PROBLEM SET 4
Due on Monday April 24, 2023, 10:00 am

I - INSTRUCTIONS

To successfully complete this problem set, please follow these steps:

1. Download this Word document file into your computer and download the datasets into a data subfolder in your problem set-specific RStudio Project directory.

2. Insert your answers into this document and organize your code in a R script. You can also insert non-Word objects such as handwritten work or screenshots in your answers.

3. Once your document is complete, please save it as a PDF.

4. Please submit an electronic copy of the **PDF** and your **replicable R script** to the Canvas assignment page.

II - IDENTIFICATION

(1) Your information

Your Last Name:	*Chaturvedi*
Your First Name:	*Shreya*

(2) Group Members (please list the classmates you worked with on this problem set):

Manisha Jha, Neha Verma

(3) Compliance with Harvard Kennedy School Academic Code[1] (mark with an X below)

	Yes	No
I certify that my work in this problem set complies with the Harvard Kennedy School Academic Code	X	

---

[1] We abide by the Harvard Kennedy School Academic code for all aspects of the course. In terms of problem sets, unless explicitly written otherwise, the norms are the following: You are free (and encouraged) to discuss problem sets with your classmates. However, you must hand in your own unique written work and code in all cases. Any copy/paste of another's work is plagiarism. In other words, you can work with your classmate(s), sitting side-by-side and going through the problem set question-by-question, but you must each type your own answers and your own code. For more details, please see syllabus.

For this problem set, we will be examining the following paper:

> Stevenson, Betsey, and Justin Wolfers. 2006. "Bargaining in the Shadow of the Law:
> Divorce Laws and Family Distress," *Quarterly Journal of Economics,* 121 (1): 267-88.

Tips: For this problem set, you may find it more efficient to go back and forth between the conceptual and data analysis questions, as many questions are paired.

Instructions: Please keep your answers *concise*. Most subquestions can be answered in 1-2 sentences. Bolding or italicizing keywords also help grading.

Conceptual Questions (31 points)

1. Read the paper.
   a. Clearly state the primary research question that the authors are trying to answer. (1 point)

   > *The authors of the paper aim to determine the beneficiaries and degree of benefit resulting from the enactment of unilateral divorce laws. They are particularly interested in examining the impact of such laws on domestic violence, suicide, and spousal homicide, as they believe that the shift in bargaining power may have resulted in reduced incidents of these types of violence.*

   b. In 2-3 sentences, explain the main finding of the paper using non-technical jargon, as if you were writing a brief policy memo. (2 points)

   > *The researchers find a significant impact on the reduction of violence due to the passage of unilateral divorce laws. They found that states that passed the laws saw a decrease in domestic violence rates of 30%, women murdered by their partners decline by 10%, and a decline in female suicides of 8-16%.*

   c. What are the two mechanisms that the authors discuss by which unilateral divorce laws may have reduced suicide rates among married women? (1 point)

   > *The authors suggest that unilateral divorce laws may have reduced suicide rates among married women through two mechanisms. First, the laws may have given individuals in "trapped" marriages the option to leave, leading to an increase in divorce rates and a reduction in suicide rates. Second, the laws may have redistributed property rights and bargaining power within the*

relationship, giving the abused more power to demand less abuse and thereby reducing the marginal value of strategic suicide attempts.

2. The authors used a difference-in-differences (DID) design because they believed a comparison between state-years with and without unilateral divorce to be lacking. What are two possible confounders that would bias the results from a simple comparison and are hard to measure? Explain the mechanism of the omitted variable and use the omitted variable bias formula to argue whether it would lead to an understatement or overstatement of the true effect. (3 points)

Two possible confounders that could bias the results of a simple comparison between state-years with and without unilateral divorce laws are:

- *Differences in political progressiveness on issues of female empowerment, where more progressive states may already have a social norm of women having more bargaining power in relationships and be less prone to suicide due to marital complications. If these states implement unilateral divorce laws, there might be an overstatement of the true effect of the laws on suicide rates. In this case, the selection bias would be: $E[Y0i \mid Di = 1] > E[Y0i \mid Di = 0]$, and hence, $E[Y0i \mid Di = 1] - E[Y0i \mid Di = 0] > TOT$.*
- *The percentage of religious couples in a state, where even if unilateral divorce laws are passed, some individuals may not unilaterally divorce due to religious reasons. If states with a higher percentage of religious people pass unilateral divorce laws, there may be an understatement of the true effect of the laws on suicide rates. The selection bias would be: $E[Y0i \mid Di = 1] < E[Y0i \mid Di = 0]$, and hence, $E[Y0i \mid Di = 1] - E[Y0i \mid Di = 0] < TOT$.*

