

Final Project

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Consider a state government in the United States that administers a child support program. This program requires non-custodial parents (NCPs) to pay monthly child support payments to custodial parents of their children. If NCPs fail to make payments, they can owe child support debt, leading to incarceration.

Suppose that a state child support agency introduced a program to provide intensive case management services to NCPs so that they could help them find jobs to make child support payments and have better relationships with their non-custodial children and the custodial parents. The program was administered in selected local child support sites across the state, and in these sites, the program was rolled out at varying dates.

Please download `final_data_dd.csv`. This dataset contains the following site-level panel data (each row in the dataset corresponds to an observation for a given site at a given calendar quarter):

- `site_id` = identification number for a local child support office site
- `year_qtr` = calendar quarter of observation (eg 2011.25 is the second quarter in 2011)
- `treatment` = indicator equal to 1 if the site was selected for treatment
- `treatment_year_qtr` = calendar quarter the site began the program if selected for treatment
- `ncp_emp_rate` = employment rate for NCPs served by the site in the calendar quarter
- `smom_emp_rate` = employment rate for single mothers served by the site in the calendar quarter
- `ncp_wdebt` = fraction of NCPs served by the site in the calendar quarter that owe child support debt
- `Nncp` = number of NCPs served by the site in the calendar quarter

1. Confirm that we have varying dates of treatment.

```
# Load the packages
```

```
library(readr)
library(ggplot2)
library(miceadds)
library(ivreg)
library(dplyr)
library(stargazer)
library(fixest)
```

```
# Load the dataset
```

```
final <- read_csv("~/Desktop/final_data_dd.csv", show_col_types = FALSE)
```

```
# Check the distribution of treatment year
```

```
table(final$treatment_year_qtr)
```

```
##
```

```
##      0      2014 2014.25 2014.5 2014.75      2015 2015.25 2015.5 2015.75      2016
```

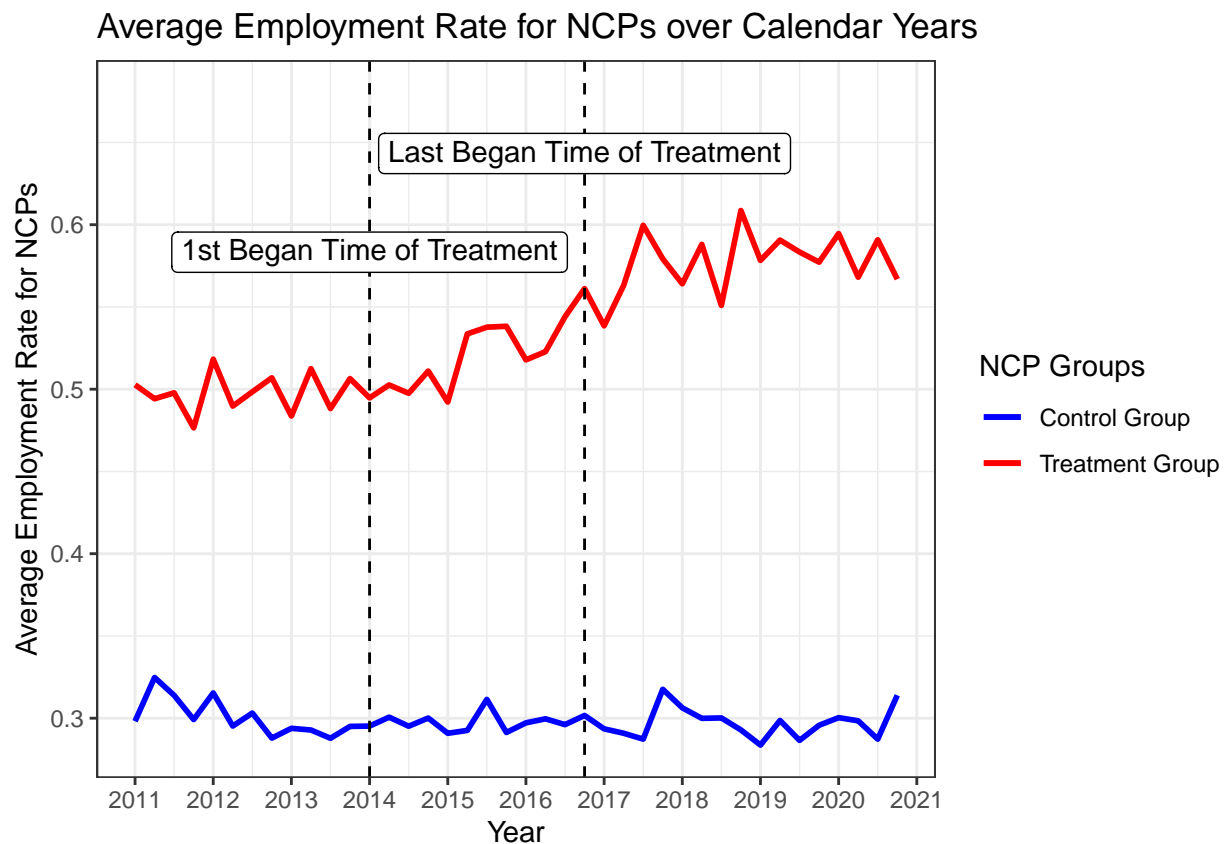
```
## 5160      40      200      200      80      240      400      160      120      40
```

```
## 2016.25 2016.5 2016.75
```

```
## 360      320      120
```

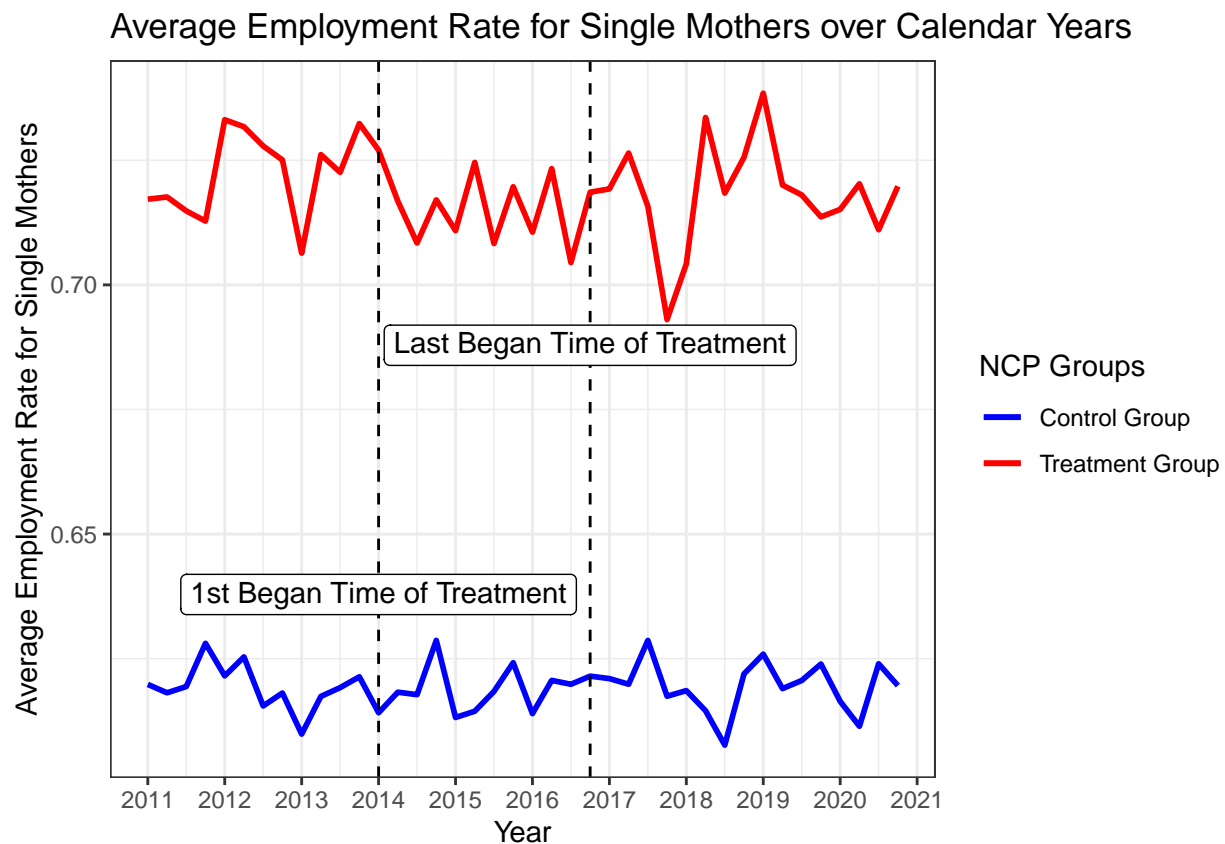
2. Plot average employment rate for NCPs served, employment rate for single mothers served, and fraction of NCPs served that owe child support debt over calendar year for the treatment and control groups.

```
# Plot average employment rate for NCPs served
### Create a new df contained mean employment rate for NCPs served in each year
plotdata <- aggregate(final$ncp_emp_rate, list(final$year_qtr, final$treatment), FUN = mean)
### Visualize the plot
ggplot(data = plotdata, aes(x = Group.1, y = x, color = as.factor(Group.2))) +
  geom_line(data = subset(plotdata, Group.2 == 1), linetype = "solid", size = 1) +
  geom_line(data = subset(plotdata, Group.2 == 0), linetype = "solid", size = 1) +
  labs(x = "Year", y = "Average Employment Rate for NCPs", title = "Average Employment Rate for NCPs over Calendar Years") +
  theme_bw() +
  xlim(2011, 2021) + scale_x_continuous(breaks = seq(2011, 2021, 1)) +
  geom_vline(xintercept=2014, color='black', linetype=2) +
  geom_vline(xintercept=2016.75, color='black', linetype=2) +
  scale_color_manual(name = "NCP Groups", values = c("blue", "red"),
    labels = c("Control Group", "Treatment Group")) +
  annotate(x=2014, y=0.62, label="1st Began Time of Treatment", vjust=2, geom="label") +
  annotate(x=2016.75, y=0.68, label="Last Began Time of Treatment", vjust=2, geom="label")
```



```
# Plot average employment rate for single mother served
### Create a new df contained mean employment rate for single mothers served in each year
plotdata1 <- aggregate(final$smom_emp_rate, list(final$year_qtr, final$treatment), FUN = mean)
### Visualize the plot
ggplot(data = plotdata1, aes(x = Group.1, y = x, color = as.factor(Group.2))) +
```

```
geom_line(data = subset(plotdata1, Group.2 == 1), linetype = "solid", size = 1) +
geom_line(data = subset(plotdata1, Group.2 == 0), linetype = "solid", size = 1) +
labs(x = "Year", y = "Average Employment Rate for Single Mothers", title = "Average Employment Rate for Single Mothers over Calendar Years") +
theme_bw() +
xlim(2011, 2021) + scale_x_continuous(breaks = seq(2011, 2021, 1)) +
geom_vline(xintercept=2014,color='black',linetype=2)+
geom_vline(xintercept=2016.75,color='black',linetype=2)+
scale_color_manual(name = "NCP Groups", values = c("blue", "red"),
                    labels = c("Control Group", "Treatment Group"))+
annotate(x=2014,y=0.65,label="1st Began Time of Treatment",vjust=2,geom="label")+
annotate(x=2016.75,y=0.7,label="Last Began Time of Treatment",vjust=2,geom="label")
```

