providers	31	35	29
% counties without providers	77	80	76
% women in counties without providers	44	52	39
Unemployment rate	5.7	5.7	5.7
Population Total	5,406,868	4,996,828	5,683,778
% Females	51	51	51
% Hispanic	8	5	10
% Black	11	14	9
% Age 15-19	7	7	7
Number of states	39	16	23
Observations	1,548	624	924

[4]Most GDL laws were implemented before 2005. For my analysis, I need the database to include at least the year GDL was implemented in each state and the year before. This is the main reason why I use the CDC figures.

[5]I also excluded Iowa since there is insufficient abortion data for this study.

[6]Guttmacher Institute's "Abortion incidence and services in the United States" reports. Data is available for the following years 1992, 1995, 2000, 2008, 2011, and 2014. As the database shows annual information, I filled in the missing data with the previous available year amounts.

[7]Dates come from Table 2 in Myers & Ladd (2020)

[8]Table 1 in Kearney & Levine (2009)

[9]ASPE

Table 2 presents summary statistics for the 39 states under study from 1992 to 2012, and the sub-samples of 16 Tough NCS and 23 Non-Tough NCS states. Abortion rates are presented for the whole sample and two age groups, teenagers (15–17) and young adults (18-19). As expected, abortion rates are lower for teenagers.

4 Estimation Design and Results

4.1 Difference-in-Difference

I start with a difference-in-difference approach that exploits the variability in the year of GDL implementation across states. I restrict the sample to teenagers aged 15 to 17. This approach compares changes in abortion rates of teen girls in GDL states (treated group) with changes in abortion rates of teen girls in non-GDL states (control group) over year t. It is important to note that all states in the sample are eventually treated in the period under analysis. The treatment is defined as the implementation of a GDL law. Formally I estimate the following equation:

$$Ln(Y_{st}) = \beta_0 + \beta_1 GDL_{st} + \beta_2 GDL_{st} \times Tough_s + \rho X_{st} + \gamma_s + \gamma_t + \epsilon_{st} \quad (1)$$

where Y_{st} is the count of abortions per 1,000 women in state s and year t. GDL_{st} is a dummy variable that takes value 1 every year since GDL implementation in state s. Tough$_s$ is a dummy variable that indicates if the state implemented tough GDL restrictions. The vector X_{st} represent the control variables described in the previous section. I include state and year fixed effects, and state-specific linear trends to control for the downward trend in abortion rates which is present in every state. Finally, I cluster the standard errors by state level and use robust standard errors to control for potential heteroskedasticity and serial correlation in the error term.

I estimate three specifications of this equation. First (1) I study homogeneous effects by including only GDL$_{st}$. In this case the parameter of interest is β_1, which measures the impact of GDL on teen abortion rates in all states. Then I study heterogeneous effects by estimating the additional impact of enacting a Tough GDL following (2) the intermediate phase duration criteria and (3) the nighttime driving curfew schedule criteria, as defined in the data section. In this case the parameter of interest is β_2, which measures the impact of GDL on teen abortion rates in Tough states relative Non-Tough states.

Table 3 shows the results of the difference-in-difference estimation. Under specification (1) the impact of GDL implementation on teen abortion is indistinguishable from zero.

Table 3: Difference-in-Difference estimators

	Ln(Abortion Rate$_{st}$)		
	(1)	(2)	(3)
GDL$_{st}$	0.002	-0.024	0.053
	(0.037)	(0.047)	(0.046)
GDL$_{st}$ x Tough$_s$ (IPD)	–	0.044	-
	-	(0.063)	-
GDL$_{st}$ x Tough$_s$ (NCS)	-	-	-0.124**
	-	-	(0.056)
Observations	774	774	774
Controls	Y	Y	Y
State FE	Y	Y	Y
Year FE	Y	Y	Y
State-specific linear trend	Y	Y	Y
Cluster by State	Y	Y	Y
Number of States	39	39	39

Robust SE in parentheses *** p<0.01, ** p<0.05, * p<0.10

Specifications (2) and (3) show the estimated coefficients for heterogeneous effects. There is no significant impact of teen abortion when the intermediate phase lasts longer (2), and the sign of the coefficient is contrary to expectations. On the other hand, when the nighttime curfew starts earlier (3), the parameter of interest β_2 is negative and statistically significant at the 5% level. In this case, the implementation of GDL decreased the abortion rates of teens by 12% in those states where the nighttime curfew restriction begins before 11 pm (Tough), relative to the states where the curfew begins after 11 pm (Non-Tough).

These results suggest that the GDL effect on teen abortion does not come from the length of the intermediate phase of the GDL, as found by Deza (2019) for teen fertility, but rather from the strength of the curfew restriction. This is in line with the theory that parental supervision and mobility restrictions affect teen unwanted pregnancies.

For further analysis, I inquire if there are heterogeneous effects of GDL on teen abortion rates across low and high-income states. To study this I define states as Low Income when the median household income in state s is in the bottom 50% of my sample. I run regression (1) replacing $Tough_s$ with $LowIncome_{st}$. The results are not statistically significant and can be found in Table A5 in the Appendix.

4.2 Triple Differences

In the difference-in-difference approach I compared abortion rates between teenagers across states and years. Even though I control for abortion and pregnancy prevention policies, I might be omitting state-specific policies that have an impact on abortion and are correlated to the implementation of GDL. To account for possible differences across states, I apply a triple differences model, comparing observations across three dimensions: year, state, and age.

Because GDL laws target teenagers between 15 and 17 years but do not impose any restriction on people over 18 [10], young adult's abortions should not be affected by the restrictions imposed by GDL. Nonetheless, all these women in the same state and year share common characteristics that might differ from characteristics in other states and years, for example, an unwanted pregnancy prevention scheme.