3. The authors' main regression is:

$$Suicide\ rate_{s,t} = \sum_{k} \beta_k Unilateral^k_{s,t}$$

$$+ \sum_{s} \eta_s State_s + \sum_{t} \lambda_t Year_t + Controls_{s,t} + \varepsilon_{s,t}.$$

What kind of regression specification is this? Explain each term in the regression. How should we interpret the β_k coefficients? (3 points)

This is an OLS regression, where the coefficient β represents the percentage change in the suicide rate due to the adoption of unilateral divorce laws k years ago. The dummy variable Unilateralks,t is set equal to one if a state has adopted unilateral divorce k years ago. The coefficient η represents the state fixed effect, and λ represents the time fixed effect. The error term ε represents unobserved factors that influence the suicide rate. The controls include variables such as the evolving economic power of women, business cycle indicators, welfare generosity, availability of abortion, and racial and age composition of the state.

4. What does the parallel trends assumption claim in this specific context? Why or why not do you think it is reasonable? Explain this in a way that someone not well-versed in statistics would understand. (2 points)

The parallel trends assumption claims that if the 37 states that passed unilateral divorce laws had not passed them, then their suicide rates, murder rates, and domestic violence rates would have followed similar trends as the 14 control states that did not pass the unilateral divorce laws. This assumption is reasonable because the event study showed that prior to the implementation of unilateral divorce laws, the difference in log of suicide rates between treatment and control groups was not statistically different from zero. Therefore, we can assume that the trends in these outcomes would have been similar between the two groups if the treatment had not been applied. In simpler terms, the assumption suggests that the two groups would have followed similar patterns over time, regardless of whether they passed the unilateral divorce laws or not.

5. What do the authors say about how they estimate standard errors in Table I? How would you estimate standard errors in this setting and why? (2 points)

The authors used robust standard errors clustered at the state level, which is appropriate in this context to account for state-level characteristics that may influence suicide rates. By estimating only the variation due to the timing of the reform, they identified a large decline in female suicide and a suggestive decline in male suicide. Including state-specific time trends increased standard errors.

6. The authors use the suicide rate for *all* women, not just those who have been married, "to avoid endogeneity problems posed by the possibility that marriage decisions may respond

to divorce regime." Give one example of such an endogeneity problem. How would it bias the results? (1 point)

If the authors were to only measure the suicide rate for married women, they may underestimate the suicide happening in other romantic relationships that are just as relevant, and end up with a selection bias problem. This is because the suicide rate for married women could be affected by factors that also affect the decision to marry, such as financial strains. For instance, if women with lower incomes and fewer employment prospects are more likely to marry and also more likely to have higher suicide rates, then the authors would overestimate the effect of divorce laws on suicide if they only included married women. By using the suicide rate for all women, the authors capture the impact on both those who remain married and those that leave their relationships, and avoid the potential endogeneity problem posed by the possibility that marriage decisions may respond to divorce regimes.

7. Comment on how the effect of divorce laws on *male* suicide differ from their effect on female suicide. Given the difference in baseline suicide rates for men and women, would you expect the elasticity of male suicide to be different from the elasticity of female suicide with respect to unilateral divorce laws? (2 points)

The study found that there was a significant decrease in female suicide rates after the implementation of unilateral divorce laws, but no discernible effect on male suicides. Despite the higher baseline suicide rate for men, the study cannot conclude that the difference is solely due to baseline differences. The difference could be due to gendered differences in the use of suicide attempts as a tool to gain bargaining power in abusive relationships, with men benefiting less from the introduction of unilateral divorce laws. Therefore, the author does not expect the elasticity of male suicide to be different from the elasticity of female suicide due to the differences in baseline suicide rates.

8. Give two ways that Figure I increases the credibility of the results presented in Table I. Would you change anything about how Figure I is presented? (2 points)

Figure I supports the causal interpretation of the results presented in Table I by demonstrating that unilateral divorce laws primarily impact prime-age women, instead of teens or the elderly, validating the robustness of the correlation. The breakdown by age also reveals which decades experienced the largest decrease in suicide rates due to the introduction of unilateral divorce laws. The fact that there is no correlation between

the passage of such laws and suicide in teens or the elderly enhances the credibility of the results. However, the current presentation of 12 graphs in Figure I appears cluttered, and a more effective way to display the data might be to either show the teen and elderly suicide rates in a separate figure or to stagger the data points by approximately five years rather than two years.