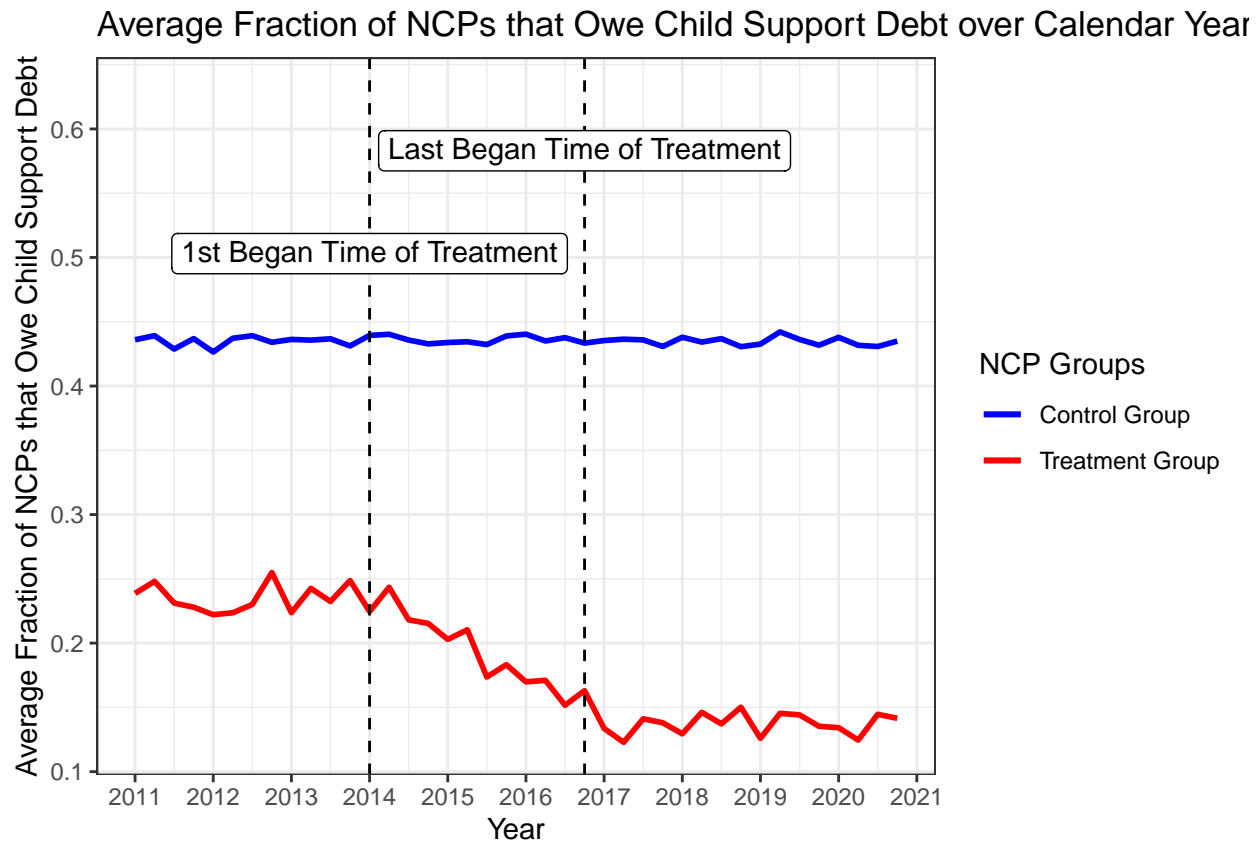


```
# Plot average fraction of NCPs served that owe child support debt
### Create a new df contained mean employment rate for single mothers served in each year
plotdata2 <- aggregate(final$ncp_wdebt, list(final$year_qtr, final$treatment), FUN = mean)
### Visualize the plot
ggplot(data = plotdata2, aes(x = Group.1, y = x,color=as.factor(Group.2))) +
  geom_line(data = subset(plotdata2, Group.2 == 1), linetype = "solid", size = 1) +
  geom_line(data = subset(plotdata2, Group.2 == 0), linetype = "solid", size = 1) +
  labs(x = "Year", y = "Average Fraction of NCPs that Owe Child Support Debt", title = "Average Fraction of NCPs that Owe Child Support Debt over Calendar Years") +
  theme_bw() +
  xlim(2011, 2021) + scale_x_continuous(breaks = seq(2011, 2021, 1)) +
  geom_vline(xintercept=2014,color='black',linetype=2)+
  geom_vline(xintercept=2016.75,color='black',linetype=2)+
  scale_color_manual(name = "NCP Groups", values = c("blue", "red"),
```

```

labels = c("Control Group", "Treatment Group"))+
annotate(x=2014,y=0.55,label="1st Began Time of Treatment",vjust=2,geom="label")+
annotate(x=2016.75,y=0.63,label="Last Began Time of Treatment",vjust=2,geom="label")

