Recreational Cannabis: Legalization and the Economic Effects

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Abstract

The rapid industrialization across the United States and a proactive research process on marijuana has explored the conversation to include recreational marijuana as a sector in states' industrial makeup. I provide a quasi-experimental research design to estimate the impact of recreational marijuana legalization on economic indicators through the cumulative use of state data before and after policy enactment. The empirical strategy follows a difference-in-differences framework with staggered adoption of policy approval on a state-level. Using recent estimator methods that account for treatment effect heterogeneity, the average treatment effects, stemming causally from the decriminalization of cannabis across states, are three-fold: First, poverty levels decrease. Second, the real gross domestic product per capita increases. Third, household income increases. Adjacent literature suggests that the results are due to transformations of consumer behavior surrounding marijuana use.

1 Introduction

Marijuana has become a prevalent drug of use in the modern world. Since 2023, the District of Columbia and 23 states have enacted legislation to legalize the use of recreational marijuana. Legalization begets discourse over the benefits and repercussions that cannabis plays in society. On one hand, advocates support the economic incentives - that is, job creation or economic growth from profit according to Popovici and French (2013) and Chakraborty et al. (2021). On the other hand, opponents underscore the social costs such as increased homelessness, crime, substance use disorders, etc., as evident by Dragone et al. (2017) and Anderson and Rees (2011). The legalization of recreational marijuana is ridiculed with complexities and nuances for policymakers to take an approachable avenue for passage. Albeit an abundance of media coverage and discourse, it is difficult to quantify potential benefits and costs of legalization due to sample sizes and limitations of data.

Typical research done on marijuana legalization focuses on social costs. Researchers are able to assess the viability of legalization and its implications from single-state aggregated data. A particular subset of research by Anderson and Rees (2023) has evaluated the potential social costs from alcohol and tobacco usage, opioids consumption, traffic fatalities, mental health, and crime. The economic effects of legalization are arguably less comprehensive to understand. And, most research has explored immediate effects of recreational marijuana legalization without understanding the dynamic results. It is imperative to understand the long-term viability of policy shifts in cannabis to properly address all of the potential ramifications. Additionally, the states that have legalized recreational marijuana have all legalized medical marijuana beforehand. However, this paper focuses on solely from the time of recreational marijuana legalization approval year without taking into account the precedent that medical marijuana legalization set earlier.

This paper evaluates the impact of recreational marijuana legalization on economic outcomes with aggregated state-level data and a staggered difference-in-differences approach with the traditional OLS estimator compared to an array of heterogeneous-robust estimators found in de Chaisemartin and D'Haultfœuille (2020), Borusyak and Jaravel (2021), Callaway and Sant'Anna (2021), and Sun and Abraham (2021). Previous research fails to identify comprehensive analysis in two ways. First, most research uses single-state samples sizes to estimate effects. This is problematic as heterogeneity bias exists for each state. Meaning, different states may succumb to different effects based on the policy passage. Second, most research estimates on a set of given outcomes in a particular time frame. Single time period analysis for policies do not reflect the extended dynamic effects and rather display a specific result at a single point in time.

Therefore, this paper attempt to contribute to the existing literature in a couple of ways. First, by using comprehensive data across all states that legalized recreational marijuana through several time periods before and after policy approval, this paper provides a wider range of analysis on the economic effects. It is important to note that this paper does not identify a narrative for cost-benefit analysis of recreational marijuana legalization; to do so, would require a much larger set of variables and time periods. Rather, the focus is to identify some economic effects by using cross-state analysis as part of the identification strategy. Second, the recent econometric literature focuses on the shortfalls of a standard staggered difference-in-differences research design with OLS as the main estimation technique. This paper adds to the literature concerning recreational marijuana legalization and two-way fixed effects modeling by applying additional estimation techniques to the analysis. Third, this paper evaluates effects from a broader scope, delineating outcomes of interest through state-based variables.

Post-legalization, I find a decrease in the state poverty rate by 0.4 percentage points. Real gross domestic product per capita increases by 0.3 percentage points and the household income increases by 0.27 percentage points. I also find the dynamic treatment effects of recreational marijuana legalization through 9 years after legalization. The state poverty rate displays a negative, downward trend while real gross domestic product per capita and household income corroborate to positive, upward trends. Results suggest that the effects of legalization were not contemporaneous, but rather extending dynamically.

The rest of the paper is as follows: Section 2 explains the context for background legalization, Section 3 identifies the empirical strategy used to estimate the effects, Section 4 illustrates the results of the study, Section 5 summarizes the paper.

2 Background

Cannabis legalization took place gradually over time. Through the Uniform State Narcotic Drug Act in 1935 and the Marijuana Tax Act of 1937, cannabis was strongly restricted according to the Drug Enforcement Administration (2023). In 1970, the United States made marijuana federally illegal in use. For a couple of decades, marijuana usage was completely restricted and unfit for societal integration. In 1996, California became the first state to legalize medical marijuana. Subsequently, the growth of marijuana legalization was at most insignificant in the years prior to 1996. In 2009, the U.S. Department of Justice re-developed its enforcement policies to include guidance for deferment of marijuana regulation and enforcement on states that had legalized medical marijuana according to Stout and Moore (2009).

Starting from 2012, Colorado and Washington became the first states to legalize recreational marijuana - setting a precedent for other states that were keen to follow. As of October 2023, 40 states and the District of Columbia have legalized medical marijuana. 23 of those states have adopted the use of recreational marijuana. Moreover, some states have decriminalized the possession of marijuana in small quantities or legalized the sale of THC CBD oil, an extracted product from the marijuana plant typically used for medical purposes. Numerous states are beginning to legalize recreational marijuana as the years progress with the latest being Delaware and Minnesota in 2023.

Figure 1 portrays the staggered adoption of the approval year for recreational marijuana legalization. The x-axis shows the year of approval labeled as "Event Time." The y-axis identifies the frequency distribution of the policy passage. The graph visualizes that not only was legalization staggered, but through cohorts. Multiple states approved cannabis legalization in the same years. As discussed in Section 3, some heterogeneous-robust estimation methods are applicable in this scenario.

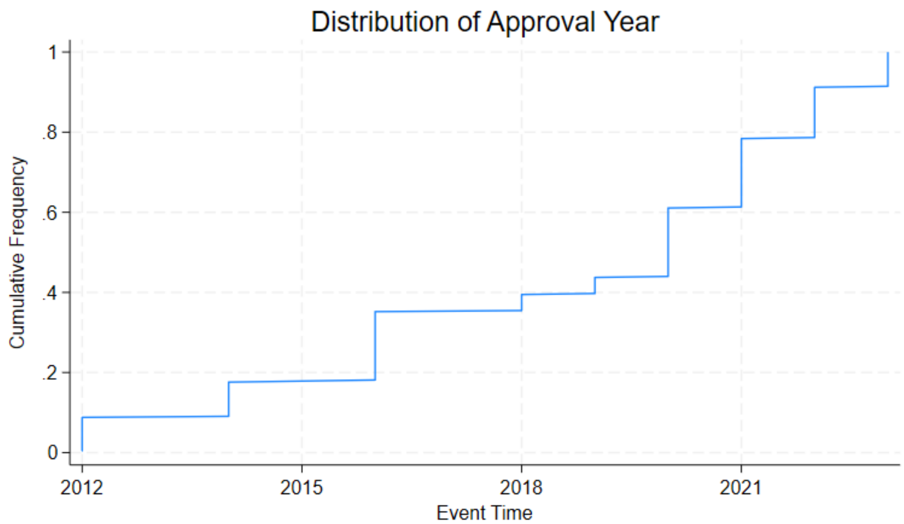


Figure 1: Marijuana Legalization Approval by Year

Coupled with the legal parameters supporting marijuana legislature is a strong public demand for access to the product. Americans, naturally, are the main consumers that benefit from recreational marijuana legalization. A poll conducted by Gallup (2021) highlights that more than two-thirds of Americans support cannabis legalization with a majority of citizens supporting the legalization for every state. It isn't uncommon to hear public support for removing the legal barriers surrounding marijuana. In fact, Colorado Amendment 64, the first amendment in the United States to legalize recreational marijuana, set the framework for legalization with Colorado voters passing the bill with 55% of the vote according to Hickenlooper (2014).