9. The authors present DID estimates of the effect of unilateral divorce laws on domestic violence in Table II. The first row presents the results from a simple DID and the next three rows sequentially add controls to address concerns about bias.

   a. Identify and interpret the treatment effect estimated by the main DID estimate in column 1 of Table II. (2 points)

      The main DID estimate in column 1 of Table II shows that the implementation of unilateral divorce laws led to a 4.3 percentage point reduction in domestic violence towards women by their husbands. The average incidence of such violence is 11.7%, but it decreased to 7.4% in states that adopted the law. These results are statistically significant at the 5% level, after controlling for state fixed effects, individual controls, state-level time-varying controls, and using probits with individual controls.

   b. What is one potential source of bias in the DID with state fixed effects and individual-level controls that would be eliminated by the addition of state-level time-varying controls? (1 point)

      Including state-level time-varying controls eliminates selection bias that arises from state-level characteristics that may vary over time and affect domestic violence, such as welfare, employment rates, and other state-specific trends. This adds more depth to the study and shows how these factors impact suicide rates.

   c. What is one potential source bias in the DID that remains even after the addition of all these controls? (1 point)

One potential source of bias that remains in the DID analysis, even with all the controls added, is the accessibility to methods to commit suicide, such as guns or poison, which could vary across states and affect the estimated treatment effect. This is an unaddressed potential source of bias that could influence the dependent variable.

10. The authors present estimates of the effect of unilateral divorce laws on intimate homicide in Table III. What is the regression specification they run in columns 1 and 2 (Hint: Read the note to Table III)? Write down the regression equation and describe the estimator's relationship to a simple DID. (3 points)

The regression specification in column 1 is:
*Homicide rate$_{it}$ = α_0 + α_1Unilateral$_i$ + α_2Post$_t$ + α_3 (Unilateral$_i$ * Post$_t$) + λ_iState$_i$ + γ_tYear$_t$ + $\varepsilon_{i,t}$*
And the regression specification in column 2 is:
*Homicide rate$_{it}$ = α_0 + α_1Unilateral$_i$ + α_2Post$_t$ + α_3 (Unilateral$_i$ * Post$_t$) + λ_iState$_i$ + γ_tYear$_t$ + Controls$_{i,t}$ + $\varepsilon_{i,t}$*
The coefficient of interest is α_3, which indicates the percentage change in the relevant homicide rate due to the implementation of unilateral divorce laws. The estimator's relationship to a simple DID would be to compare the change in homicide rate over time in states that adopted the laws to the change in states that did not, while controlling for state-level characteristics that may affect the outcome variable. However, this estimator includes variation in treatment timing since each state passed the unilateral divorce law in different years. Therefore, in a given year, a state that passed the law would be compared to untreated states in that same year, but also to treated states in previous years.

11. Figure II plots an event study of the effect of unilateral divorce laws on intimate homicide.

    a. What econometric concerns does this figure raise? (1 point)

    The figure raises the concern that the parallel trends assumption may be violated due to a decline in homicide rate differences before the law was passed. This could lead to the regression results picking up the effects of an alternate phenomenon that predated the divorce law reform. Additionally, the figure only shows the % change in intimate homicide rates over time and does not include the baseline metric of non-intimate homicides. A stronger figure

would include the intimate homicide rate plotted against the non-intimate homicide rate as a baseline.

b. How does the triple-difference (reported in column 4 of Table III) address some of these concerns? (1 point)

The triple-difference in Column 4 of Table III addresses the concern of the parallel trends assumption by using the change in non-intimate homicide as a relevant baseline. It compares the change in intimate femicide with the change in non-intimate homicide, which shows that the former decreased when compared with the non-intimate counterfactual, but this difference was not statistically significant.

c. Write down a regression equation to estimate the triple-difference results in Table III and indicate the coefficient of interest. (1 point)

The regression equation to estimate the triple-difference results in Table III is
$Homicide_{s,t} = \beta Unilateral + \gamma Nonintimate + \delta Unilateral \times Nonintimate + {}_{ss}States + {}_{tt}Year_t + Controls_{s,t}$.
The coefficient of interest is δ, which represents the interaction between states where unilateral divorce laws were passed and homicide rates for nonintimate homicides. Nonintimate homicide rates are calculated as the difference between the total homicide rate and the intimate homicide rate.