I exploit the fact that girls aged 18 and 19 are untreated to perform a triple differences strategy. The new control group controls for more unobservable characteristics that are year-state specific and could be biasing the estimations in the regular difference-in-difference regression. This approach estimates the treatment effect of the policy change by comparing the double difference in Teen_a=1 (studied in section 4.1) with the double difference in Teen_a=0 (corresponding to ages 18-19). As long as the bias is the same in both groups, this procedure will cancel it out (Gruber, 1994).

I estimate the following triple differences model:

$$Ln(Y_{ast}) = \beta_0 + \beta_1 GDL_{st} + \beta_2 GDL_{st} \times Teen_a + \rho X_{st} + \gamma_t + \gamma_{as} + \epsilon_{ast} \quad (2)$$

where the dependent variable is the natural logarithm of abortions per 1,000 women of age a in state s and in year t. The parameter of interest β_2 measures the change in abortion rate for teenagers relative to young adults after the implementation of GDL. The vector X_{st} includes the same group of control variables as in equation (1). The parameter γ_t represents the year fixed effects and γ_{as} represents the age-state fixed effects. I include age-state linear trends, which controls for the downward trend in abortion rates by age group in each state. Finally, ϵ_{ast} is the error term. Standard errors are robust and

[10] Also women tend to date older men according to Table A2.

clustered at the state level.

Table 4: Triple differences estimators

	Ln(Abortion $Rate_{st}$)		
	(1)	(2)	(3)
GDL_{st}	0.022	-0.009	0.024
	(0.035)	(0.053)	(0.037)
$Teen_a$ x GDL_{st}	-0.026*	-0.037	0.031
	(0.015)	(0.045)	(0.034)
$Teen_a$ x GDL_{st} x $Tough_s$ (IPD)	-	0.018	-
	-	(0.066)	-
$Teen_a$ x GDL_{st} x $Tough_s$ (NCS)	-	-	-0.138**
	-	-	(0.068)
Observations	1,548	1,548	1,548
Controls	Y	Y	Y
Year FE	Y	Y	Y
Age-State FE	Y	Y	Y
Age-State linear trend	Y	Y	Y
Cluster by State	Y	Y	Y
Number of States	39	39	39

Robust SE in parentheses, *** p<0.01, ** p<0.05, * p<0.10

Table 4 show the results for the triple differences estimation. As expected, there is no effect of GDL on young adults as reflected by parameter β_1. In specification (1) I find a 3% drop in teen abortion rates after the GDL implementation. The result is statistically significant at the 10% level. In specification (3) I add the interaction with Tough NCS states [11]. The result shows a decrease of 14% in teen abortion rates in Tough NCS states relative to Non-Tough NCS states. This estimator is similar to the one from the difference-in-difference approach (12%). Finally, I find no differential impact on Tough IPD states (2). Again, these results suggest that the reduction in teen abortion is driven by stricter nighttime curfew measures and not by the extension of the intermediate phase of the GDL law.

4.3 Validation

For the estimations of a difference-in-difference strategy to be valid, the following two conditions must be met. First, the abortion trend of the control group should be similar

[11] $Ln(Y_{ast}) = \beta_0 + \beta_1 GDL_{st} + \beta_2 GDL_{st} \times Teen_a + \beta_3 GDL_{st} \times Tough_s + \beta_4 GDL_{st} \times Teen_a \times Tough_s + \rho X_{st} + \gamma_t + \gamma_{as} + \epsilon_{ast}$

to that of the treatment group in absence of the treatment. This is called the parallel trends assumption. Second, the abortion levels in the control group should not be affected by the assignment of the treatment to other units. This is called the Stable Unit Treatment Value Assumption (SUTVA).

4.3.1 Parallel trends assumption

Since we do not observe the abortion rates that treated units would have had in the absence of treatment, it is not possible to test the parallel trend assumption. However, we can at least check that the trends for abortion rates in treated and control units were parallel before the treatment took place. If the pre-treatment trends were parallel, it seems credible to assume that the trends would have remained parallel in the absence of treatment. To test the pre-treatment parallel trends, I estimate the following leads and lags model:

$$Ln(Y_{st}) = \sum_{k=q^-}^{q^+} \beta^k GDL_{st}^k + \rho X_{st} + \gamma_s + \gamma_t + \epsilon_{st} \tag{3}$$

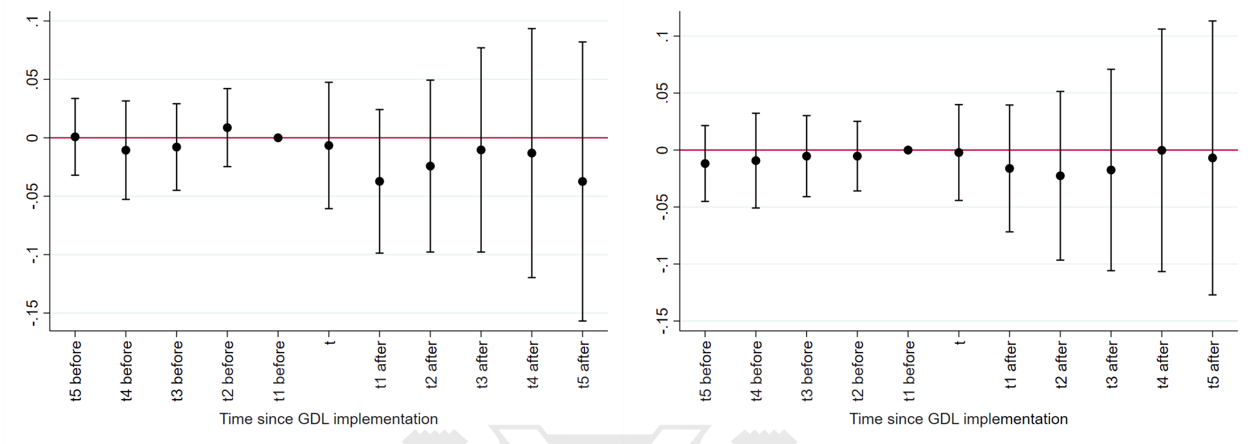
The variable GDL_{st}^k is a dummy that takes value 1 when the treatment took place k periods ago, q^- is the pre-period furthest back and q^+ is the post-period furthest after the implementation of GDL. The vector X_{st} includes the same group of control variables as in equation (1). I include state and year fixed effects. As a result, the parameter of interest β^k will measure the effect k periods after the treatment took place when k is positive, and k periods before the treatment took place when k is negative. I normalize β^{-1} to zero and interpret the β^j coefficients as the effect of GDL relative to the year before the law was implemented.