One of the major contentions regarding recreational marijuana legalization is in regards to its economic implications. Along with the advent of a new good introduced into retail markets comes the necessary analysis to determine the benefits to the economy. A direct effect of cannabis legalization is new regulated sales of marijuana. Retailers deliver a variety of products to dispensaries which are, in turn, purchased by consumers. States impose heavy taxes on the marijuana industry and gathers a larger amount of tax collections. An increase in tax collections means that the government has higher levels of spending and can increase the demand of goods and services. Broadly, marijuana sales can produce revenue and spending for local and state governments. Additionally, the legalization of cannabis can re-adjust consumer decision-making. Instead of sorting to illegal purchases or turning to other avenues of income, consumers may be able to balance the new regulated good into their consumption. As a result, savings may increase or general consumption behaviors may shift elsewhere.

3 Empirical Strategy

3.1 Data

I collected and designed a strongly balanced panel that follows states over time from year and a collection of outcomes related to marijuana usage, household income and state GDP. I collected data compiled by the RAND Corporation Opioid Tools and Information Center Resources (RAND-OPTIC) on marijuana legalization status. The data runs from 1990 to 2019 and I extended the data up to 2023. All other data was collected from the Federal Reserve Bank of St. Louis database (FRED) over the years of 2006 to 2021. The time periods, in yearly increments, were selected due to data availability across states; an extension of the analysis would include a larger scope of data, but the primary purpose of this paper is to identify effects in a general range before and after policy approval. Poverty, real GDP, and household income were the three delineated measures to evaluate the economic effects of recreational marijuana legalization and provide a general understanding of how policy approval changes these dynamics through state-level aggregation. Appendix Figure 10 visualizes the panel and treatment status structure of the data used in the model.

To assess recreational marijuana legalization's economic effects without the presence of confounding and uncontrollable input, I use a set of state-level covariates to condition out any additional bias. The *unemployment rate* was used in the design to accommodate for any potential trends with poverty, real GDP, or household income. Unemployed individuals will cease to provide income and contribute to the gross domestic product; thus, I add it as an independent variable in the research design. The *population*, a general quantity of the respective state's population, may include a state trend where the rise in population may be associated with the outcome variables. And, the *bachelor's degree* rate, a rate indicative of how many people have a bachelor's degree or higher, was included to condition out any educational correlation to the outcome variables.

3.2 Identification

Recreational marijuana legalization on a cross-state level was not immediate, rather it followed a staggered design amongst states. Table 1 in the appendix illustrates the state by year approval of recreational marijuana legalization. *N/A* in the *Year* column indicates that the state has not approved recreational marijuana legalization. I use approval year as the main identification strategy for policy enactment. The earliest legalization having been in 2012 (Colorado and Washington) and the latest in 2023 (Delaware and Minnesota). Additionally, note that because the data estimates up to 2020, all states that approved the policy after 2020 are included in the treatment portion of the model. This includes New Mexico, New York, Connecticut, Virginia, Rhode Island, Maryland, Missouri, Delaware, and Minnesota.

I estimate the effects of recreational marijuana legalization using a staggered difference-in-differences (DID) approach with the timing as the year of legalization in an event study framework on the poverty rate, the log of the real gross domestic product, and the log of household income. The two-way fixed effects (TWFE) estimation technique is specified and compared with 4 heterogeneous-robust estimators.

$$y_{it} = \alpha_i + \gamma_t + \beta M_{it} + \epsilon_{it} \tag{1}$$

$$y_{it} = \alpha_i + \gamma_t + \beta M_{it} + X_{it}\delta + \epsilon_{it} \tag{2}$$

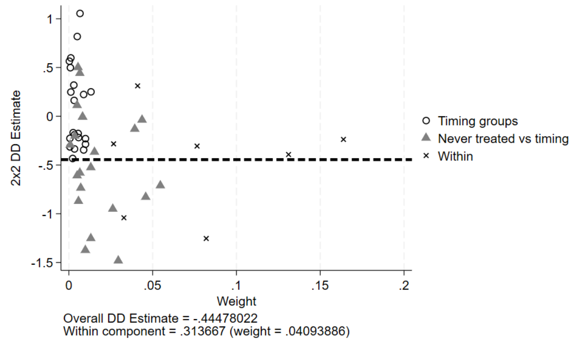
Equation 1 is the baseline equation of interest where y_{it} is the outcome variable for state i in year t, M_{it} refers to whether marijuana is legal for recreational use in state i in year t, α_i and γ_t are the state and time-fixed effects, while ϵ_{it} is the residual in state i

and year t. β, the coefficient of interest, measures the impact of recreational marijuana legalization by state. Equation 2 is an extended-version of equation 1 that includes X_{it} as the set of time-varying covariates in state i and year t. In both equations, I estimate using OLS and cluster standard errors at the state level.

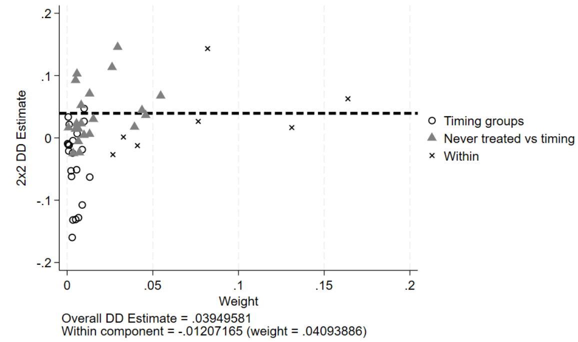
To the extent that, without recreational marijuana legalization, the economic indicator outcome variables would grow with parallel trends, and assuming that average treatment effects are completely homogeneous across states, β will reliably produce an average treatment effect on the economic indicators after approval.

A substantive argument against the viability of the causal results is related to the plausibility of the parallel trends assumption along with the potential for pre-trends – rather, states in different approval year periods may be on different economic indicator trends, contaminating the average treatment effect. To rectify these claims, I add three prongs of robustness to my analysis: (1) I estimate a fully dynamic version of Equation 1 and Equation 2 with visual checks for significant pre-trends, (2) I re-validate the estimation from (1) through 4 additional heterogeneous-robust estimation techniques, (3) I check results through a combination of an F-test, placebo test, and equivalence test through the *fect* package introduced by Liu et al. (2020). These accountability methods, further explained in Section 4, should remedy concerns about the violation of parallel trends assumption and potential for pre-trends in the research design.