12. What is a specific example of a potential threat to a) internal validity and b) external validity in this study? (2 points)

One potential threat to internal validity is omitted variable bias, particularly the exclusion of cultural attitudes towards divorce which may impact suicide rates and domestic violence. This could affect the treatment effect of unilateral divorce laws in different contexts.
As for external validity, the results of the study may not be generalizable to modern times due to changing social norms around divorce. Additionally, the study may not apply to countries with weaker legal systems where the option of unilaterally divorcing may not lead to significant changes for those trapped in abusive marriages.

Prof. Will Dobbie
Advanced Quantitative Methods II (API-210)

Harvard Kennedy School
Harvard University

Data Analysis (21 points)

For this problem set, you can rely on a two-part demo: constructing variables for DID, and estimating DID coefficients with the two-way fixed effects estimator. That said, the techniques involved (e.g. fixed effects) are not new. A data appendix at the end describes the dataset and the key variables.

In this section, we will estimate the effect of unilateral divorce laws on female suicide. In the problem set link, we have provided a lightly cleaned version of their main analysis files: `stevenson_wolfers_210.dta`. The data we are using is available from Justin Wolfers' website.

13. We will begin by estimating a simple 2x2 difference-in-differences regression.

   a. The year in which the greatest number of states passed unilateral divorce laws was 1973. Using data on states that passed unilateral divorce laws in 1973 and those that never passed unilateral divorce laws, run a simple 2x2 DID regression to estimate the effect of unilateral divorce laws on ln(suiciderate_jag) for women, clustering standard errors at the state level. Report the estimated effect and the standard error below. (2 points)

```
(Intercept)   treat_post    treatTRUE     postTRUE
  -10.01033     -0.07045      0.33039      0.01902
```

   b. Interpret the point estimate. Explain which treatment/control groups are being compared and how the effect is estimated so that someone without statistical training could understand. (2 points)

   The point estimate of -0.0704 indicates a 7.04% decrease in female suicide rates for states that passed unilateral divorce laws after 1973 compared to states that never passed such laws. The comparison is between the treatment group, consisting of states that passed the law in 1973, and the control group, consisting of states that never passed the law within the dataset. The effect is estimated by assuming that the suicide rates in treated states would have been the same as the control group if they had not passed the law. The final DID estimate is obtained by subtracting the baseline differential in female suicide rates between control and treatment states prior to 1973 from the difference in suicide rates observed between the two groups after 1973.

c. Are the results significant? Can you rule out substantively meaningful effect sizes? (1 point)

> *The results are not statistically significant and thus we can rule out substantively meaningful effect sizes.*

14. Now we will assess whether the parallel trends assumption is reasonable in this setting by estimating an event study, pooling data from all the states.

a. Consider the following event study regression specification:

$$Y_{st} = \sum_{j \neq -1} \beta_j \mathbf{1}(t - divyear_s = j) + \gamma_s + \delta_t + \epsilon_{st},$$

Interpret the coefficients. (2 points)

> *β_j is the coefficient that signifies the variation between the treatment and control groups in the jth period, compared to the period just prior to the implementation of the treatment.*