Before running the regression, I exclude from the database all the observations that are more than 8 years before or 5 years after the implementation of GDL in each state. This is done to avoid assigning unequal weight to states that implemented GDL policies early or late (Deza, 2019). I run the regression for two age groups (a) teenagers aged 15-17, and (b) young adults aged 18-19.

The estimates of equation (3) are reported in Figure 3 and Table A7 in the Appendix. All the pre-event dummies are individually equal to zero. This makes my assumption credible, as it means that the difference in abortion rates before GDL implementation was relatively constant for (a) teenagers and (b) young adults in GDL states and Non-GDL states. The coefficients after the treatment implementation are also indistinguishable from zero but show a negative trend for teenagers.

Figure 3: Pre-treatment trends and dynamic patterns

(a) Sequence of β^k for teenagers (15-17) (b) Sequence of β^k for young adults (18-19)



Note: Standard errors clustered at the State level.

I run a second specification including the interaction of GDL_{st}^k with $ToughNCS_s$. The parallel trend still holds. The results are reported in Table A7 and Figure A2 in the Appendix.

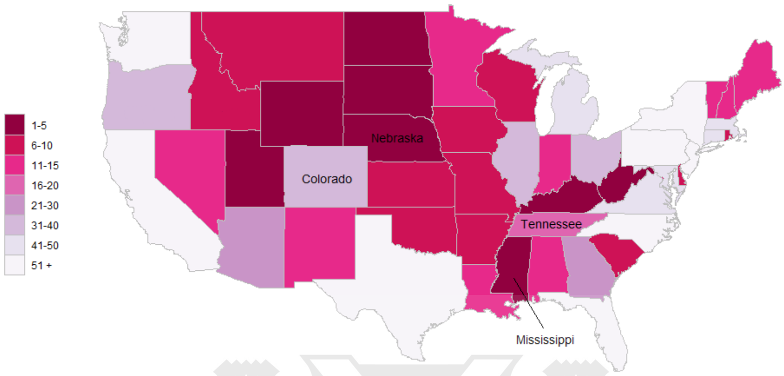
4.3.2 SUTVA

When analyzing the impact of GDL on abortion rates, it is crucial that the outcome in states without GDL is not affected by the implementation of GDL in another state. Since my data includes abortion by the state of procedure, rather than the state of residence of the woman aborting, I must consider the possibility of teenagers crossing to a neighboring state to abort. Spillover effects such as these could bias my estimates because the untreated states would be affected by GDL implementation in a neighboring state.

The evidence on teenagers crossing states to get an abortion is mixed. On the one hand, Levine et al. (1996) find that travel between states to get an abortion was significant in the U.S. at the time of the study. On the other hand, Jewell & Brown (2000) and Joyce et al. (2013) find that the abortion rate of teens is inversely related to the travel distance to the nearest abortion provider. In addition, Gerdts et al. (2016) find an increase in out-of-pocket costs when traveling longer distances to get an abortion.

This problem may be exacerbated if a state has few abortion providers because in that case, it would be more likely for women to cross states to get an abortion. Figure 4 shows a map with the number of abortion providers by state in the year 2000. We can see that states with few providers are close to each other and are mostly in the Midwest and Mountain areas. Based on this, it is not far-fetched to think that women might be traveling to neighboring states to get an abortion (e.g. Nebraska and Colorado).

Figure 4: Number of abortion providers by state in 2000



Source: data from Guttmacher Institute's "Abortion Incidence and Services in the United States" report

However, I hope to show that, if anything, the spillover between states works against my estimator. Consider what happens when GDL is implemented in a state with few abortion providers that is neighboring an untreated state with many abortion providers. An example is Mississippi with 4 providers (GDL implemented in 2000), neighbor to Tennessee with 16 providers (GDL implemented in 2001). Assume that GDL reduces teen abortion rates the year it was implemented, and imagine that residents from Mississippi regularly cross to Tennessee to get an abortion. A reduction in abortion demand from Mississippi teen residents should also reduce abortions in Tennessee. In the extreme case that all Mississippi teenagers get their abortions in Tennessee, all the effect from the implementation of GDL in Mississippi (treated unit) will be reflected in the abortion rates of Tennessee (control unit). Hence, we would see no impact from GDL on abortion rates in Mississippi. Rather, because abortions are declining in Tennessee, it would seem as if GDL produces higher abortion rates in treated units relative to control units.

This example illustrates how the effect of the GDL on teen abortion could spill from the treated units to the control units. If GDL causes abortion rates to decline in treated and control units simultaneously, then our estimate would be biased towards zero. This means that my estimation can be interpreted as a lower bound estimate of the real effect of the policy.