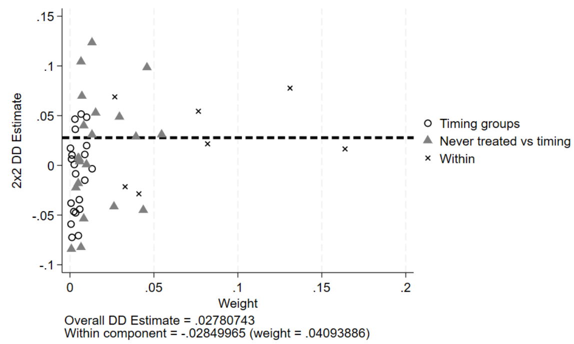
More specifically, a central concern of the TWFE OLS estimator through a staggered adoption research design is emphasized in Goodman-Bacon (2021). The average treatment effect, in a multiple treatment timing and periods set-up, is a convex combination of all possible 2 x 2 difference-in-differences comparisons between groups of units with different treatment timing. Treatment effects must be homogeneous for the TWFE estimator to consistently provide a proper average treatment effect on the treated (ATT). Moreover, if treatment effects are heterogeneous across groups of time, the TWFE estimator cannot reliably produce optimal estimates for the ATT. Goodman-Bacon (2021) derives the 2 x 2 difference-in-differences estimates to ultimately identify a negative-weighting issue in the aggregation of the TWFE estimator that is caused by already treated units taking the place of the control group, which, in turn, damages the reliability of the estimates.



(a) Poverty



(b) Real GDP



(c) Household Income

Figure 2: Bacon-Decomposition of Outcome Variables

Figure 2 visualizes the negative weighting issue of all 2x2 difference-in-differences comparisons for each of the outcome variables. The horizontal dotted line reflects the average treatment effect before and after approval year of recreational marijuana legalization. The negative weighting is primarily prevalent in the ”never treated vs timing” and ”within” groups, indicative of heterogeneity bias after policy approval.

Thus, to alleviate the inconsistencies of the TWFE estimator, I replicate the results dynamically with a series of heterogeneous treatment effect (HTE)-robust estimators presented in de Chaisemartin and D'Haultfœuille (2020); Borusyak and Jaravel (2021); Callaway and Sant'Anna (2021); and Sun and Abraham (2021) through an event study model. These HTE-robust estimators were specifically chosen to explore different ATT aggregation processes to mitigate, rather eliminate the existing heterogeneity bias in treatment effects: (i) de Chaisemartin and D'Haultfœuille (2020) optimize a matching technique that eliminates already-treated units from the ATT, (ii) Borusyak and Jaravel (2021) use an imputation method without treated units factored into the ATT, (iii) Callaway and Sant'Anna (2021) and Sun and Abraham (2021) exemplify an interaction-weighted approach with cohorts to estimate the CATT, and then the eventual ATT. With the elimination of specific 2 x 2 difference-in-differences comparisons that incorporate already treated units and newly treated units, the HTE-robust estimators can effectively bypass the heterogeneity bias in treatment effects across time periods and/or treated units whilst producing consistent, specified ATTs under the event-study framework.

4 Results

4.1 Main Results

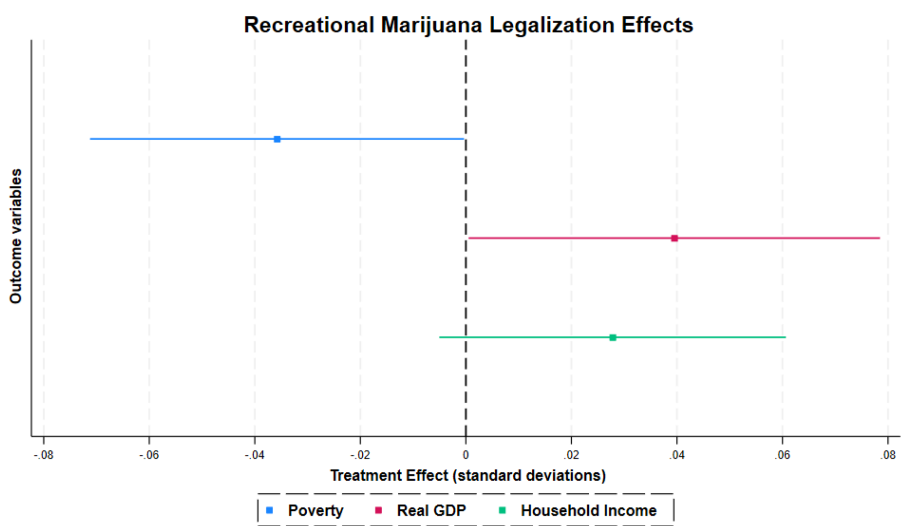
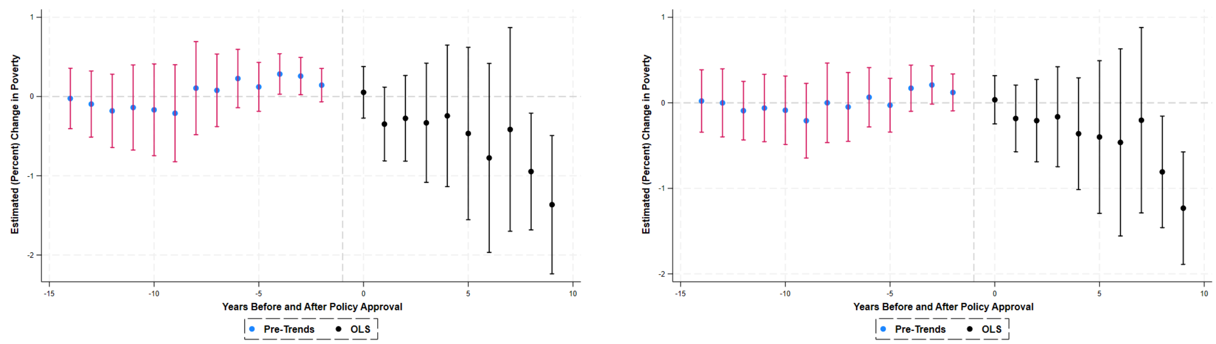


Figure 3: Effects of Recreational Marijuana Legalization

Figure 3 illustrates the average treatment effect of approving cross-state recreational marijuana legalization on the poverty, real gross domestic product, and household income. To account for accurate representation of the distribution, I take the natural log of the outcome variables and produce the effects in the following results. State poverty levels decrease, on average, by 0.03% after the approval. Conversely, the real gross domestic product per capita and household income increases by 0.04% and 0.027% respectively.

The following sections detail the dynamic treatment effects of recreational marijuana legalization. Table 2 explains the full output of the dynamic treatment effects from 14 pre-periods and 9 post-periods.

4.1.1 Poverty



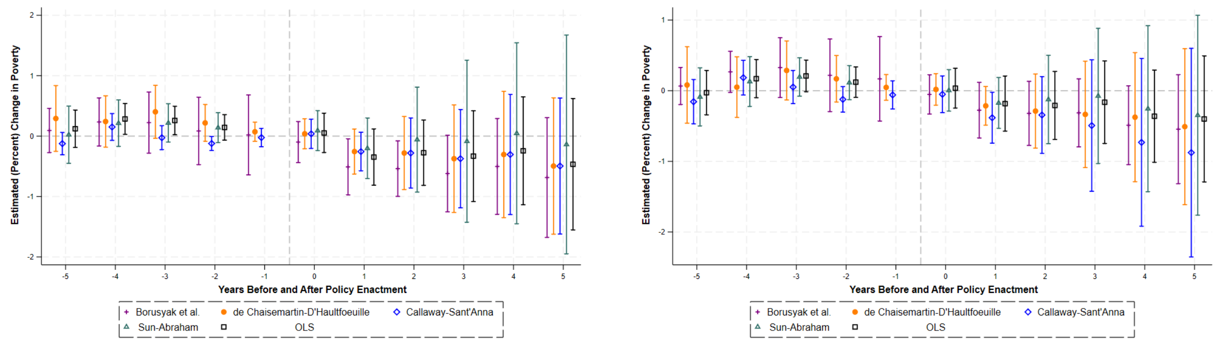
(a) Baseline

(b) Covariates

Figure 4: TWFE Estimates of Marijuana Legalization on Poverty from/to Policy Approval

Recreational marijuana legalization significantly reduced the poverty rates statewide. Figure 4 depicts the event-study model TWFE coefficient values of poverty before and after the approval year through 15 periods with OLS. Holistically, there is a downward trend in poverty rates before and after policy approval. The point-wise estimates, up to period 10, show a decrease of over 1%. Figure 4(a), in the left panel, establishes the baseline results of the model in which the pre-approval periods hover around 0 indicating the efficacy of the parallel trends assumption and allowing the safe rejection of any reflective pre-trends. The right panel, 4(b), replicates the event-study design with covariates. The treatment effects on poverty are similar in both panels and are consistent with no significant effect prior to legalization and after.