b. Plot the event study, being sure to include confidence bands as well as point estimates (Hint: Follow Andrew Goodman-Bacon's mini-guide here). (3 points)
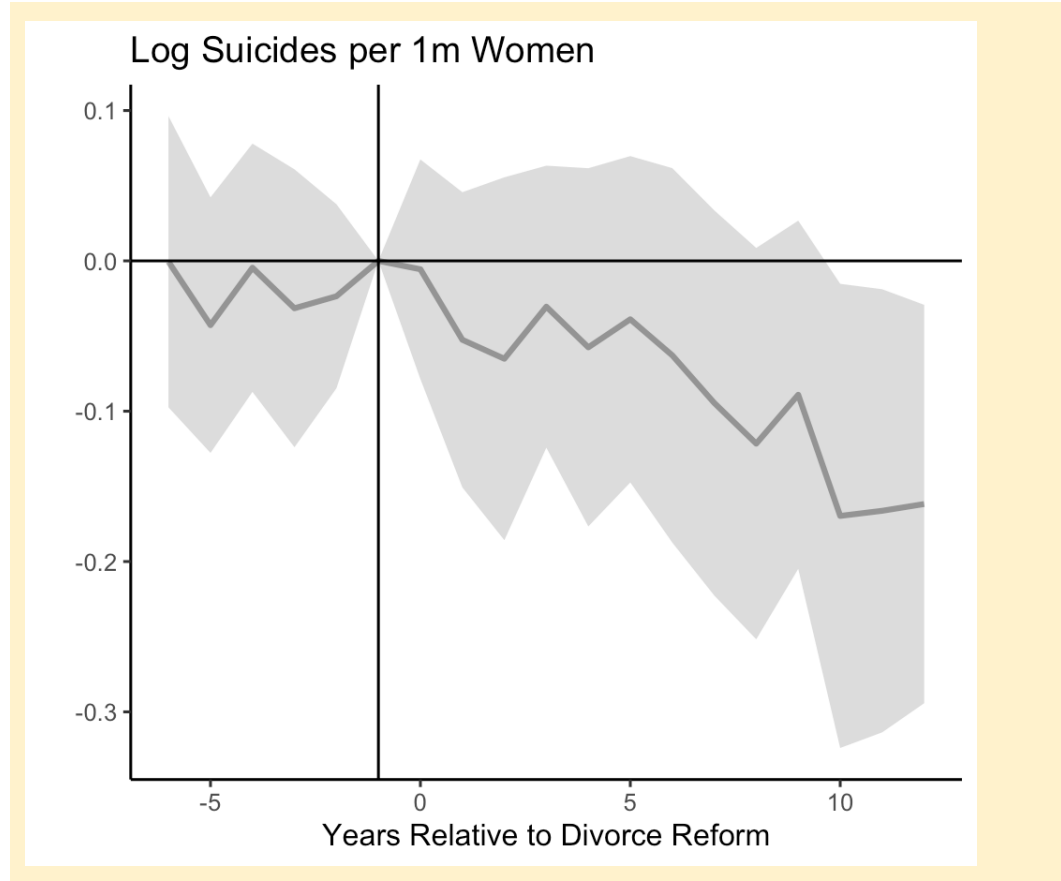
c. Interpret the figure. Does it support the parallel trends assumption? How do the effects of the reform appear to unfold over time? (2 points)

The figure illustrates the impact of unilateral divorce laws on the female suicide rate. Prior to the passage of the reform, there were no statistically significant differences between treatment and control states, indicating support for the parallel trends assumption. Over time, we observe larger decreases in the female suicide rate, especially 5-10 years after the passage of the law. The decline in the female suicide rate in treatment groups relative to control groups appears to be significant only 10 years after the reforms were implemented.

d. Read the abstract and introduction of Rambachan and Roth (2023), "A More Credible Approach to Parallel Trends." Explain the potential concerns with using the above event study regression estimates to assess the parallel trends assumptions. (2 points)

Bonus: Read the introduction of Sun and Abraham (2020) and explain the concern with event studies when there is staggered timing in treatment adoption.

Rambachan and Roth have raised concerns regarding event studies, particularly related to pre-trends tests. They argue that such tests are often underpowered against violations of parallel trends, leading to under-coverage of conventional confidence intervals. They also express concerns that statistical distortions can further undermine conventional inference procedures. Additionally, they suggest that parametric approaches to controlling pre-existing trends may be sensitive to functional form assumptions. In the case of staggered timing in treatment adoption, they observe that regression coefficients from conventional approaches may fail to produce convex weighted averages of treatment effects even if parallel trends hold. Similarly, Sun and Abraham (2020) suggest that unless strong assumptions about treatment effects homogeneity hold, the estimate of the coefficient for dynamic treatment effects in DiDs with staggered timing in treatment adoption may be contaminated by terms that include treatment effects from other relative periods and will not cancel out.

15. Now estimate the pooled DID effect using a two-way fixed-effect regression specification.

   a. Report the coefficient and standard error clustered at the state level. How does the point estimate compare to the simple 2x2 estimate from question 13? How do the standard errors compare? (3 points)

```
  term          estimate std.error statistic p.value
  <chr>            <dbl>     <dbl>     <dbl>   <dbl>
1 unilateral     -0.0699    0.0482     -1.45   0.153
```

The point estimate and standard errors are both lower compared to question 13.

   b. How should we think about the two-way fixed-effects estimate? What comparisons are being made? How many are there? Categorize these comparisons into four distinct groups. (2 points)

The two-way fixed-effects estimate involves four distinct comparisons, categorized as: Early Group vs untreated group, Late Group vs untreated group, Early Group vs Late Group (before Late Group is treated), and Late Group vs Early Group (after Early Group is treated). These comparisons make both "clean" comparisons between treated and