4.4 Medium-term effects

I study what happens to abortion rates of young adults when they were exposed to GDL in the past. I follow Deza and Litwok (2016) and construct a dummy variable indicating when women aged 18 and 19 were affected by the GDL law when they were 16. I estimate the following equation for women aged 18 and 19 separately:

$$Ln(Y_{st}) = \alpha + \beta GDL_{s,t-(k)} + \rho X_{st} + \gamma_t + \epsilon_{st} \tag{4}$$

where the variable $GDL_{s,t-(k)}$ indicates that GDL law was introduced by the year in which the 18 and the 19 year old cohorts were 16. I set $k = 2$ for 18 year old women and $k = 3$ for 19 year old women. I include state-specific trends and use robust standard errors, clustered at the state level. Since the effect of GDL on abortion came from Tough NCS GDL states, I also run the regression interacting the variable $GDL_{s,t-(k)}$ with $Tough_s$.

The results are reported in Table 5. Women that were affected by GDL laws in Tough NCS states when they were 16 years old still show a reduction in abortion rates of 11% two and three years later. For those in Non-Tough NCS states, these women show an 8% increase in abortion rates. These results suggest that GDL restrictions had some effects on teen abortion reates 2-3 years after the implementation.

Table 5: Medium-term effects of GDL implementation

	Ln(Abortion Rate)			
	Age 18		Age 19	
	(1)	(2)	(3)	(4)
GDL implemented when cohort was 16	0.009	0.055	0.033	0.079**
	(0.027)	(0.036)	(0.028)	(0.036)
GDL implemented when cohort was 16 x $Tough_s$ (NCS)	-	-0.109*	-	-0.112**
	-	(0.044)	-	(0.052)
Observations	774	774	774	774
Controls	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
State-specific linear trend	Y	Y	Y	Y
Cluster by State	Y	Y	Y	Y
Number of States	39	39	39	39

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

Conclusion

This paper finds that Graduated Driving Licensing (GDL) laws have a positive externality on teenage abortion rates. Using a triple differences strategy, I find a 3% reduction in abortion rates among teen girls aged 15-17 after GDL implementation. I also find evidence that this effect is stronger in states with stricter nighttime curfew restrictions. The differential effect is a 14% drop in abortion rates relative to states with more relaxed curfew restrictions. On the other hand, I find no evidence that the extension of the intermediate phase of GDL affects teen abortion rates. Taken together, this suggests that the time of the nighttime curfew is more important to prevent unwanted pregnancies than the amount of months the restrictions hold.

These findings complement the literature on parental supervision and unwanted teenage pregnancies. After the implementation of GDL in most states, teenagers driving during nighttime hours must be accompanied by an adult. Since teen girls tend to have their first sexual intercourse away from home and during the night, this policy may be preventing them from traveling to have sex. Future studies can expand on additional mechanisms working behind this effect on abortion rates.

The findings in this paper are relevant because of the negative consequences of abortion. In countries where abortion is illegal, consequences for the aborter are high, with many women dying or getting chronic diseases and disabilities (WHO, 1998). These consequences tend to be stronger for teenagers, as they are more likely than adults to delay the abortion, resort to unskilled providers, use dangerous methods, and delay the abortion when complications arise (Olukoya et al., 2001). In addition, the society benefits from a reduction in government spending. A reduction in abortions is a proxy for a reduction in unwanted pregnancies, since, by definition, women who choose to abort do not want to give birth. Unintended pregnancies impose a cost for the government, adding up to an average of $11.3 billion in the U.S. in 2001, representing a $9.000 cost per taxpayer (Monea & Thomas, 2011). A reduction in teen abortion rates have positive consequences for women and for society.

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Appendix

Table A1: Graduated Driver Licensing law implementation by state

State	GDL Date	Date of restriction implementation		Characteristics at time of implementation	
		Nighttime	Passenger	Curfew begins	Min. age to lift curfew
Alabama*	Oct 2002	Oct 2002	Oct 2002	12 am	17 years
Alaska	Jan 2005	Jan 2005	Jan 2005	1 am	16 years, 6 m
Arizona	Jun 2008	Jun 2008	Jun 2008	12 am	16 years, 6 m
Arkansas	Jul 2009	Jul 2009	Jul 2009	11 pm	18 years
California	Jul 1998	Jul 1998	Jul 1998	12 am	17 years
Colorado	Jul 1999	Jul 1999	Jul 2005	12 am	17 years
Connecticut*	Oct 2003	Oct 2005	Oct 2003	12 am	18 years
Delaware	Jul 1999	Jul 1999	Jul 1999	9 pm	16 years, 10 m
District of Col	Jan 2001	Jan 2001	Jan 2001	Seasonal (11 pm/12 am)	18 years
Florida	Jul 1996	Jul 1996	None	11 pm (16) 1 am (17)	18 years
Georgia	Jul 1997	Jul 1997	Jul 1997	1 am	18 years
Hawaii	Jan 2006	Jan 2006	Jan 2006	11 pm	17 years
Idaho	Jan 2001	Only for learner permit holders	May 2007	None	16 years
Illinois	Jan 1998	1963^+	Jun 2004	11 pm (Sun–Thu) 12 am (Fri–Sat)	18 years
Indiana	Jan 1999	Jul 1998	Jul 1998	11 pm (Sun–Fri) 1 am (Sat–Sun)	18 years
Iowa	Jan 1999	Jan 1999	None	12:30 am	17 years
Kansas	Jan 2010	Jan 2010	Jan 2010	9 pm	16 years, 6 m
Kentucky	Apr 2007	Apr 2007	Apr 2007	12 am	17 years
Louisiana	Jan 1998	1968^+	None	11 pm (Mon–Fri) 12 am (Sat–Sun)	17 years
Maine	Aug 2000	Sep 2003	Aug 2000	12 am	16 years, 6 m
Maryland	Jul 1999	1979^+	Oct 2005	12 am	17 years, 9 m
Massachusetts*	Nov 1998	$< 1975^+$	Nov 1998	12 am	18 years
Michigan	Apr 1997	Apr 1997	Mar 2011	12 am	17 years
Minnesota	Aug 2008	Aug 2008	Aug 2008	12 am	16 years, 6 m
Mississippi	Jul 2000	Jul 2000	None	10 pm	16 years
Missouri	Jan 2001	Jan 2001	Aug 2006	1 am	18 years
Montana	Jul 2006	Jul 2006	Jul 2006	11 pm	16 years
Nebraska	Jan 1999	Jan 1999	Jan 2008	12 am	17 years
Nevada	Jul 2001	Oct 2005	Jul 2001	10 pm	18 years
New Hampshire	Jan 1998	Jan 1998	Jan 2003	1 am	17 years, 1 m
New Jersey	Jan 2001	Jan 2001	Jan 2001	12 am	18 years
New Mexico	Jan 2000	Jan 2000	Jan 2000	12 am	16 years, 6 m
New York*	Sep 2003	$< 1970^+$	Sep 2003	9 pm	17 years
North Carolina*	Dec 1997	Dec 1997	Dec 2002	9 pm	16 years, 6 m
North Dakota	Jan 2012	Jan 2012	None	9 pm	16 years
Ohio	Jan 1999	Jan 1999	Apr 2007	1 am	17 years
Oklahoma*	Nov 2005	Nov 2005	Nov 2005	11 pm	16 years, 6 m
Oregon	Mar 2000	Mar 2000	Mar 2000	12 am	17 years
Pennsylvania*	Dec 1999	$< 1977^+$	Dec 2011	11 pm	17 years
Rhode Island	Jan 1999	Jan 1999	Jul 2005	1 am	17 years, 6 m
South Carolina	Jul 1998	$< 1976^+$	Mar 2002	8 pm	16 years, 6 m
South Dakota	Jan 1999	< 1995	None	8 pm	16 years
Tennessee	Jul 2001	Jul 2001	Jul 2001	11 pm	17 years
Texas	Jan 2002	Jan 2002	Jan 2002	12 am	16 years, 6 m
Utah	Jul 1999	Jul 1999	Jul 2001	12 am	17 years
Vermont	Jul 2000	None	Jul 2000	None	None
Virginia	Jul 2001	Jul 2001	Jul 1998	12 am	18 years
Washington	Jul 2001	Jul 2001	Jul 2001	1 am	17 years
West Virginia	Jan 2001	Jan 2001	Jan 2001	11 pm	17 years
Wisconsin*	Sep 2000	Sep 2000	Sep 2000	12 am	16 years, 9 m
Wyoming*	Sep 2005	Sep 2005	Sep 2005	11 pm	16 years, 6 m