Figure 5 visualizes a truncated event-study model with heterogeneous-robust estimate values of poverty before and after the approval year of recreational marijuana legalization through 5 periods. Since the policy approval year's inception, both panel 5(a) and 5(b) illustrate a downward trend in the poverty estimates. The decrease may be linked to individuals re-adjusting their behaviors as recreational marijuana becomes a legal good,

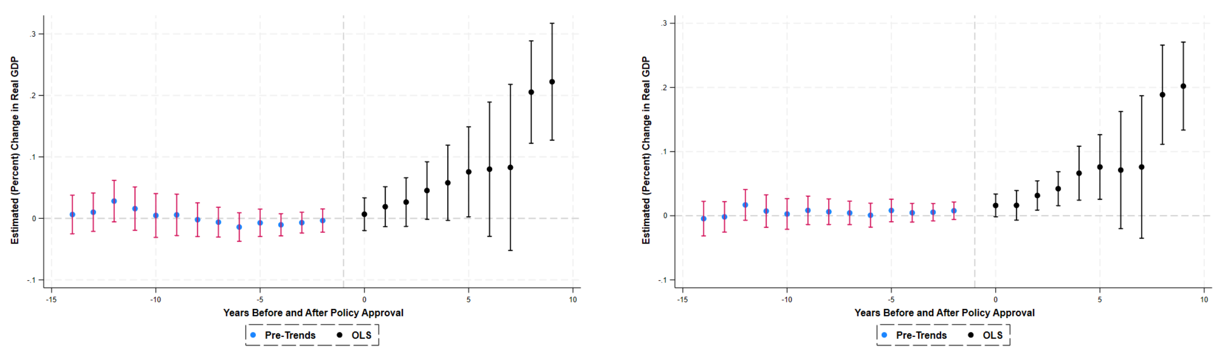


(a) Baseline (b) Covariates

Figure 5: HTE-Robust Estimates of Marijuana Legalization on Poverty from/to Policy Approval

that is, consumers change purchasing decisions when marijuana becomes a product. As a result, consumers are smarter in decision-making and can allocate their income more wisely. Another potential link to the decrease in poverty is a reduction in crime. Addicts might turn to crime to purchase marijuana illegally, but with the advent of recreational marijuana legalization, marijuana is accessible without the need for crime.

4.1.2 GDP

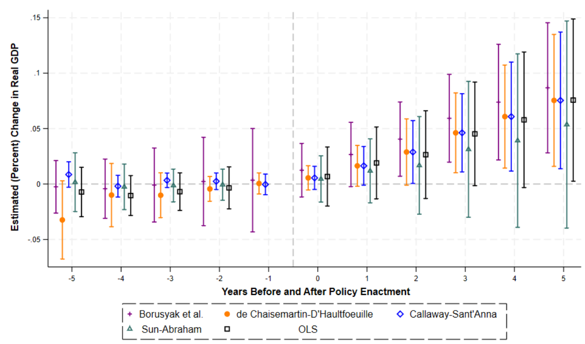


(a) Baseline (b) Covariates

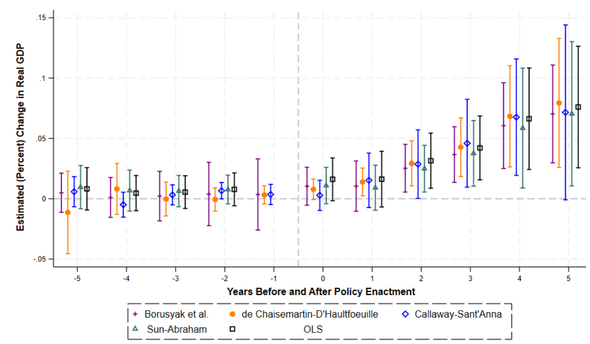
Figure 6: TWFE Estimates of Marijuana Legalization on Real GDP from/to Policy Approval

Next, I identify the economic effects of the legalization of cannabis for recreational use. Figure 6 depicts the event-study model TWFE coefficient values of the log of real

GDP before and after the approval year through 15 periods through the OLS estimator. A couple of things to notice. Both panels identify an upwards trend of the real gross domestic product per capita before and after policy approval through 15 periods. There are slight, positive contemporaneous effects through period 1 that eventually grows in magnitude. From period 0 to 5, the growth jumps to 0.6%. From period 5 onward, the magnitude increases. Figure 6(a), in the left panel, establishes the baseline results of the model in which the pre-approval periods contain confidence intervals that pass through zero which satisfies the parallel trends assumption and allowing the safe rejection of any reflective pre-trends. The right panel, 6(b), replicates the event-study design with covariates to display similar results.



(a) Baseline

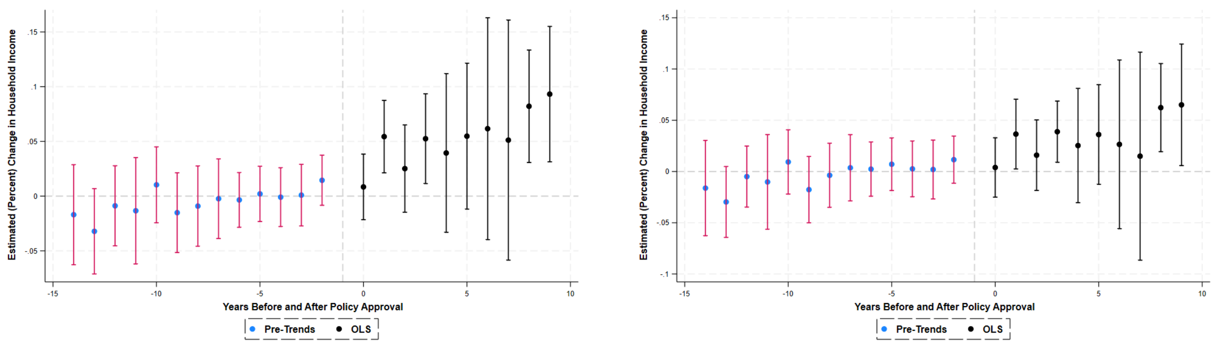


(b) Covariates

Figure 7: HTE-Robust Estimates of Marijuana Legalization on Real GDP from/to Policy Approval

Figure 7 portrays a truncated event-study model with heterogeneous-robust estimate values of the log of the real gross domestic product before and after the approval year of recreational marijuana legalization through 5 periods. Since the policy approval year's inception, both panel 7(a) and 7(b) illustrate an upward trend in the gross domestic product estimates. Through the elimination of heterogeneity bias, it is clear that post-policy approval, there is a large increase in the real gross domestic product per capita. I can reasonably conclude that recreational marijuana legalization has improved the real gross domestic product over time. The increase is most likely attributed to consumers reaping the benefits of a new good in the market. An increase in demand for recreational marijuana means that more purchases are likely to occur as the new good enters dispensaries. Furthermore, the increase in demand might require additional dispensaries to open up, and subsequently, an increase in products for the local economy. Another potential reason for the increase in GDP may be substance use disorder. Cannabis users may become addicted and thus, purchase more marijuana. The result is more profit from the dispensaries.