```



- Using observations for treated NCP only, create time since treatment and plot employment rate for NCPs served, employment rate for single mothers served, and fraction of NCPs served that owe child support debt by time since treatment.

```

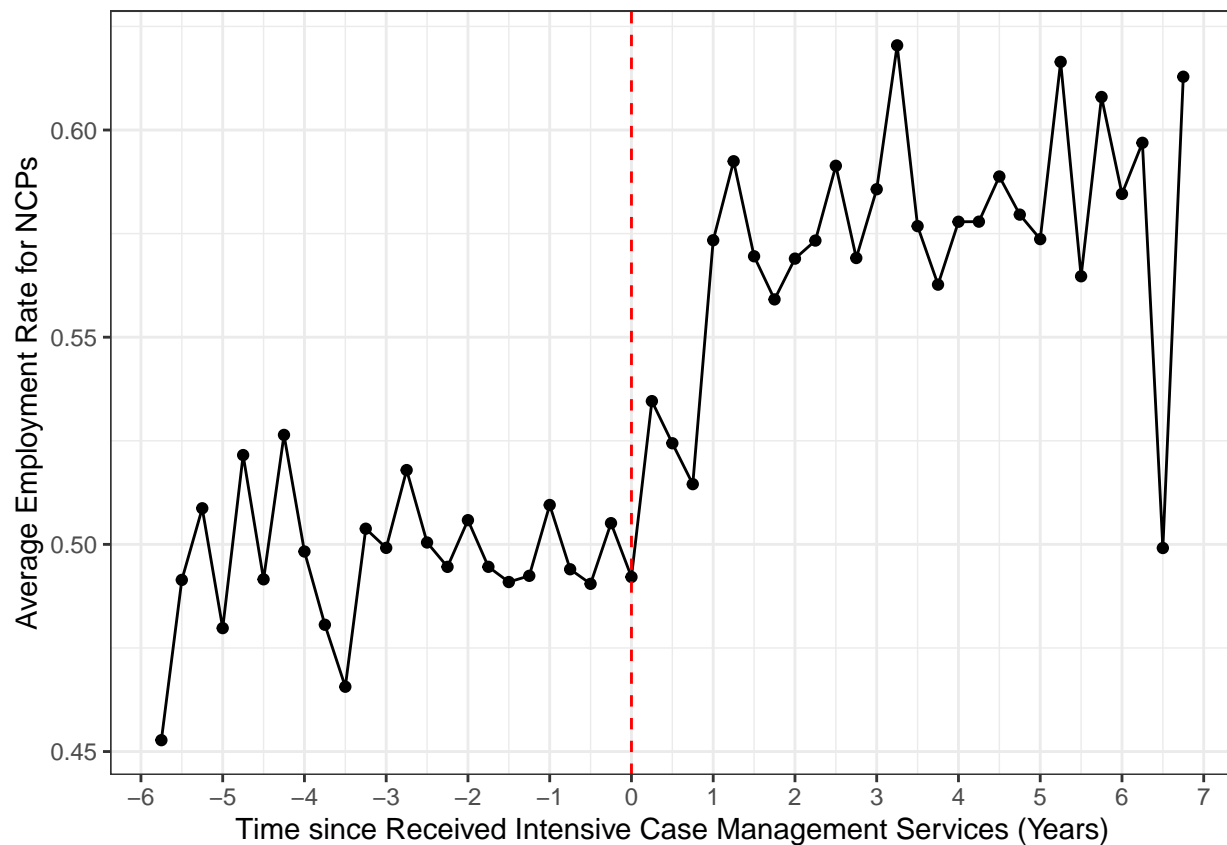
# Create a new final1 contained observations for treated NCP only
final1 <- final[final$treatment ==1,]

# Create a new variable "time_since_treatment"
final1$time_since_treatment <- final1$year_qtr - final1$treatment_year_qtr

# Calculate average employment rate for NCPs served by time since treatment
plotdata3 <- aggregate(final1$ncp_emp_rate, list(final1$time_since_treatment), FUN = mean)

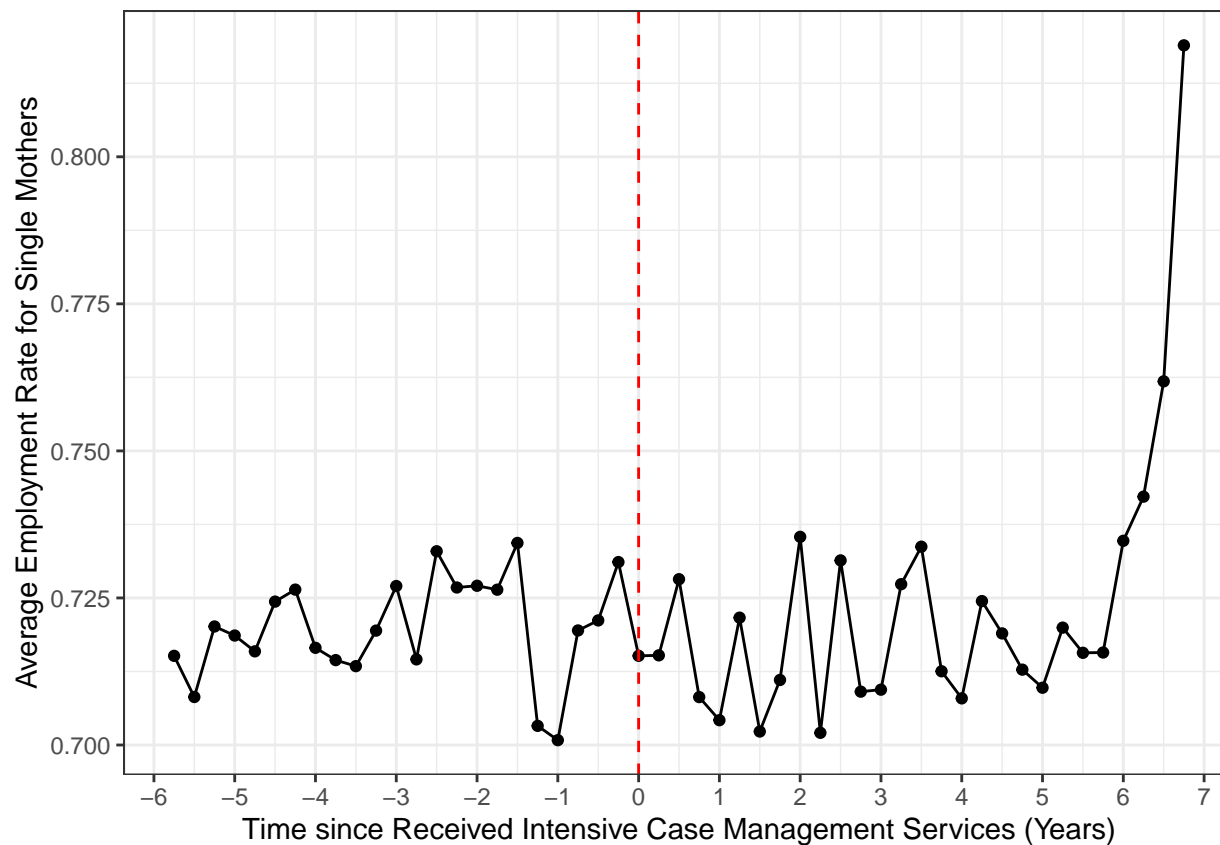
# Visualize the plot
ggplot(data = plotdata3, aes(x = Group.1, y = x)) +
  geom_point() +
  geom_line() +
  geom_vline(xintercept=0,color='red',linetype=2) +
  labs(x = "Time since Received Intensive Case Management Services (Years)", y = "Average Employment Rate") +
  xlim(-6, 7) + scale_x_continuous(breaks = seq(-6, 7, 1)) +
  theme_bw()

```



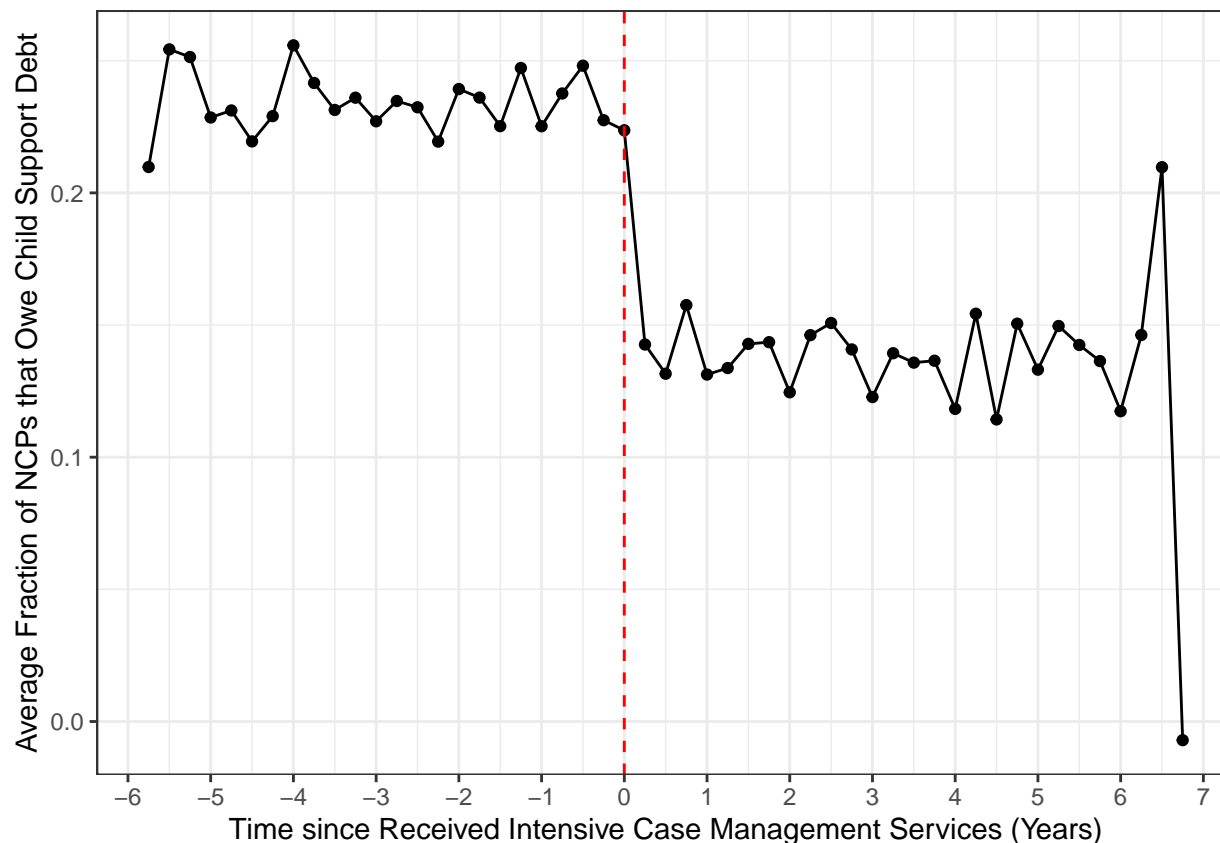
```
# , title = "Average Employment Rate for NCPs by Time since Treatment"
# Calculate average employment rate for single mothers served by time since treatment
plotdata4 <- aggregate(final1$smom_emp_rate, list(final1$time_since_treatment), FUN = mean)

# Visualize the plot
ggplot(data = plotdata4, aes(x = Group.1, y = x)) +
  geom_point() +
  geom_line() +
  geom_vline(xintercept=0,color='red',linetype=2) +
  labs(x = "Time since Received Intensive Case Management Services (Years)", y = "Average Employment Rate") +
  xlim(-6, 7) + scale_x_continuous(breaks = seq(-6, 7, 1)) +
  theme_bw()
```



```
# , title = "Average Employment Rate for Single Mothers by Time since Treatment"
# Calculate average fraction of NCPs that owe child support debt by time since treatment
plotdata5 <- aggregate(final1$ncp_wdebt, list(final1$time_since_treatment), FUN = mean)

# Visualize the plot
ggplot(data = plotdata5, aes(x = Group.1, y = x)) +
  geom_point() +
  geom_line() +
  geom_vline(xintercept=0,color='red',linetype=2) +
  labs(x = "Time since Received Intensive Case Management Services (Years)", y = "Average Fraction of NCPs that owe child support debt") +
  xlim(-6, 7) + scale_x_continuous(breaks = seq(-6, 7, 1)) +
  theme_bw()
```



```
# , title = "Average Fraction of NCPs that Owe Child Support Debt by Time since Treatment"
```