Source: Based on Table 1 in Deza (2019) with data from Insurance Institute for Highway Safety (IIHS)

$^+$ years from Williams & Preusser (1997)

* In my database I input the year after the actual implementation of the GDL law in these states. As the abortion data has annual frequency and most abortions are done between the second and third weeks of gestation, a State with GDL implemented on September will only show a variation in abortions for 2 months, I consider this is too short a period to see any significant reduction in abortions.

Table A2: Descriptive statistics of teenage sexual behaviors

	Female				Male			
	All	Age of first-time			All	Age of first-time		
		< 16	16-17	18 +		< 16	16-17	18 +
Panel A: Time of day in which first sexual experience occurred								
7am–12:00pm	4.28	5.37	3.53	3.78	6.19	8.2	4.89	4.03
12:00pm–3pm	8.97	11.04	10.01	5.2	10.51	14.06	9.05	5.66
3:00pm–6:00pm	14.39	18.38	14.6	9.17	15.23	19.45	14.12	8.71
6:00pm–10:00pm	27.81	28.21	31.83	22.68	24.34	22.55	27.24	24.18
10pm–7am	44.54	36.99	40.03	59.17	43.73	35.74	44.71	57.41
N	3599	1322	1219	1058	3730	1707	1105	918
Panel B: Location in which first sexual experience occurred								
Your family home	17.1	22.22	17.5	10.23	23.6	26.05	25.76	16.41
Your own home/apt/dorm	6.03	2.68	3.08	13.58	6.67	3.11	2.78	18.03
Partner's family home	29.67	32.59	35.41	19.44	23.82	25.59	27.11	16.52
Partners home/apt/dorm	17.1	10.81	14.83	27.53	8.2	6.61	5.57	14.36
Friend's home	9.32	12.3	9.48	5.4	13.97	16.1	14.54	9.29
Car or truck	3.97	3.36	5.11	3.44	5.77	3.8	8.17	6.59
Hotel or motel	6.79	4.47	5.92	10.7	5.56	4.31	4.49	9.18
Park or outdoor place	2.58	3.65	2.19	1.67	3.92	5.29	4.04	1.19
Someplace else	7.45	7.9	6.48	8	8.49	9.14	7.54	8.42
N	3650	1341	1234	1075	3779	1739	1114	926
Panel C: Age of Partner at time of first sexual experience								
Mean age of partner	18.97	17.14	18.16	21.84	17.36	15.99	16.90	19.96
Partner at most 18 years old	57.80	80.54	69.74	20.37	78.37	91.09	90.40	46.41
N	3770	1331	1236	1203	3874	1684	1104	1086

Source: Table 3 in Deza (2019) with data from the National Longitudinal Survey of Youth from 1997 (NLSY97)

Table A3: Correlation of abortion counts by the CDC and Guttmacher (1992, 1996, 2000, 2005-2016)