4.1.3 Household Income

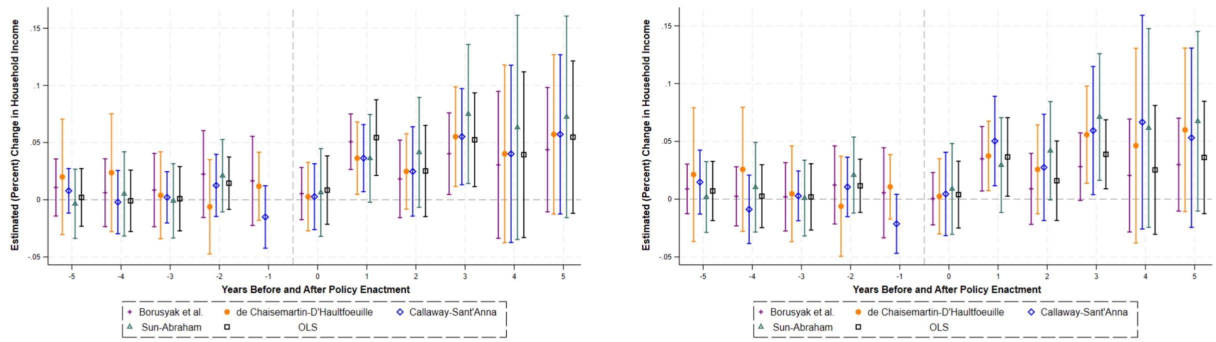


(a) Baseline (b) Covariates

Figure 8: TWFE Estimates of Marijuana Legalization on Household Income from/to Policy Approval

Lastly, I take a look at the economic effects of recreational cannabis legalization at the household level. Figure 8 illustrates the dynamic average treatment effects of the log of household income through an event-study model before and after the approval year through 15 periods using the OLS estimator. Figure 8(a), in the left panel, explains the baseline results of the model in which the pre-approval periods hover around 0 indicating the efficacy of the parallel trends assumption and reject the notion of potential pre-trends. The right panel, 8(b), replicates the event-study design with covariates. There are immediate contemporaneous effects through period 1 that eventually grows in magnitude. Both panels identify an upwards trend of the real gross domestic product per capita before and after policy approval through 15 periods.

Figure 9 portrays a truncated event-study model with heterogeneous-robust estimate values of the log of the household income before and after the approval year of recreational marijuana legalization through 5 periods. Since the policy approval year's inception, both panel 9(a) and 9(b) illustrate an upward trend in the household income



(a) Baseline (b) Covariates

Figure 9: HTE-Robust Estimates of Marijuana Legalization on Real GDP from/to Policy Approval

estimates. Through the elimination of heterogeneity bias, the coefficient values of each of the estimators compared to OLS correspond well. A likely explanation is supplemented by Jeffers et al. (2021): where users in a \$25,000 - \$74,000 income bracket tend to use marijuana at a lower rate than that of the below \$25,000 bracket. The linkage is apparent. Legalization of recreational marijuana means consumers in the former bracket are less likely to use income to purchase marijuana, and are much more likely to restrain their income for other sources. Indirectly, consumers may have better income sources for marijuana purchase and do not need to resort to illegal purchases. Recreational marijuana may be fit into consumer's daily or weekly routines given its legality and require them to increase income to meet their own demands.

4.2 Robustness and Limitations

Some concern leveraging approval year versus policy enforcement year may introduce anticipation effects when creating a DID model that incorporates extended time periods in the dynamic treatment effects as cited by Callaway and Sant'Anna (2021) - of which consumers may opt to lifestyle changes or behavioral incentives to accommodate the legalization of recreational marijuana in their agenda in the months or year prior to enforcement; nonetheless, to combat these inadequacies, I use statistical testing through placebo tests, f-tests, and equivalence tests in the pre-periods of policy approval. Through estimation, I conclude that there is limited, rather no anticipation effect before policy enforcement takes place. Figures 11, 12, and 13 in the appendix detail the results of the respective testing mechanisms. Second, I estimate the event study model from 14 pre-periods to 9 post-periods to visually ensure no detectable change in the point-estimates for all estimators. Figures 14, 15, and 16 explore these results through 10 periods before and after recreational marijuana legalization approval, and indicate no discernible change in the long-term.

An extension to this paper would include additional covariates to identify any discrepancies in the point-estimates of the outcome variables. I solicited to include life expectancy and death rates as population-oriented covariates as the dearth of data per state made it impossible to include them in a strongly balanced panel format - a powerful requisite for staggered difference-in-difference research design. Finding additional data sources that include these covariates along with others may improve the coefficient estimates.

Another potential extension would be to aggregate effects based off of age and race. Teenagers and young adults are much more sensitive to recreational marijuana legalization, and would be prime customers for consumers. Marijuana production companies may cater advertisement towards this demographic and assessing the outcome would extend this paper's results. Along the same lines, race is a category often paired with drug usage. By evaluating the effects of recreational marijuana on race, it might extend insight on how legalization affects a specific demographic.

Moreover, branching effects to include medical marijuana legalization and recreational marijuana legalization may prove insightful for delineating more specific economic effects. However, the main scope of the paper was to identify simply the before and after of recreational marijuana approval with or without medical marijuana previously approved. It is also important to note that inclusion of all states in the treatment group may provide additional consistencies in the estimates. Given the treatment group consisted of 10 states, additional states would specify the comparison of *never-treated* units to *timing* groups further.

5 Conclusion

Ultimately, the legality of cannabis is a never-ending battle. Public debate over the benefits and consequences of legalizing recreational marijuana will continue amidst the literature. Proponents argue about the economic incentives that improve the real gross domestic product and increase household income. Additionally, the structural control of legalization may incentivize individuals to manage their own marijuana addiction and substance abuse. On the other hand, opponents discuss the negative repercussions on mental health and crime insofar that there may be reverse causality that incites consumers to turn to alternative means of finding income to purchase cannabis. And, the abundant use of recreational cannabis can deteriorate the mental capacity of most individuals, inducing effects to mental health such as anxiety, depression, or substance use disorders. Often times, each side attempts to extrapolate an avenue to warrant the legalization through social, economic, behavioral and other mechanisms.

I take a look holistically at the economic incentives and identified the main effects on poverty, household income, and real gross domestic product per capita. Taking advantage of a staggered difference-in-differences approach, I compare the OLS estimates to HTE-robust estimates as a means of robustness in an event-study model and find the dynamic effects of the natural log of poverty, the natural log of GDP, and the natural log of household income are decreased by 0.03%, increased by 0.04%, and increased by 0.027% respectively. The contemporaneous effects are much more transparent as consumers opt to take advantage of the policy approval in recreational marijuana legalization. Consumers presumably change their purchasing decisions and can safely incorporate recreational cannabis in their supply of goods. Overall, results show the economic advantages of legalizing recreational marijuana onto the state and their respective consumers.