4. Define time since treatment and estimate the following regression specification:

$$\gamma_{it} = \alpha_0 + \alpha_1 T_i + \sum_{k \neq 0} [\delta_k D_{ik}] + \gamma_n + \gamma_s + \gamma_t + \epsilon_{it}$$

where γ_{it} denote employment rate (debt rate) for NCP i in year t , T_i denote an indicator for receiving intensive case management services, D_{ik} denotes an indicator variable for receiving intensive case management and having time since treatment = k , γ_n denotes number of NCPs served by the site fixed effects, γ_s denotes site id dummies and γ_t denotes calendar year dummies. Plot the δ_k coefficients over time since treatment.

```
# Create a new variable "time_since_treatment"
final$time_since_treatment = case_when(final$treatment == 1 ~ final$year_qtr - final$treatment_year_qtr

# Estimate the Average Employment Rate for NCP Regression
ddreg = feols(ncp_emp_rate ~ i(time_since_treatment, treatment, ref = 0) | year_qtr+site_id+Nncp, data =
summary(ddreg)

## OLS estimation, Dep. Var.: ncp_emp_rate
## Observations: 7,440
## Fixed-effects: year_qtr: 40,  site_id: 186,  Nncp: 58
## Standard-errors: Clustered (year_qtr)
##
```

```

## time_since_treatment::-5.75:treatment -0.051248 0.014642 -3.499997 1.1806e-03
## time_since_treatment::-5.5:treatment -0.008073 0.020186 -0.399913 6.9140e-01
## time_since_treatment::-5.25:treatment 0.004189 0.014870 0.281681 7.7968e-01
## time_since_treatment::-5:treatment -0.025159 0.023769 -1.058482 2.9635e-01
## time_since_treatment::-4.75:treatment 0.021387 0.017649 1.211745 2.3290e-01
## time_since_treatment::-4.5:treatment -0.006742 0.016988 -0.396894 6.9361e-01
## time_since_treatment::-4.25:treatment 0.028735 0.015852 1.812737 7.7575e-02
## time_since_treatment::-4:treatment 0.000357 0.018679 0.019118 9.8484e-01
## time_since_treatment::-3.75:treatment -0.019688 0.017421 -1.130120 2.6533e-01
## time_since_treatment::-3.5:treatment -0.030723 0.018908 -1.624868 1.1225e-01
## time_since_treatment::-3.25:treatment 0.007102 0.018999 0.373831 7.1055e-01
## time_since_treatment::-3:treatment 0.004206 0.019594 0.214633 8.3117e-01
## time_since_treatment::-2.75:treatment 0.023878 0.017497 1.364683 1.8018e-01
## time_since_treatment::-2.5:treatment 0.006722 0.019594 0.343058 7.3340e-01
## time_since_treatment::-2.25:treatment 0.000745 0.017140 0.043472 9.6555e-01
## time_since_treatment::-2:treatment 0.011324 0.017385 0.651396 5.1861e-01
## time_since_treatment::-1.75:treatment 0.003907 0.017321 0.225553 8.2273e-01
## time_since_treatment::-1.5:treatment -0.000057 0.016393 -0.003500 9.9723e-01
## time_since_treatment::-1.25:treatment 0.000353 0.016466 0.021430 9.8301e-01
## time_since_treatment::-1:treatment 0.014552 0.018320 0.794316 4.3182e-01
## time_since_treatment::-0.75:treatment 0.000824 0.018061 0.045647 9.6382e-01
## time_since_treatment::-0.5:treatment -0.000811 0.020386 -0.039805 9.6845e-01
## time_since_treatment::-0.25:treatment 0.012920 0.017893 0.722032 4.7458e-01
## time_since_treatment::0.25:treatment 0.039242 0.018237 2.151804 3.7663e-02
## time_since_treatment::0.5:treatment 0.032719 0.009547 3.427311 1.4508e-03
## time_since_treatment::0.75:treatment 0.025243 0.020041 1.259567 2.1531e-01
## time_since_treatment::1:treatment 0.079930 0.017772 4.497497 6.0248e-05
## time_since_treatment::1.25:treatment 0.094666 0.018944 4.997055 1.2641e-05
## time_since_treatment::1.5:treatment 0.074421 0.016174 4.601229 4.3686e-05
## time_since_treatment::1.75:treatment 0.067026 0.014615 4.586106 4.5787e-05
## time_since_treatment::2:treatment 0.077074 0.015499 4.972919 1.3641e-05
## time_since_treatment::2.25:treatment 0.080834 0.020727 3.899934 3.6891e-04
## time_since_treatment::2.5:treatment 0.096594 0.016252 5.943391 6.2070e-07
## time_since_treatment::2.75:treatment 0.075643 0.020522 3.685951 6.9146e-04
## time_since_treatment::3:treatment 0.091668 0.017031 5.382553 3.7226e-06
## time_since_treatment::3.25:treatment 0.127987 0.016712 7.658623 2.7182e-09
## time_since_treatment::3.5:treatment 0.083029 0.019494 4.259281 1.2517e-04
## time_since_treatment::3.75:treatment 0.070313 0.017342 4.054425 2.3265e-04
## time_since_treatment::4:treatment 0.086815 0.022017 3.943089 3.2453e-04
## time_since_treatment::4.25:treatment 0.090648 0.016607 5.458344 2.9240e-06
## time_since_treatment::4.5:treatment 0.095327 0.017446 5.464031 2.8714e-06
## time_since_treatment::4.75:treatment 0.088014 0.015379 5.722828 1.2567e-06
## time_since_treatment::5:treatment 0.082536 0.019210 4.296569 1.1171e-04
## time_since_treatment::5.25:treatment 0.124191 0.022841 5.437083 3.1290e-06
## time_since_treatment::5.5:treatment 0.070311 0.025935 2.711024 9.9217e-03
## time_since_treatment::5.75:treatment 0.108909 0.023354 4.663317 3.6012e-05
## time_since_treatment::6:treatment 0.096316 0.029702 3.242750 2.4281e-03
## time_since_treatment::6.25:treatment 0.104756 0.045891 2.282697 2.7982e-02
## time_since_treatment::6.5:treatment 0.001692 0.016163 0.104691 9.1716e-01
## time_since_treatment::6.75:treatment 0.123613 0.018993 6.508482 1.0204e-07
##
## time_since_treatment::-5.75:treatment **
## time_since_treatment::-5.5:treatment
## time_since_treatment::-5.25:treatment

```



```

## time_since_treatment::-5:treatment
## time_since_treatment::-4.75:treatment
## time_since_treatment::-4.5:treatment
## time_since_treatment::-4.25:treatment .
## time_since_treatment::-4:treatment
## time_since_treatment::-3.75:treatment
## time_since_treatment::-3.5:treatment
## time_since_treatment::-3.25:treatment
## time_since_treatment::-3:treatment
## time_since_treatment::-2.75:treatment
## time_since_treatment::-2.5:treatment
## time_since_treatment::-2.25:treatment
## time_since_treatment::-2:treatment
## time_since_treatment::-1.75:treatment
## time_since_treatment::-1.5:treatment
## time_since_treatment::-1.25:treatment
## time_since_treatment::-1:treatment
## time_since_treatment::-0.75:treatment
## time_since_treatment::-0.5:treatment
## time_since_treatment::-0.25:treatment
## time_since_treatment::0.25:treatment *
## time_since_treatment::0.5:treatment **
## time_since_treatment::0.75:treatment
## time_since_treatment::1:treatment ***
## time_since_treatment::1.25:treatment ***
## time_since_treatment::1.5:treatment ***
## time_since_treatment::1.75:treatment ***
## time_since_treatment::2:treatment ***
## time_since_treatment::2.25:treatment ***
## time_since_treatment::2.5:treatment ***
## time_since_treatment::2.75:treatment ***
## time_since_treatment::3:treatment ***
## time_since_treatment::3.25:treatment ***
## time_since_treatment::3.5:treatment ***
## time_since_treatment::3.75:treatment ***
## time_since_treatment::4:treatment ***
## time_since_treatment::4.25:treatment ***
## time_since_treatment::4.5:treatment ***
## time_since_treatment::4.75:treatment ***
## time_since_treatment::5:treatment ***
## time_since_treatment::5.25:treatment ***
## time_since_treatment::5.5:treatment **
## time_since_treatment::5.75:treatment ***
## time_since_treatment::6:treatment **
## time_since_treatment::6.25:treatment *
## time_since_treatment::6.5:treatment
## time_since_treatment::6.75:treatment ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.090194      Adj. R2: 0.59611
##                               Within R2: 0.048112

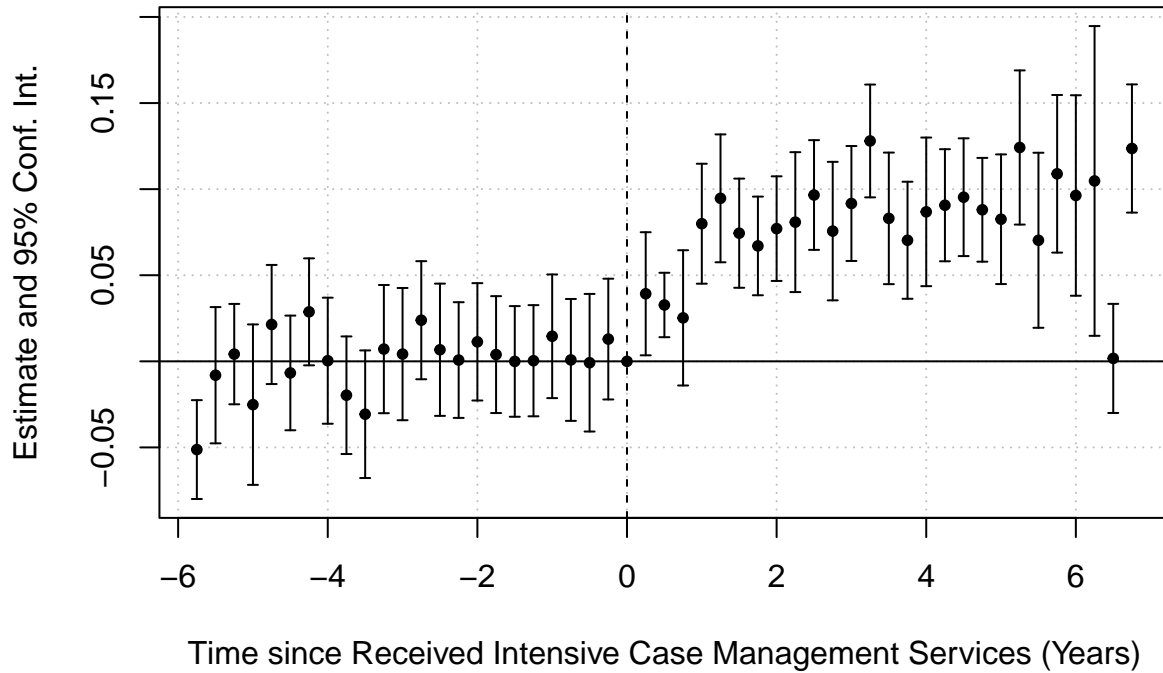
```

```

# Plot the Average Employment Rate for NCP Coefficients
ipplot(ddreg, xlab = 'Time since Received Intensive Case Management Services (Years)',