State	Correlation 15-17
Alabama	96.7%
Alaska	94.6%
Arizona	95.4%
Arkansas	95.9%
Colorado	88.3%
Connecticut	98.6%
Delaware	93.8%
District of Columbia	43.8%
Georgia	99.4%
Hawaii	94.9%
Idaho	87.5%
Indiana	97.3%
Kansas	98.4%
Kentucky	99.4%
Louisiana	91.5%
Maine	98.5%
Massachusetts	96.9%
Michigan	99.2%
Minnesota	99.9%
Mississippi	90.6%
Missouri	96.5%
Montana	99.4%
Nebraska	98.8%
Nevada	85.8%
New Jersey	97.5%
New Mexico	96.8%
New York	99.4%
North Carolina	98.5%
North Dakota	83.5%
Ohio	96.2%
Oklahoma	99.7%
Oregon	99.2%
Pennsylvania	99.3%
Rhode Island	99.2%
South Carolina	93.2%
South Dakota	99.2%
Tennessee	98.4%
Texas	95.5%
Utah	99.4%
Vermont	97.6%
Virginia	99.2%
Washington	98.4%
West Virginia	97.2%
Wisconsin	99.9%

Figure A1: Evolution of abortion rates by age group and state. GDL implementation year (vertical line)

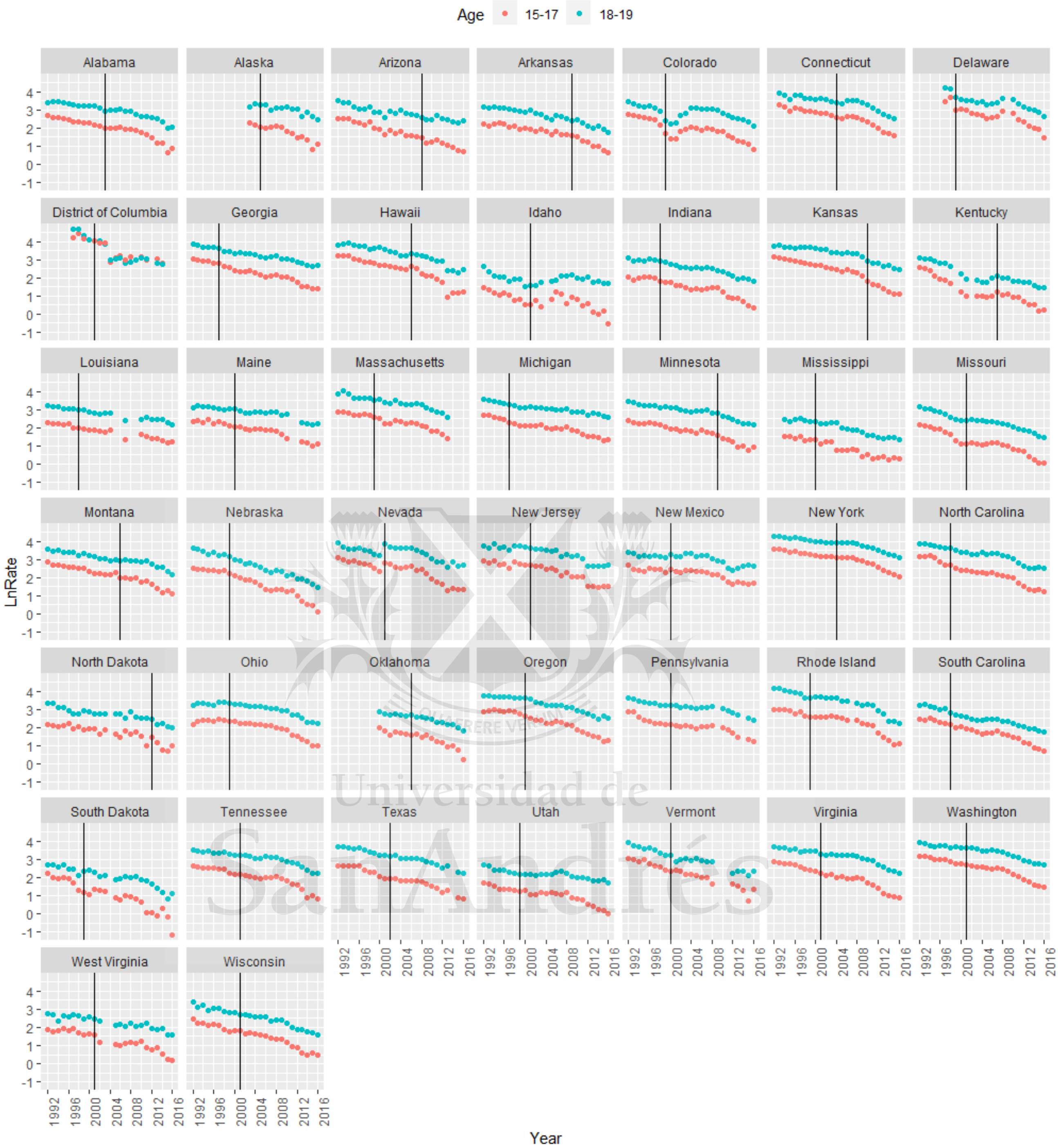


Table A4: Difference-in-Difference estimators for women aged 15-16

	Ln(Abortion Rate$_{st}$)		
	(1)	(2)	(3)
GDL$_{st}$	-0.008	-0.042	0.041
	(0.038)	(0.054)	(0.046)
GDL$_{st}$ x Tough$_{st}$ (IPD)	–	0.060	-
	-	(0.070)	-
GDL$_{st}$ x Tough$_{st}$ (NCS)	-	-	-0.119*
	-	-	(0.061)
Observations	774	774	774
Controls	Y	Y	Y
State FE	Y	Y	Y
Year FE	Y	Y	Y
State-specific linear trend	Y	Y	Y
Cluster by State	Y	Y	Y
Number of States	39	39	39

Robust SE in parentheses *** p<0.01, ** p<0.05, * p<0.10

Table A5: Difference-in-Difference estimators. Heterogeneous effects for household income

	Ln(Abortion Rate$_{st}$)	
	15-17	15-16
GDL$_{st}$	-0.005	-0.013
	(0.039)	(0.043)
GDL$_{st}$ x LowIncome$_{st}$	0.011	0.010
	(0.045)	(0.047)
Observations	774	774
Controls	Y	Y
State FE	Y	Y
Year FE	Y	Y
State-specific linear trend	Y	Y
Cluster by State	Y	Y
Number of States	39	39

Robust SE in parentheses *** p<0.01, ** p<0.05, * p<0.10

Median Household Income data source: U.S. Census Bureau.