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Appendix: Additional Figures and Tables

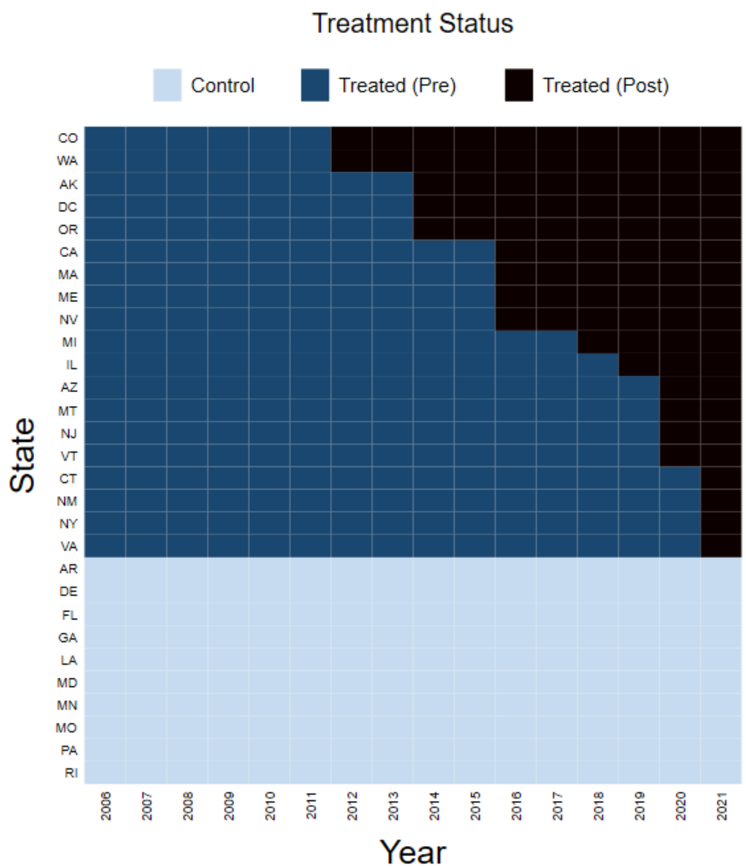
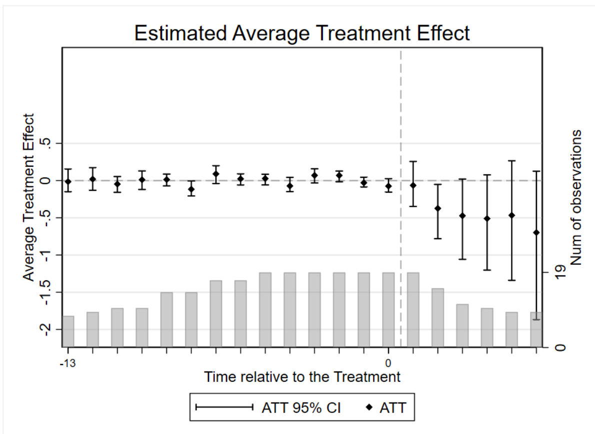
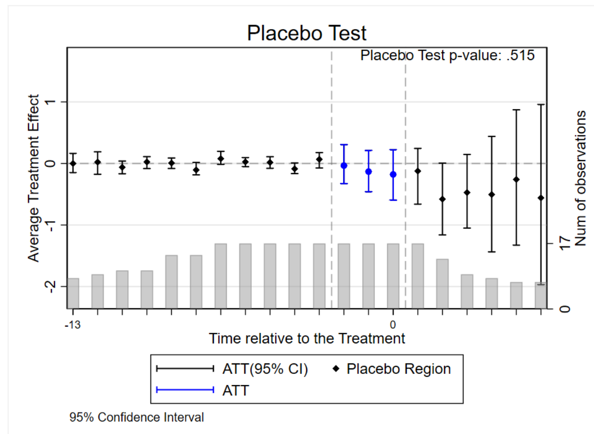


Figure 10: Empirical Data Design

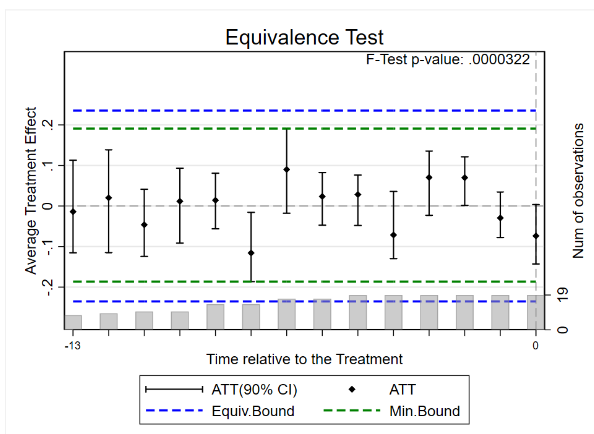
Notes: The figure displays the panel breakdown of recreational marijuana legalization across states over time.



(a) General Results



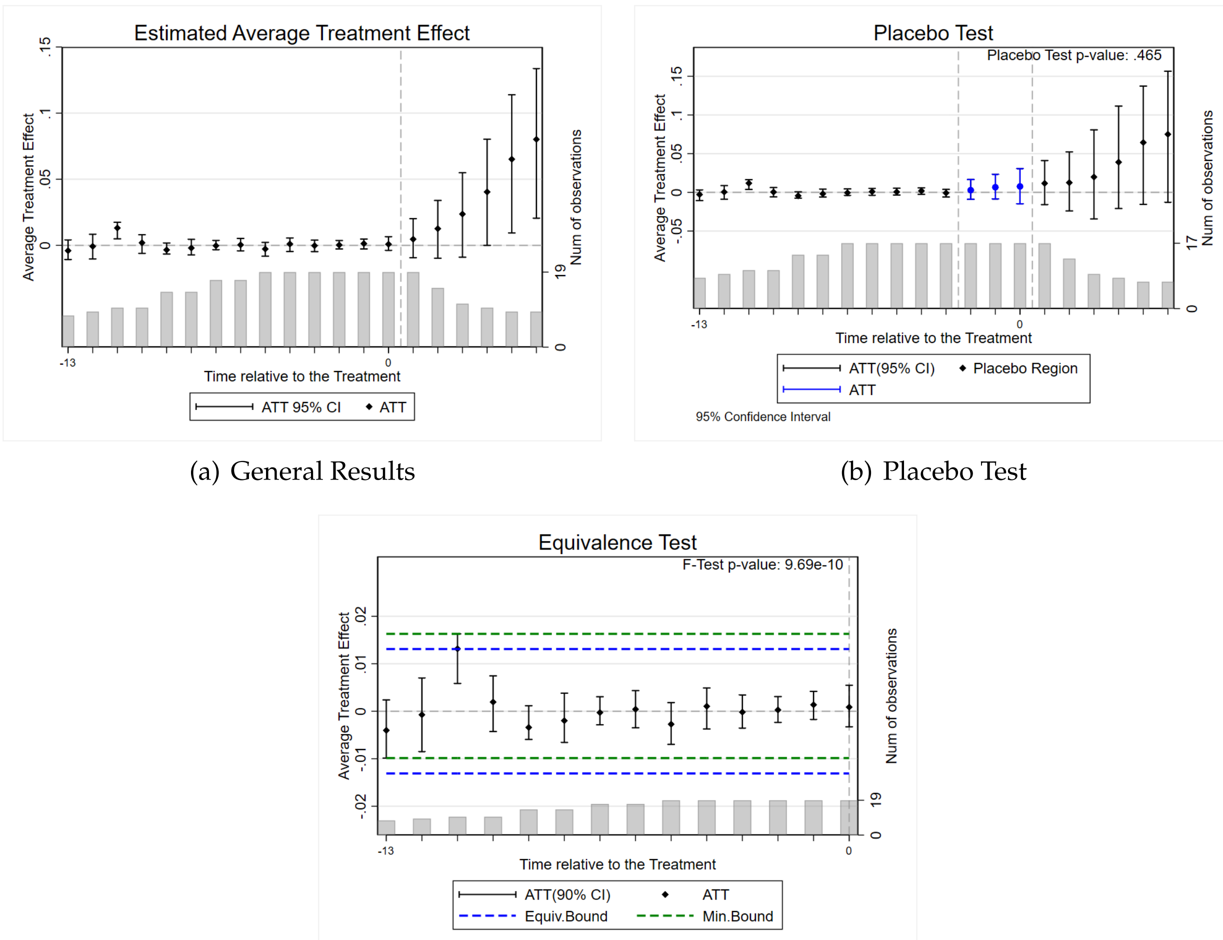
(b) Placebo Test



(c) Equivalence Test

Figure 11: *fect* Results on Poverty Estimates

Notes: The figure shows the output of the *fect* package on poverty. Panel a depicts general estimation with the *fect* estimator and the F-test. Panel b depicts the placebo test results. Panel c depicts the equivalence test results.