```

```
main = '')
```



```
#Average Employment Rate for NCPs DD Coefficients
```

```
# Estimate the Average Employment Rate for Single Mothers Regression
```

```
ddreg1 = feols(smom_emp_rate ~ i(time_since_treatment, treatment, ref = 0) | year_qtr+site_id+Nncp,data)
summary(ddreg1)
```

```
## OLS estimation, Dep. Var.: smom_emp_rate
```

```
## Observations: 7,440
```

```
## Fixed-effects: year_qtr: 40, site_id: 186, Nncp: 58
```

```
## Standard-errors: Clustered (year_qtr)
```

```
##
```

	Estimate	Std. Error	t value	Pr(> t)
## time_since_treatment::-5.75:treatment	-0.007999	0.010751	-0.744035	4.6131e-01
## time_since_treatment::-5.5:treatment	-0.012379	0.008394	-1.474657	1.4833e-01
## time_since_treatment::-5.25:treatment	0.006064	0.018456	0.328585	7.4423e-01
## time_since_treatment::-5:treatment	0.004979	0.011364	0.438103	6.6373e-01
## time_since_treatment::-4.75:treatment	-0.000691	0.013521	-0.051090	9.5951e-01
## time_since_treatment::-4.5:treatment	0.007570	0.010520	0.719613	4.7605e-01
## time_since_treatment::-4.25:treatment	0.010562	0.011335	0.931776	3.5718e-01
## time_since_treatment::-4:treatment	-0.000086	0.009500	-0.009104	9.9278e-01
## time_since_treatment::-3.75:treatment	-0.000016	0.010857	-0.001475	9.9883e-01
## time_since_treatment::-3.5:treatment	-0.002404	0.012928	-0.185921	8.5347e-01
## time_since_treatment::-3.25:treatment	0.004866	0.012668	0.384115	7.0298e-01
## time_since_treatment::-3:treatment	0.007336	0.011094	0.661280	5.1232e-01
## time_since_treatment::-2.75:treatment	-0.002696	0.008838	-0.305103	7.6191e-01

```

## time_since_treatment::-2.5:treatment 0.016147 0.010371 1.556970 1.2756e-01
## time_since_treatment::-2.25:treatment 0.012339 0.010310 1.196797 2.3861e-01
## time_since_treatment::-2:treatment 0.011593 0.009781 1.185345 2.4305e-01
## time_since_treatment::-1.75:treatment 0.010596 0.012093 0.876191 3.8629e-01
## time_since_treatment::-1.5:treatment 0.019014 0.009629 1.974709 5.5412e-02
## time_since_treatment::-1.25:treatment -0.011008 0.011823 -0.931093 3.5753e-01
## time_since_treatment::-1:treatment -0.014774 0.008388 -1.761368 8.6015e-02
## time_since_treatment::-0.75:treatment 0.003040 0.009409 0.323083 7.4836e-01
## time_since_treatment::-0.5:treatment 0.004793 0.012260 0.390907 6.9799e-01
## time_since_treatment::-0.25:treatment 0.016853 0.008793 1.916647 6.2631e-02
## time_since_treatment::0.25:treatment 0.000158 0.010876 0.014503 9.8850e-01
## time_since_treatment::0.5:treatment 0.011123 0.013248 0.839613 4.0624e-01
## time_since_treatment::0.75:treatment -0.009118 0.008041 -1.133927 2.6375e-01
## time_since_treatment::1:treatment -0.013143 0.011288 -1.164365 2.5135e-01
## time_since_treatment::1.25:treatment 0.005939 0.010549 0.562998 5.7666e-01
## time_since_treatment::1.5:treatment -0.013680 0.008804 -1.553822 1.2831e-01
## time_since_treatment::1.75:treatment -0.005278 0.010369 -0.508976 6.1364e-01
## time_since_treatment::2:treatment 0.019314 0.010119 1.908778 6.3670e-02
## time_since_treatment::2.25:treatment -0.013944 0.012426 -1.122186 2.6864e-01
## time_since_treatment::2.5:treatment 0.013271 0.013818 0.960439 3.4275e-01
## time_since_treatment::2.75:treatment -0.008523 0.010361 -0.822590 4.1574e-01
## time_since_treatment::3:treatment -0.005642 0.014500 -0.389130 6.9930e-01
## time_since_treatment::3.25:treatment 0.012287 0.009625 1.276532 2.0932e-01
## time_since_treatment::3.5:treatment 0.018773 0.012147 1.545546 1.3029e-01
## time_since_treatment::3.75:treatment -0.005047 0.011135 -0.453223 6.5290e-01
## time_since_treatment::4:treatment -0.009526 0.013563 -0.702393 4.8661e-01
## time_since_treatment::4.25:treatment 0.008130 0.012141 0.669666 5.0702e-01
## time_since_treatment::4.5:treatment 0.001453 0.010029 0.144856 8.8557e-01
## time_since_treatment::4.75:treatment -0.006635 0.010050 -0.660161 5.1303e-01
## time_since_treatment::5:treatment -0.006783 0.011721 -0.578665 5.6614e-01
## time_since_treatment::5.25:treatment 0.004002 0.011268 0.355193 7.2436e-01
## time_since_treatment::5.5:treatment -0.005932 0.011771 -0.503937 6.1714e-01
## time_since_treatment::5.75:treatment -0.002048 0.011051 -0.185336 8.5393e-01
## time_since_treatment::6:treatment 0.013045 0.010557 1.235732 2.2395e-01
## time_since_treatment::6.25:treatment 0.023619 0.030733 0.768516 4.4681e-01
## time_since_treatment::6.5:treatment 0.050321 0.011265 4.466993 6.6199e-05
## time_since_treatment::6.75:treatment 0.088657 0.013214 6.709272 5.3856e-08
##
## time_since_treatment::-5.75:treatment
## time_since_treatment::-5.5:treatment
## time_since_treatment::-5.25:treatment
## time_since_treatment::-5:treatment
## time_since_treatment::-4.75:treatment
## time_since_treatment::-4.5:treatment
## time_since_treatment::-4.25:treatment
## time_since_treatment::-4:treatment
## time_since_treatment::-3.75:treatment
## time_since_treatment::-3.5:treatment
## time_since_treatment::-3.25:treatment
## time_since_treatment::-3:treatment
## time_since_treatment::-2.75:treatment
## time_since_treatment::-2.5:treatment
## time_since_treatment::-2.25:treatment
## time_since_treatment::-2:treatment

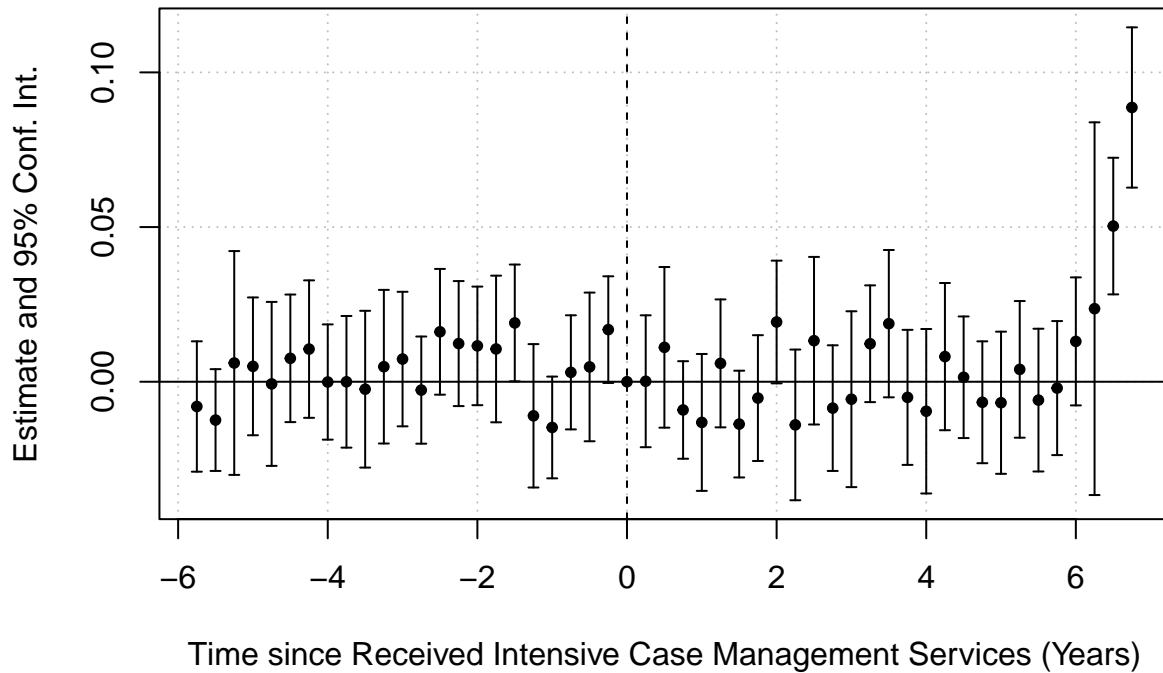
```

```

## time_since_treatment::-1.75:treatment
## time_since_treatment::-1.5:treatment .
## time_since_treatment::-1.25:treatment
## time_since_treatment::-1:treatment .
## time_since_treatment::-0.75:treatment
## time_since_treatment::-0.5:treatment
## time_since_treatment::-0.25:treatment .
## time_since_treatment::0.25:treatment
## time_since_treatment::0.5:treatment
## time_since_treatment::0.75:treatment
## time_since_treatment::1:treatment
## time_since_treatment::1.25:treatment
## time_since_treatment::1.5:treatment
## time_since_treatment::1.75:treatment
## time_since_treatment::2:treatment .
## time_since_treatment::2.25:treatment
## time_since_treatment::2.5:treatment
## time_since_treatment::2.75:treatment
## time_since_treatment::3:treatment
## time_since_treatment::3.25:treatment
## time_since_treatment::3.5:treatment
## time_since_treatment::3.75:treatment
## time_since_treatment::4:treatment
## time_since_treatment::4.25:treatment
## time_since_treatment::4.5:treatment
## time_since_treatment::4.75:treatment
## time_since_treatment::5:treatment
## time_since_treatment::5.25:treatment
## time_since_treatment::5.5:treatment
## time_since_treatment::5.75:treatment
## time_since_treatment::6:treatment
## time_since_treatment::6.25:treatment
## time_since_treatment::6.5:treatment ***
## time_since_treatment::6.75:treatment ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.058693      Adj. R2: 0.368692
##                      Within R2: 0.009484

# Plot the Average Employment Rate for Single Mothers Coefficients
iplot(ddreg1, xlab = 'Time since Received Intensive Case Management Services (Years)',
      main = '')