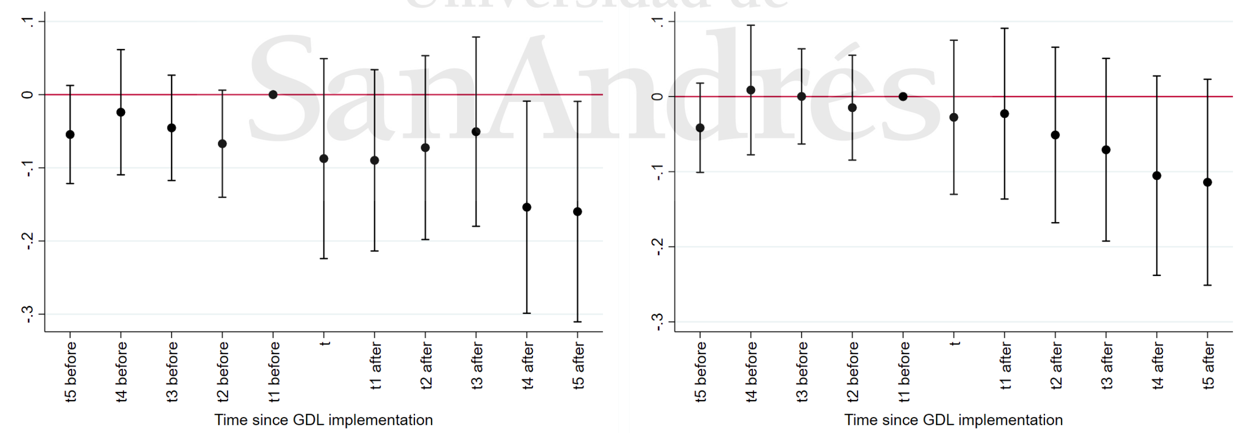
Table A6: Triple differences estimators for women aged 15-16

	Ln(Abortion Rate$_{st}$)		
	(1)	(2)	(3)
GDL$_{st}$	0.024	-0.010	0.027
	(0.038)	(0.053)	(0.037)
Teen$_a$ x GDL$_{st}$	-0.041**	-0.053	0.010
	(0.018)	(0.051)	(0.038)
Teen$_a$ x GDL$_{st}$ x Tough$_{st}$(IPD)	-	0.020	-
	-	(0.071)	-
Teen$_a$ x GDL$_{st}$ x Tough$_{st}$ (NCS)	-	-	-0.122*
	-	-	(0.069)
Observations	1,548	1,548	1,548
Controls	Y	Y	Y
Year FE	Y	Y	Y
Age-State FE	Y	Y	Y
Age-State linear trend	Y	Y	Y
Cluster by State	Y	Y	Y
Number of States	39	39	39

Robust SE in parentheses, *** p<0.01, ** p<0.05, * p<0.10

Figure A2: Pre-treatment trends and dynamic patterns for second specification

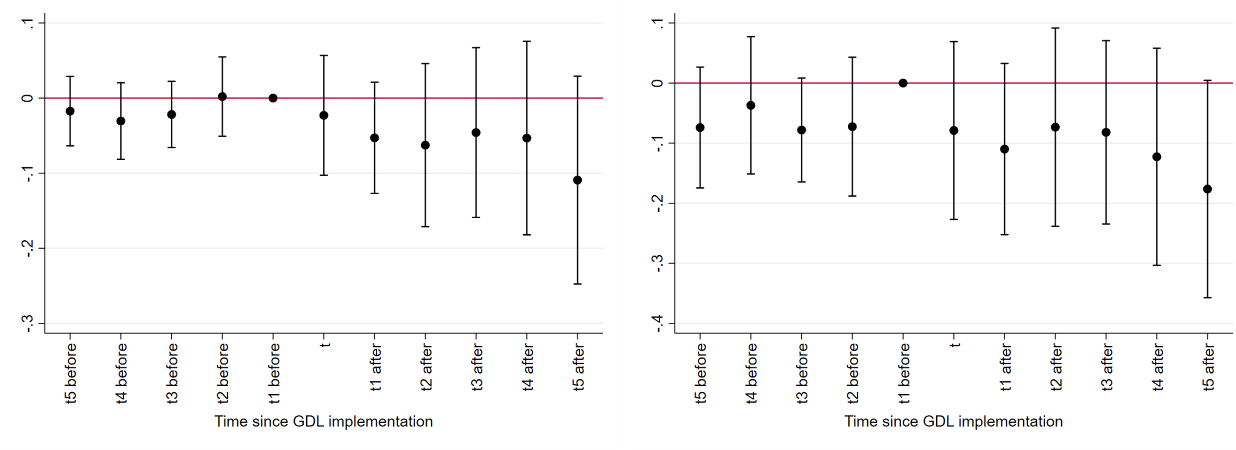
(a) Sequence of β^k for teenagers (15-17) (b) Sequence of β^k for young adults (18-19)



Note: Standard errors clustered at the State level.

Figure A3: Pre-treatment trends and dynamic patterns for teenagers 15-16

(a) Sequence of β^k for first specification (b) Sequence of β^k for second specification



Note: Standard errors clustered at the State level.