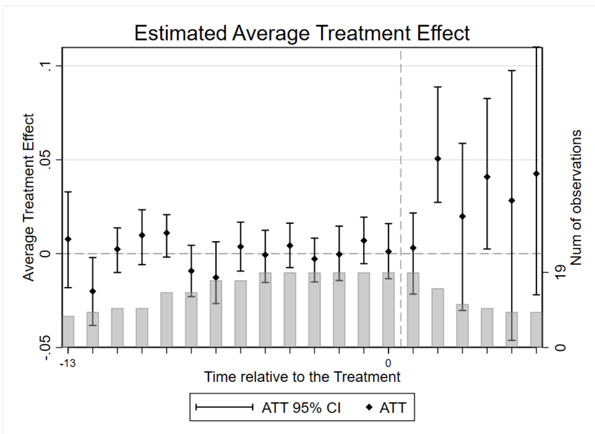
(a) General Results

(b) Placebo Test

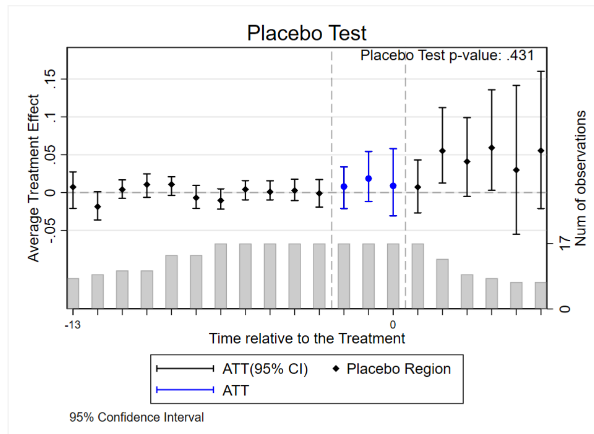
(c) Equivalence Test

Figure 12: *fect* Results on Real GDP Estimates

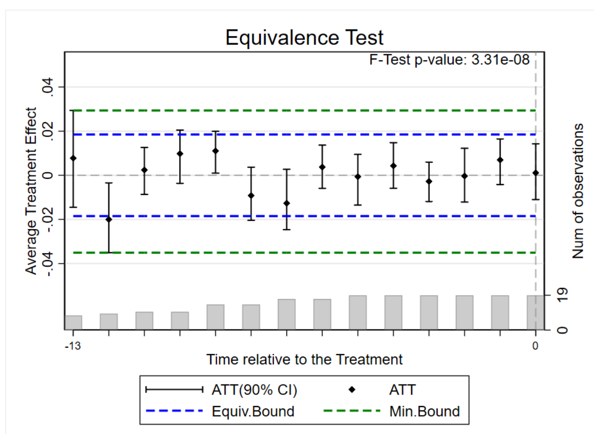
Notes: The figure shows the output of the *fect* package on the log of real gross domestic product. Panel a depicts general estimation with the *fect* estimator and the F-test. Panel b depicts the placebo test results. Panel c depicts the equivalence test results.



(a) General Results



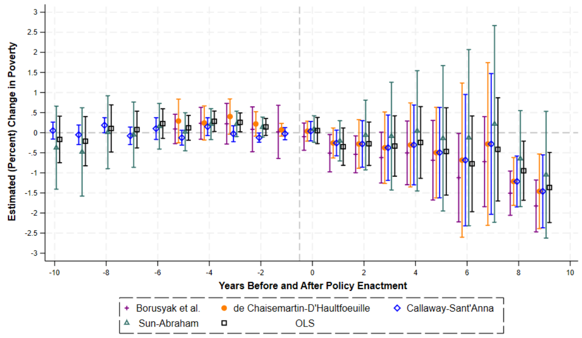
(b) Placebo Test



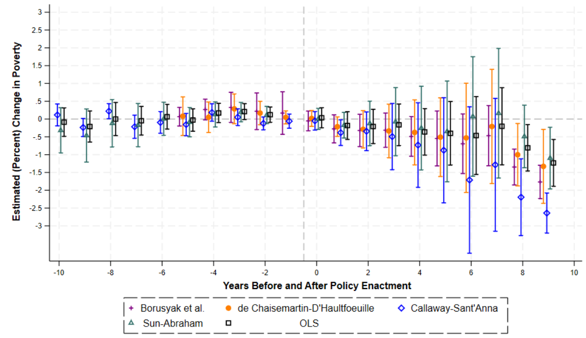
(c) Equivalence Test

Figure 13: $fect$ Results on Household Income Estimates

Notes: The figure shows the output of the *fect* package on the log of household income. Panel a depicts general estimation with the *fect* estimator and the F-test. Panel b depicts the placebo test results. Panel c depicts the equivalence test results.



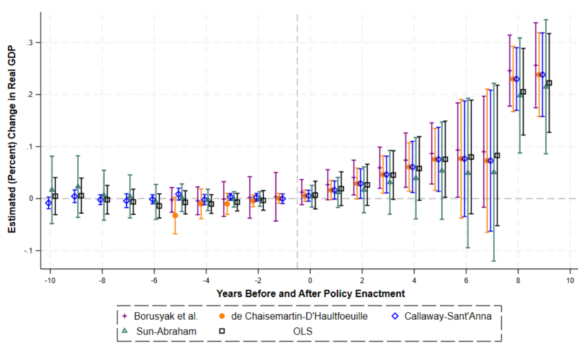
(a) Baseline



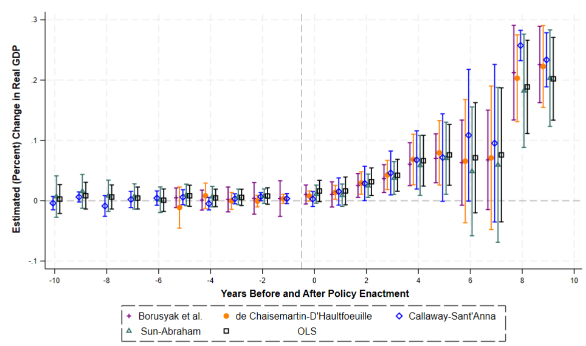
(b) Covariates

Figure 14: Event-Study of Recreational Marijuana Legalization on Poverty from/to Policy Approval

Notes: The figure shows the dynamic treatment effects of recreational marijuana legalization on poverty through an event study model of 10 periods before and after policy approval. The heterogeneous-robust estimators are compared to OLS and are reflected in the legend. Panel a depicts the baseline model while panel b depicts the model with covariates. Standard errors are clustered at the state level and 95% confidence intervals are shown in the graph.