```



#Average Employment Rate for Single Mothers DD Coefficients

Estimate the Average Employment Rate for Single Mothers Regression

```
ddreg2 = feols(ncp_wdebt ~ i(time_since_treatment, treatment, ref = 0) | year_qtr+site_id+Nncp, data = f)
summary(ddreg2)
```

OLS estimation, Dep. Var.: ncp_wdebt

Observations: 7,440

Fixed-effects: year_qtr: 40, site_id: 186, Nncp: 58

Standard-errors: Clustered (year_qtr)

	Estimate	Std. Error	t value
## time_since_treatment::-5.75:treatment	-0.031160	0.012630	-2.467236
## time_since_treatment::-5.5:treatment	0.025871	0.026410	0.979607
## time_since_treatment::-5.25:treatment	0.024149	0.010537	2.291782
## time_since_treatment::-5:treatment	0.003472	0.018755	0.185105
## time_since_treatment::-4.75:treatment	0.009202	0.015301	0.601400
## time_since_treatment::-4.5:treatment	-0.004313	0.012932	-0.333496
## time_since_treatment::-4.25:treatment	0.008557	0.014588	0.586548
## time_since_treatment::-4:treatment	0.031455	0.015837	1.986204
## time_since_treatment::-3.75:treatment	0.018053	0.010784	1.674116
## time_since_treatment::-3.5:treatment	0.007746	0.013692	0.565712
## time_since_treatment::-3.25:treatment	0.012392	0.011873	1.043731
## time_since_treatment::-3:treatment	0.003359	0.012242	0.274374
## time_since_treatment::-2.75:treatment	0.010339	0.012035	0.859047
## time_since_treatment::-2.5:treatment	0.008057	0.013629	0.591204
## time_since_treatment::-2.25:treatment	-0.004155	0.010641	-0.390512

```

## time_since_treatment::-2:treatment      0.015792    0.013373    1.180945
## time_since_treatment::-1.75:treatment    0.012796    0.012116    1.056128
## time_since_treatment::-1.5:treatment      0.001731    0.012827    0.134979
## time_since_treatment::-1.25:treatment     0.024255    0.012559    1.931300
## time_since_treatment::-1:treatment        -0.000361    0.011034   -0.032754
## time_since_treatment::-0.75:treatment     0.014326    0.011148    1.285090
## time_since_treatment::-0.5:treatment      0.025851    0.010177    2.540140
## time_since_treatment::-0.25:treatment     0.004990    0.010667    0.467730
## time_since_treatment::0.25:treatment     -0.080367    0.013429   -5.984418
## time_since_treatment::0.5:treatment       -0.091688    0.012875   -7.121446
## time_since_treatment::0.75:treatment      -0.065190    0.012360   -5.274379
## time_since_treatment::1:treatment         -0.092112    0.013040   -7.063595
## time_since_treatment::1.25:treatment      -0.088163    0.012829   -6.871908
## time_since_treatment::1.5:treatment       -0.081386    0.013840   -5.880568
## time_since_treatment::1.75:treatment      -0.079914    0.013274   -6.020430
## time_since_treatment::2:treatment         -0.099184    0.010634   -9.327448
## time_since_treatment::2.25:treatment      -0.076539    0.013251   -5.776282
## time_since_treatment::2.5:treatment       -0.070836    0.013859   -5.111312
## time_since_treatment::2.75:treatment      -0.082834    0.012743   -6.500476
## time_since_treatment::3:treatment         -0.101910    0.011517   -8.848540
## time_since_treatment::3.25:treatment      -0.084259    0.012031   -7.003352
## time_since_treatment::3.5:treatment       -0.086706    0.012982   -6.678699
## time_since_treatment::3.75:treatment      -0.085292    0.010940   -7.796491
## time_since_treatment::4:treatment         -0.105295    0.012161   -8.658647
## time_since_treatment::4.25:treatment      -0.067724    0.014891   -4.548110
## time_since_treatment::4.5:treatment       -0.106996    0.012405   -8.625594
## time_since_treatment::4.75:treatment      -0.071331    0.014603   -4.884662
## time_since_treatment::5:treatment         -0.088403    0.015066   -5.867929
## time_since_treatment::5.25:treatment      -0.071556    0.014385   -4.974310
## time_since_treatment::5.5:treatment       -0.078770    0.011302   -6.969639
## time_since_treatment::5.75:treatment      -0.083320    0.012896   -6.460723
## time_since_treatment::6:treatment         -0.104416    0.016020   -6.517772
## time_since_treatment::6.25:treatment      -0.078653    0.024798   -3.171737
## time_since_treatment::6.5:treatment       -0.012693    0.029979   -0.423416
## time_since_treatment::6.75:treatment      -0.226972    0.015494  -14.649208
##                                     Pr(>|t|)
## time_since_treatment::-5.75:treatment 1.8112e-02 *
## time_since_treatment::-5.5:treatment  3.3332e-01
## time_since_treatment::-5.25:treatment 2.7401e-02 *
## time_since_treatment::-5:treatment     8.5411e-01
## time_since_treatment::-4.75:treatment  5.5105e-01
## time_since_treatment::-4.5:treatment    7.4055e-01
## time_since_treatment::-4.25:treatment  5.6089e-01
## time_since_treatment::-4:treatment      5.4071e-02 .
## time_since_treatment::-3.75:treatment  1.0211e-01
## time_since_treatment::-3.5:treatment    5.7483e-01
## time_since_treatment::-3.25:treatment  3.0304e-01
## time_since_treatment::-3:treatment      7.8525e-01
## time_since_treatment::-2.75:treatment  3.9556e-01
## time_since_treatment::-2.5:treatment    5.5779e-01
## time_since_treatment::-2.25:treatment  6.9828e-01
## time_since_treatment::-2:treatment      2.4478e-01
## time_since_treatment::-1.75:treatment  2.9741e-01
## time_since_treatment::-1.5:treatment    8.9332e-01