> *untreated units, as well as "forbidden" comparisons between units that are both already treated. The Early Group consists of states that adopted unilateral divorce laws in 1973, the Late Group consists of states that adopted the law in 1990, and the Untreated Group consists of states that never passed the law.*

   c. Given the event study you estimated in question 14, what concerns might you have about some of these comparisons? Do you think the two-way fixed-effects estimate may be biased? If so, in what direction? (2 points)

> *The pooled DID regression estimates a single average treatment effect across all treated groups, while the 2x2 DID regression estimates treatment effects separately for each treatment group. However, the two-way fixed-effects estimate is likely biased because it includes the forbidden comparison of the 1973 and 1990 adopted states. This results in the TWFE underestimating the reduction in the female suicide rate after the adoption of unilateral divorce laws, as it does not account for the effect becoming more pronounced in the early group after the 1990 states adopted the laws.*

DIDs in Your Own Work (8 points)

16. Drawing from your own experience and interests, suggest a question that you might try to answer using a difference-in-differences model. As you think through what this would entail, explain the following aspects of your proposed analysis:

   a. Propose a specific policy question. Explain why you think this is an interesting and important policy question. Provide evidence that there is ***not*** already a conclusive answer to this question. (1 point)

> *Can implementing a minimum wage increase impact employment rates in the fast food industry? This is an interesting and important policy question since minimum wage increases are being implemented in several states, and it is crucial to understand the impact on employment rates. While there is some research on the topic, there is not yet a conclusive answer, and a difference-in-differences model can help to provide more accurate and robust results.*

   b. Describe your treatment group. (1 point)

In this study, the treatment group would be made up of fast food restaurants located in states or cities that have increased their minimum wage, either through legislative action or through a ballot initiative.

c. Propose a comparison group and explain why you chose that group. In your answer, make sure to explain what the parallel trends assumption would mean for your analysis and whether you think that assumption will be satisfied. (1 point)

For the comparison group, I would choose another industry that is not affected by minimum wage policy, such as the grocery store industry. The parallel trends assumption for this analysis would mean that the fast food and grocery store industries have similar trends in the outcome variable (such as employment levels) before the minimum wage policy change. If the parallel trends assumption holds, any difference in outcomes after the policy change can be attributed to the policy change itself. It is difficult to predict whether this assumption will be satisfied without conducting further analysis.

d. Describe the fixed effects that you would use in your difference-in-differences specification. (1 point)

Fixed effects that could be might include year fixed effects to control for time-varying factors that affect all industries, and location fixed effects to control for any time-invariant differences across regions that may affect the outcome.

e. Describe how you would cluster your standard errors, if at all. (1 point)

To cluster the standard errors, we would group together the fast food restaurants within each state, as the policy change affects all restaurants within a given state. This would help to account for potential correlation in the errors within each state.

f. Provide three examples of confounding issues that would be addressed by using the fixed effects that you include. (1.5 points)

Some examples of confounding issues that could be addressed by using fixed effects in a difference-in-differences analysis of the minimum wage impact on the fast food industry include:
- *Time-invariant differences in the fast food industry across different states that may affect outcomes, such as industry competition or consumer preferences*
- *State-specific policies or events that may affect fast food industry outcomes, such as changes in tax rates or natural disasters.*

> - *Differences in the fast food industry that are correlated with the adoption of minimum wage policies, such as urbanization levels or the presence of labor unions.*

g. Provide three examples of additional issues that might still bias your estimates despite using a difference in differences specification. How might you consider addressing those issues? (1.5 points)

> *Three examples of additional issues that might still bias estimates despite using a difference in differences specification are:*
> - *Selection bias: The treatment group and comparison group may differ systematically in ways that could affect the outcome. To address this, one could use propensity score matching to ensure that individuals in the treatment and comparison groups are similar on observable characteristics.*
> - *Measurement error: The outcome variable or treatment variable may be measured with error, leading to biased estimates. To address this, one could use instrumental variables or find alternative data sources to validate the measures.*
> - *Spillover effects: The policy change may have unintended effects on individuals or groups outside the treatment group. To address this, one could use a spatial difference-in-differences approach or examine subgroups of the treatment group to see if there are differential effects*

Reminder: please include your replicable script separately in your submission.

Appendix for Data Analysis

The data for this problem set is a state-by-year panel. Observations are uniquely identified by state, year, and sex. The data has the following key variables:

- `st` and `year` are the state and year variables.
- `sex` indicates whether the outcome is observed for males or females. It is coded as 1 for males and 2 for females.
- `divyear` is the year of unilateral divorce reform.
- `unilateral` indicates whether unilateral divorce is legal.
- `suiciderate_jag` is the suicide rate.