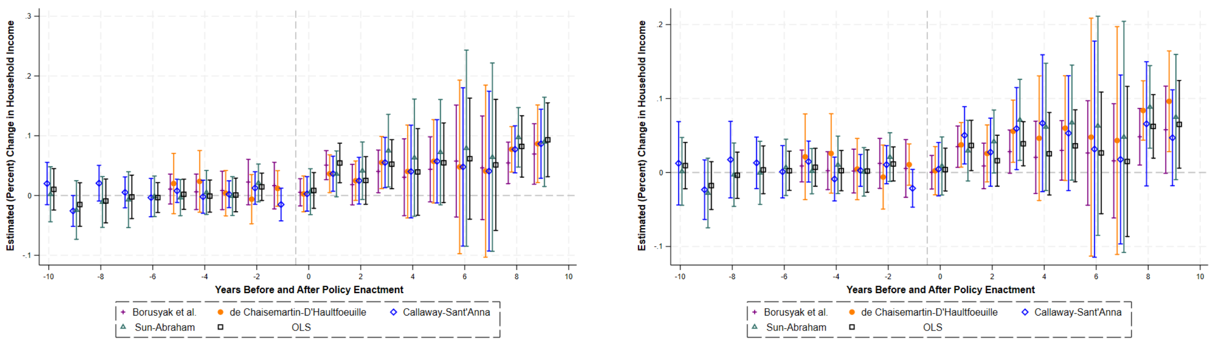
(a) Baseline



(b) Covariates

Figure 15: Event-Study of Recreational Marijuana Legalization on GDP per capita from/to Policy Approval

Notes: The figure shows the dynamic treatment effects of recreational marijuana legalization on real gross domestic product per capita through an event study model of 10 periods before and after policy approval. The heterogeneous-robust estimators are compared to OLS and are reflected in the legend. Panel a depicts the baseline model while panel b depicts the model with covariates. Standard errors are clustered at the state level and 95% confidence intervals are shown in the graph.



(a) Baseline (b) Covariates

Figure 16: Event-Study of Recreational Marijuana Legalization on Household Income from/to Policy Approval

Notes: The figure shows the dynamic treatment effects of recreational marijuana legalization on household income through an event study model of 10 periods before and after policy approval. The heterogeneous-robust estimators are compared to OLS and are reflected in the legend. Panel a depicts the baseline model while panel b depicts the model with covariates. Standard errors are clustered at the state level and 95% confidence intervals are shown in the graph.

State	Year
Colorado	2012
Washington	2012
Oregon	2014
Alaska	2014
District Of Columbia	2014
California	2016
Maine	2016
Nevada	2016
Massachusetts	2016
Michigan	2018
Illinois	2019
Arizona	2020
Vermont	2020
New Jersey	2020
Montana	2020
New Mexico	2021
New York	2021
Connecticut	2021
Virginia	2021
Rhode Island	2022
Maryland	2022
Missouri	2022
Delaware	2023
Minnesota	2023
Arkansas	N/A
Florida	N/A
Georgia	N/A
Louisiana	N/A
Pennsylvania	N/A

Table 1: Recreational Marijuana Legalization Approval Year by State

	Poverty		Real GDP		Household Income	
	(1)	(2)	(3)	(4)	(5)	(6)
Period -14	0.144	0.121	-0.00349	0.00776	0.0145	0.0116
	(1.34)	(1.10)	(-0.36)	(1.12)	(1.24)	(0.98)
Period -13	0.258*	0.209	-0.00689	0.00550	0.000894	0.00195
	(2.15)	(1.83)	(-0.80)	(0.79)	(0.06)	(0.13)
Period -12	0.284*	0.171	-0.0104	0.00465	-0.000946	0.00255
	(2.18)	(1.24)	(-1.14)	(0.63)	(-0.07)	(0.18)
Period -11	0.122	-0.0282	-0.00719	0.00821	0.00204	0.00708
	(0.77)	(-0.18)	(-0.63)	(0.92)	(0.16)	(0.54)
Period -10	0.227	0.0652	-0.0141	0.000824	-0.00348	0.00233
	(1.21)	(0.37)	(-1.19)	(0.09)	(-0.27)	(0.17)
Period -9	0.0780	-0.0481	-0.00612	0.00444	-0.00237	0.00361
	(0.33)	(-0.23)	(-0.50)	(0.48)	(-0.13)	(0.22)
Period -8	0.106	0.0000793	-0.00210	0.00620	-0.00911	-0.00370
	(0.35)	(0.00)	(-0.15)	(0.61)	(-0.49)	(-0.23)
Period -7	-0.211	-0.209	0.00571	0.00835	-0.0151	-0.0177
	(-0.67)	(-0.94)	(0.33)	(0.74)	(-0.81)	(-1.07)
Period -6	-0.168	-0.0874	0.00474	0.00276	0.0103	0.00933
	(-0.57)	(-0.43)	(0.26)	(0.23)	(0.58)	(0.58)
Period -5	-0.138	-0.0609	0.0159	0.00727	-0.0134	-0.0102
	(-0.51)	(-0.30)	(0.88)	(0.56)	(-0.54)	(-0.43)
Period -4	-0.181	-0.0922	0.0281	0.0169	-0.00885	-0.00497
	(-0.77)	(-0.53)	(1.64)	(1.38)	(-0.47)	(-0.33)
Period -3	-0.0951	-0.000796	0.0101	-0.00176	-0.0322	-0.0297
	(-0.45)	(-0.00)	(0.64)	(-0.15)	(-1.62)	(-1.68)
Period -2	-0.0243	0.0213	0.00633	-0.00454	-0.0170	-0.0162
	(-0.12)	(0.11)	(0.40)	(-0.33)	(-0.73)	(-0.68)
Period 0	0.0531	0.0356	0.00677	0.0161	0.00844	0.00393
	(0.32)	(0.25)	(0.50)	(1.78)	(0.55)	(0.27)
Period 1	-0.347	-0.183	0.0190	0.0162	0.0544**	0.0365*
	(-1.46)	(-0.92)	(1.15)	(1.37)	(3.22)	(2.10)
Period 2	-0.275	-0.209	0.0265	0.0315*	0.0252	0.0159
	(-1.00)	(-0.85)	(1.31)	(2.70)	(1.24)	(0.91)
Period 3	-0.331	-0.163	0.0453	0.0421**	0.0525*	0.0388*
	(-0.86)	(-0.55)	(1.90)	(3.12)	(2.51)	(2.55)
Period 4	-0.244	-0.361	0.0579	0.0663**	0.0394	0.0253
	(-0.53)	(-1.08)	(1.86)	(3.09)	(1.07)	(0.89)
Period 5	-0.466	-0.400	0.0757	0.0760**	0.0548	0.0361
	(-0.84)	(-0.88)	(2.03)	(2.96)	(1.61)	(1.45)
Period 6	-0.774	-0.463	0.0800	0.0712	0.0616	0.0265
	(-1.27)	(-0.83)	(1.44)	(1.53)	(1.19)	(0.63)
Period 7	-0.415	-0.203	0.0829	0.0760	0.0512	0.0149
	(-0.63)	(-0.37)	(1.20)	(1.34)	(0.91)	(0.29)
Period 8	-0.947*	-0.808*	0.205***	0.189***	0.0821**	0.0623**
	(-2.52)	(-2.43)	(4.83)	(4.78)	(3.13)	(2.84)
Period 9	-1.365**	-1.232**	0.222***	0.202***	0.0932**	0.0650*
	(-3.06)	(-3.67)	(4.58)	(5.78)	(2.95)	(2.15)
Covariates	No	Yes	No	Yes	No	Yes
Observations	464	464	464	464	464	464

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Dynamic Treatment Effects from Recreational Marijuana Legalization

Notes: The figure shows the full dynamic treatment effects of recreational marijuana legalization on all outcomes of interest through an event study model before and after policy approval. Periods -14 through -2 indicate pre-policy approval and periods 0 to 9 indicate post-policy approval. Standard errors are clustered at the state-level and *t* statistics are in parentheses.