```

```

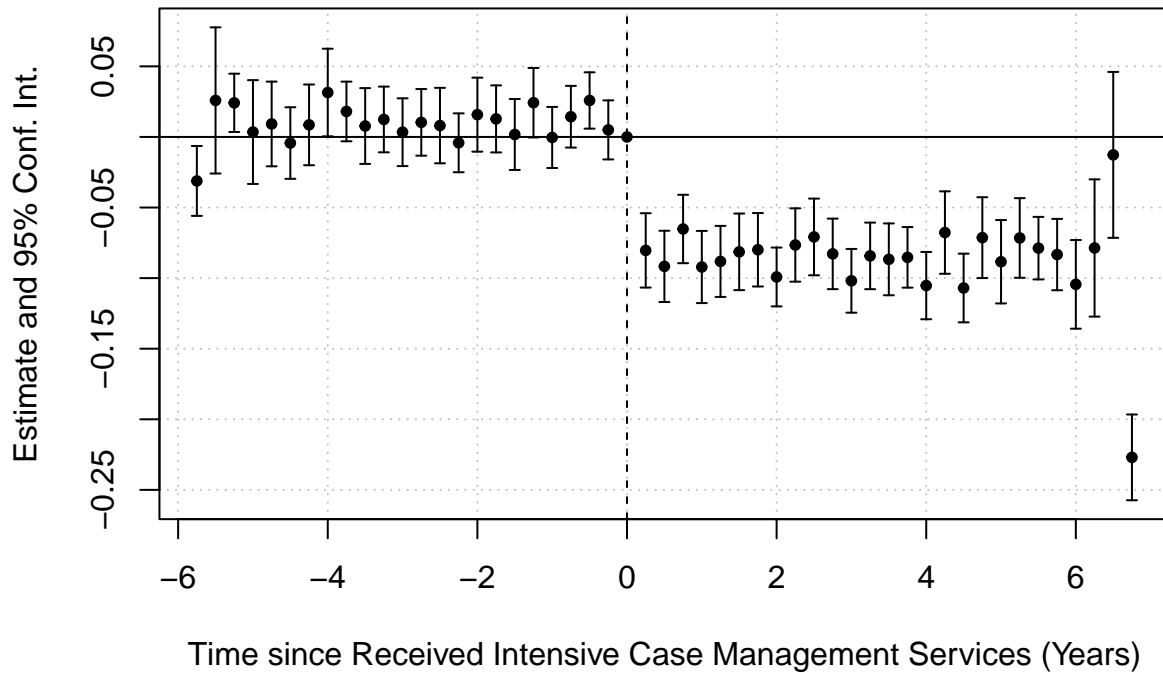
## time_since_treatment::-1.25:treatment 6.0737e-02 .
## time_since_treatment::-1:treatment 9.7404e-01
## time_since_treatment::-0.75:treatment 2.0634e-01
## time_since_treatment::-0.5:treatment 1.5176e-02 *
## time_since_treatment::-0.25:treatment 6.4258e-01
## time_since_treatment::0.25:treatment 5.4436e-07 ***
## time_since_treatment::0.5:treatment 1.4607e-08 ***
## time_since_treatment::0.75:treatment 5.2517e-06 ***
## time_since_treatment::1:treatment 1.7531e-08 ***
## time_since_treatment::1.25:treatment 3.2143e-08 ***
## time_since_treatment::1.5:treatment 7.5885e-07 ***
## time_since_treatment::1.75:treatment 4.8513e-07 ***
## time_since_treatment::2:treatment 1.7696e-11 ***
## time_since_treatment::2.25:treatment 1.0593e-06 ***
## time_since_treatment::2.5:treatment 8.8094e-06 ***
## time_since_treatment::2.75:treatment 1.0468e-07 ***
## time_since_treatment::3:treatment 7.2603e-11 ***
## time_since_treatment::3.25:treatment 2.1205e-08 ***
## time_since_treatment::3.5:treatment 5.9353e-08 ***
## time_since_treatment::3.75:treatment 1.7728e-09 ***
## time_since_treatment::4:treatment 1.2806e-10 ***
## time_since_treatment::4.25:treatment 5.1513e-05 ***
## time_since_treatment::4.5:treatment 1.4141e-10 ***
## time_since_treatment::4.75:treatment 1.8011e-05 ***
## time_since_treatment::5:treatment 7.9016e-07 ***
## time_since_treatment::5.25:treatment 1.3581e-05 ***
## time_since_treatment::5.5:treatment 2.3590e-08 ***
## time_since_treatment::5.75:treatment 1.1883e-07 ***
## time_since_treatment::6:treatment 9.9065e-08 ***
## time_since_treatment::6.25:treatment 2.9503e-03 **
## time_since_treatment::6.5:treatment 6.7432e-01
## time_since_treatment::6.75:treatment < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.050281      Adj. R2: 0.842561
##                               Within R2: 0.174515

```

```

# Plot the Average Employment Rate for Single Mothers Coefficients
ipplot(ddreg2, xlab = 'Time since Received Intensive Case Management Services (Years)',
       main = '')

```



Average Fraction of NCPs that Owe Child Support Debt DD Coefficients

5. Introduce a new variable called TAfter. TAfter is defined as T multiplied by After, where T is an indicator for a treatment observation and After is an indicator for time since treatment being positive. We then estimate the following regression:

$$\gamma_{it} = \alpha_0 + \alpha_1 T_i + \delta T_i \text{After} + \gamma_n + \gamma_s + \gamma_t + \epsilon_{it}$$

We estimate the coefficients between TAfter and the outcome variables and use them to calculate the effect of a 1% increase in employment rate on the debt fraction.

```
# Generate two new indicators
final$After = case_when(final$time_since_treatment > 0 ~ 1, final$time_since_treatment <= 0 ~ 0)
final$TAfter = final$treatment*final$After

# Regression of employment rate for NCPs
tafter_reg1 = feols(ncp_emp_rate ~ TAfter | Nncp+ year_qtr + site_id, data = final)
summary(tafter_reg1)

## OLS estimation, Dep. Var.: ncp_emp_rate
## Observations: 7,440
## Fixed-effects: Nncp: 58, year_qtr: 40, site_id: 186
## Standard-errors: Clustered (Nncp)
##      Estimate Std. Error t value Pr(>|t|)
## TAfter 0.073555  0.004972  14.794 < 2.2e-16 ***
```



```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.090825      Adj. R2: 0.593242
##                      Within R2: 0.034745
```

```
# Regression of employment rate for single mothers
```

```
tafter_reg2 = feols(smom_emp_rate ~ TAfter | Nncp+ year_qtr+ site_id, data = final)
summary(tafter_reg2)
```

```
## OLS estimation, Dep. Var.: smom_emp_rate
## Observations: 7,440
## Fixed-effects: Nncp: 58, year_qtr: 40, site_id: 186
## Standard-errors: Clustered (Nncp)
##      Estimate Std. Error t value Pr(>|t|)
## TAfter -0.004474  0.002938 -1.52261  0.13338
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.058964      Adj. R2: 0.367211
##                      Within R2: 3.158e-4
```

```
# Regression of debt fraction for NCPs
```

```
tafter_reg3 = feols(ncp_wdebt ~ TAfter | Nncp+ year_qtr+ site_id, data = final)
summary(tafter_reg3)
```

```
## OLS estimation, Dep. Var.: ncp_wdebt
## Observations: 7,440
## Fixed-effects: Nncp: 58, year_qtr: 40, site_id: 186
## Standard-errors: Clustered (Nncp)
##      Estimate Std. Error t value Pr(>|t|)
## TAfter -0.094847  0.002661 -35.6445 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.050685      Adj. R2: 0.841118
##                      Within R2: 0.161206
```

```
# Calculate the effect
```

```
num = tafter_reg3$coefficients[1]/tafter_reg1$coefficients[1]*1
```

```
cat("An 1% increase in the employment rate for NCPs corresponds around", -round(num,3), "% decrease in debt fraction")
```

```
## An 1% increase in the employment rate for NCPs corresponds around 1.289 % decrease in debt fraction
```

6. Implement a permutation test taking into account the differential introduction of intensive case management services across sites and calendar years. Show how the true estimates compare to the permutation estimates.

```
# Create treatment and control groups
```

```
treatment <- final[final$treatment == 1,]
control <- final[final$treatment == 0,]
```

```
# Set number of permutations
```

```
n_perms <- 1000
```

```

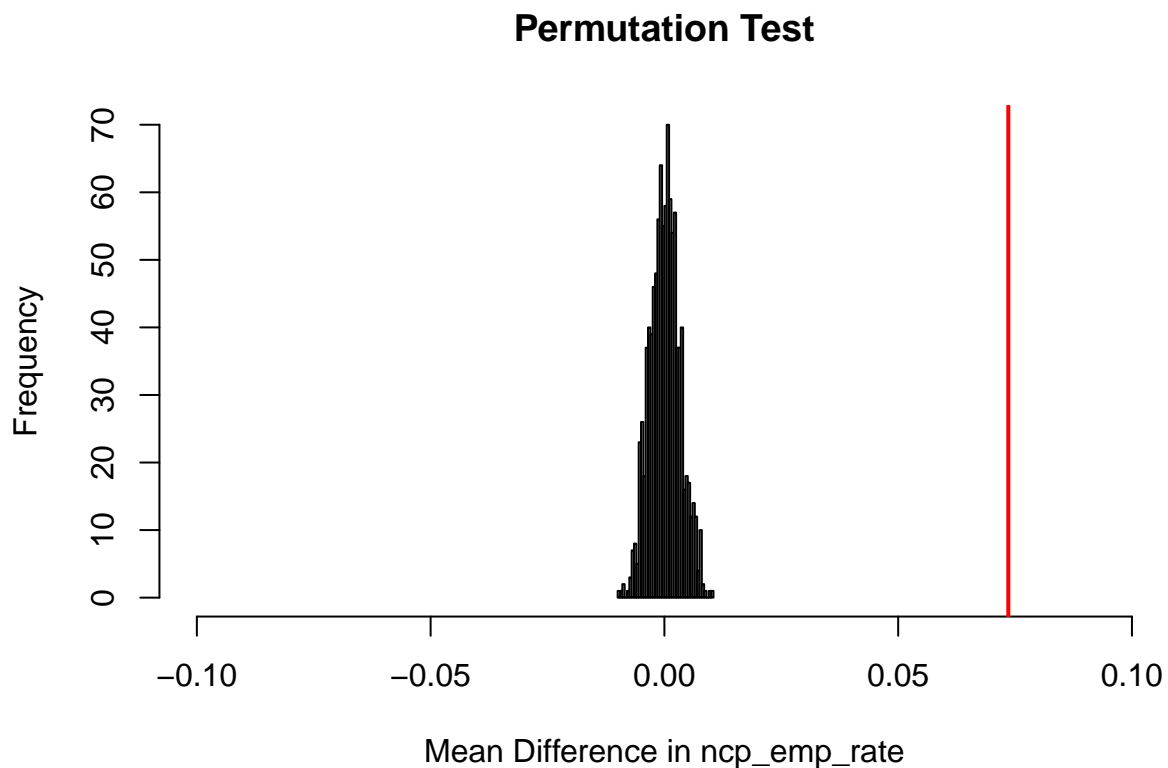
t <- coefficients(taafter_reg1)

# Initialize null distribution
null_dist <- rep(NA, n_perms)

# Permute treatment variable and calculate mean difference
for (i in 1:n_perms) {
  perm_treatment <- sample(c(0,1), size=nrow(final), replace=TRUE)
  perm_mean_diff <- mean(final$ncp_emp_rate[perm_treatment==1]) - mean(final$ncp_emp_rate[perm_treatment==0])
  null_dist[i] <- perm_mean_diff
}

# Plot histogram of null distribution with true mean difference
hist(null_dist, breaks=30, col="grey", xlab="Mean Difference in ncp_emp_rate", main="Permutation Test",
      abline(v=t, col="red", lwd=2))