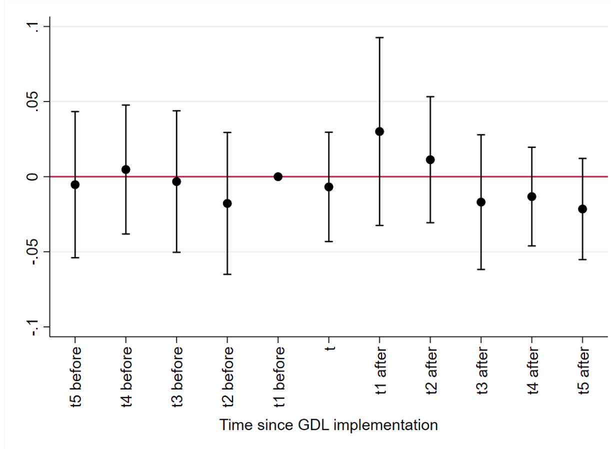
Table A7: Pre-treatment trends and dynamic patterns

	Ln(Abortion Rate)					
	GDL_{st}^k			$GDL_{st}^k ToughNCS_s$		
	15-17	15-16	18-19	15-17	15-16	18-19
t5 before	0.001	-0.017	-0.012	-0.054	-0.074	-0.042
	(0.016)	(0.023)	(0.016)	(0.033)	(0.050)	(0.029)
t4 before	-0.011	-0.031	-0.009	-0.024	-0.037	0.009
	(0.021)	(0.025)	(0.021)	(0.042)	(0.056)	(0.043)
t3 before	-0.008	-0.022	-0.005	-0.045	-0.078*	0.000
	(0.018)	(0.022)	(0.018)	(0.036)	(0.043)	(0.031)
t2 before	0.009	0.002	-0.005	-0.067*	-0.073	-0.015
	(0.016)	(0.026)	(0.015)	(0.036)	(0.057)	(0.034)
t1 before	-	-	-	-	-	-
t	-0.007	-0.023	-0.002	-0.087	-0.079	-0.028
	(0.027)	(0.039)	(0.021)	(0.067)	(0.073)	(0.051)
t1 after	-0.037	-0.053	-0.016	-0.090	-0.110	-0.023
	(0.030)	(0.037)	(0.027)	(0.061)	(0.070)	(0.056)
t2 after	-0.024	-0.063	-0.023	-0.072	-0.073	-0.051
	(0.036)	(0.054)	(0.037)	(0.062)	(0.081)	(0.058)
t3 after	-0.010	-0.046	-0.017	-0.051	-0.082	-0.071
	(0.043)	(0.056)	(0.044)	(0.064)	(0.075)	(0.060)
t4 after	-0.013	-0.053	-0.000	-0.154**	-0.123	-0.105
	(0.053)	(0.064)	(0.053)	(0.072)	(0.089)	(0.066)
t5 after	-0.037	-0.109	-0.007	-0.160**	-0.176*	-0.114
	(0.059)	(0.068)	(0.059)	(0.074)	(0.089)	(0.068)
Observations	497	497	497	497	497	497

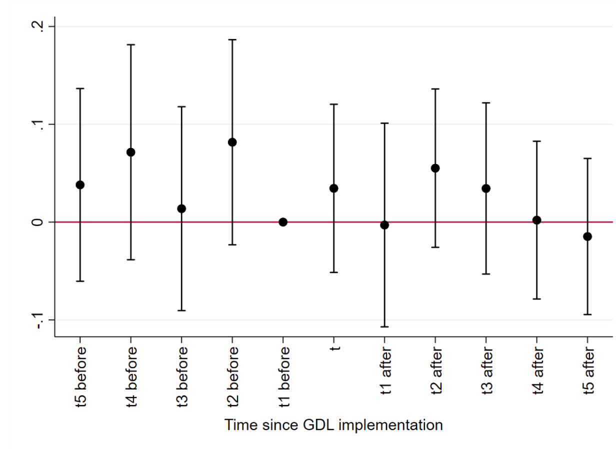
Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10

Figure A4: Pre-treatment trends and dynamic patterns for GDL implemented when cohort was 16

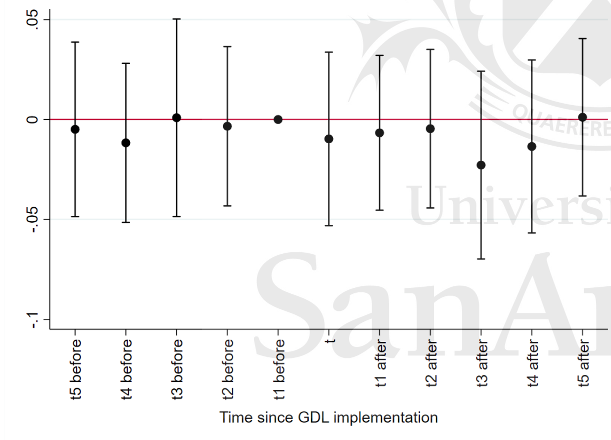
(a) Sequence of β^k for women aged 18
first specification



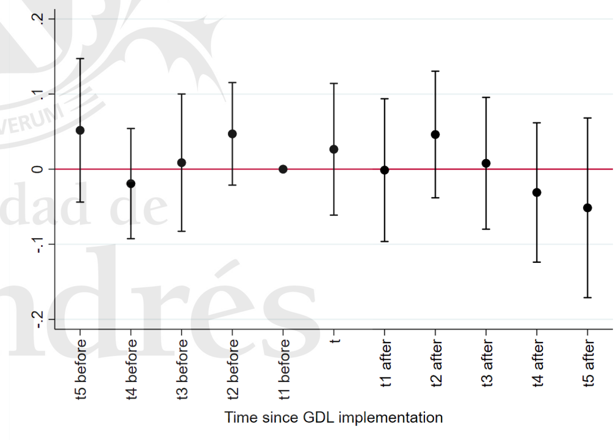
(b) Sequence of β^k for women aged 18
second specification



(c) Sequence of β^k for women aged 19
first specification



(d) Sequence of β^k for women aged 19
second specification



Note: Standard errors clustered at the State level.