```



```

# Set number of permutations
n_perms <- 1000
t1 <- coefficients(taafter_reg2)

# Initialize null distribution
null_dist1 <- rep(NA, n_perms)

# Permute treatment variable and calculate mean difference
for (i in 1:n_perms) {

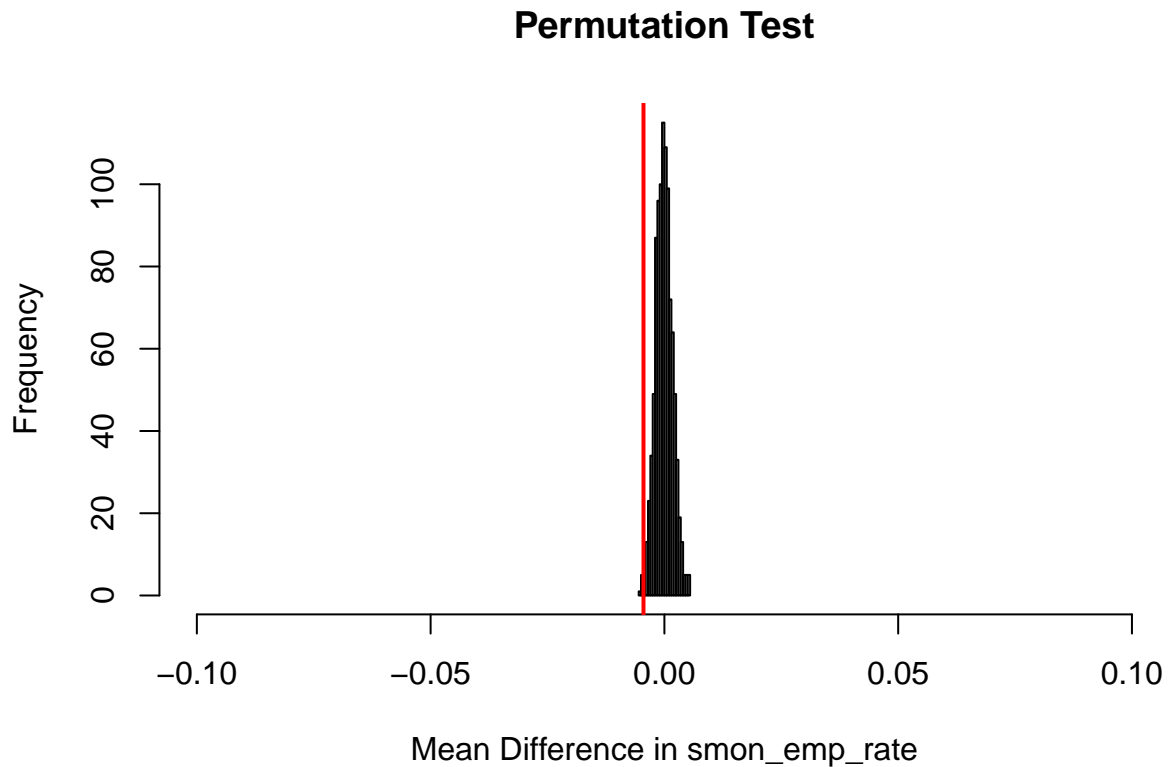
```

```

perm_treatment1 <- sample(c(0,1), size=nrow(final), replace=TRUE)
perm_mean_diff1 <- mean(final$smom_emp_rate[perm_treatment1==1]) - mean(final$smom_emp_rate[perm_treatment1==0])
null_dist1[i] <- perm_mean_diff1
}

# Plot histogram of null distribution with true mean difference
hist(null_dist1, breaks=30, col="grey", xlab="Mean Difference in smom_emp_rate", main="Permutation Test")
abline(v=t1, col="red", lwd=2)

```



```

# Set number of permutations
n_perms <- 1000
t2 <- coefficients(taafter_reg3)

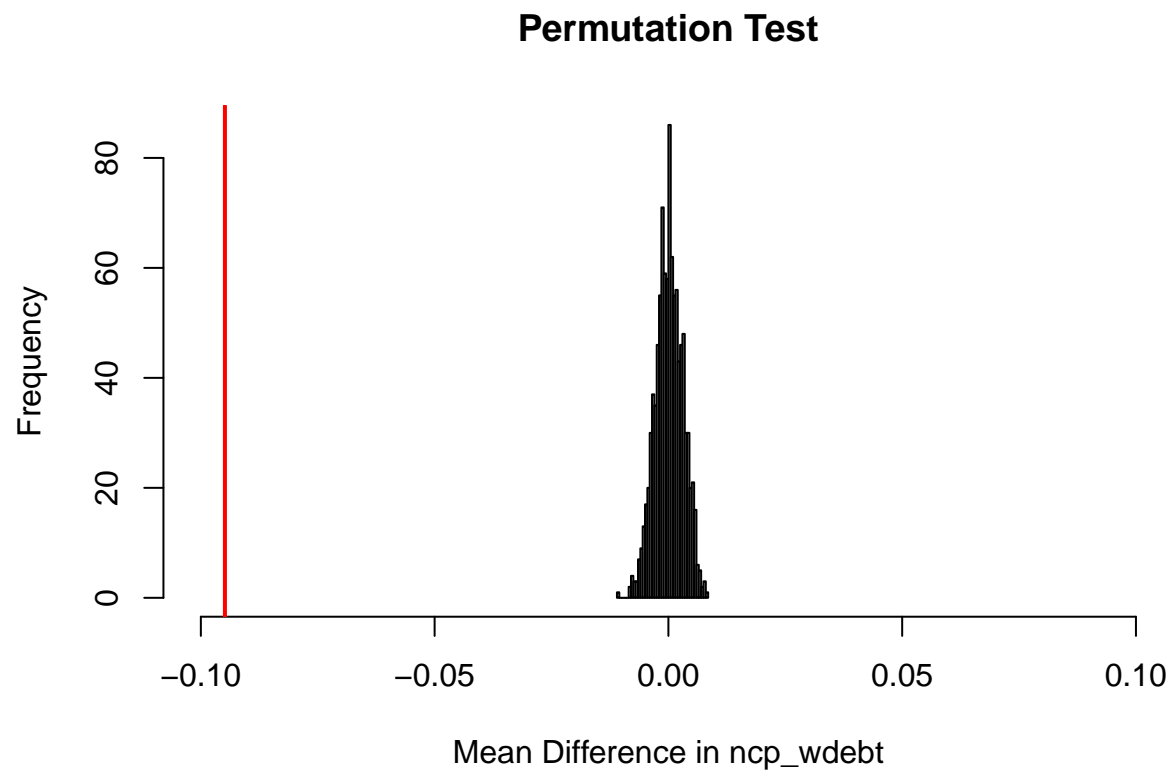
# Initialize null distribution
null_dist2 <- rep(NA, n_perms)

# Permute treatment variable and calculate mean difference
for (i in 1:n_perms) {
  perm_treatment2 <- sample(c(0,1), size=nrow(final), replace=TRUE)
  perm_mean_diff2 <- mean(final$ncp_wdebt[perm_treatment2==1]) - mean(final$ncp_wdebt[perm_treatment2==0])
  null_dist2[i] <- perm_mean_diff2
}

# Plot histogram of null distribution with true mean difference
hist(null_dist2, breaks=30, col="grey", xlab="Mean Difference in ncp_wdebt", main="Permutation Test", xli

```

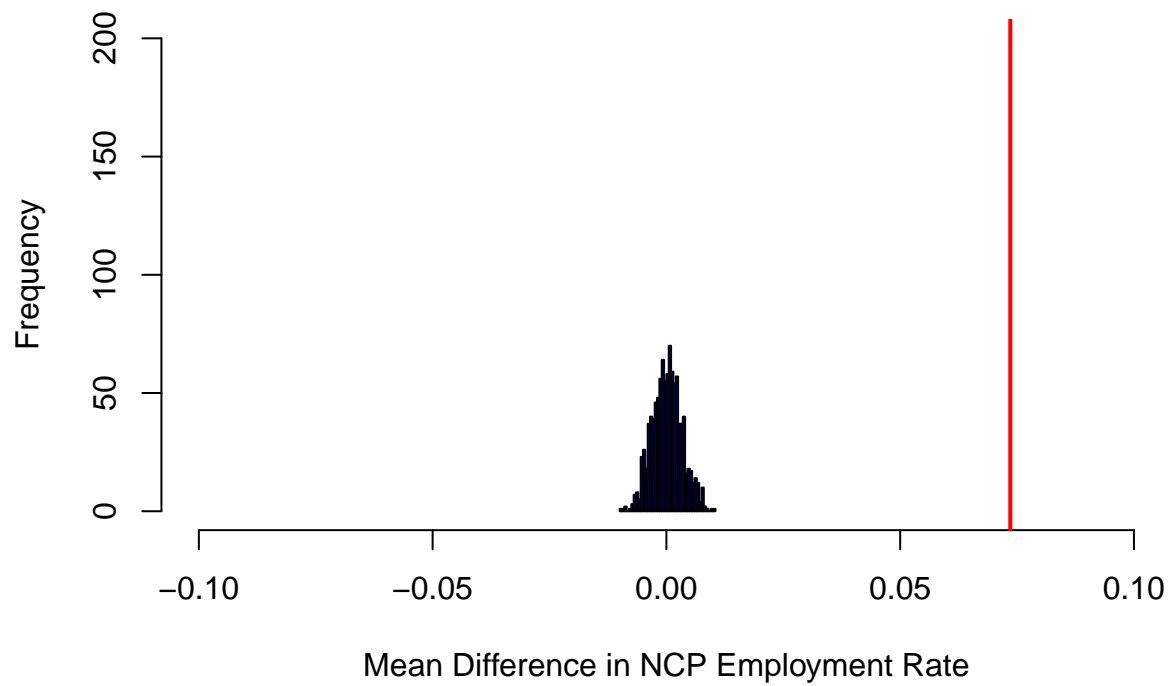
```
abline(v=t2, col="red", lwd=2)
```



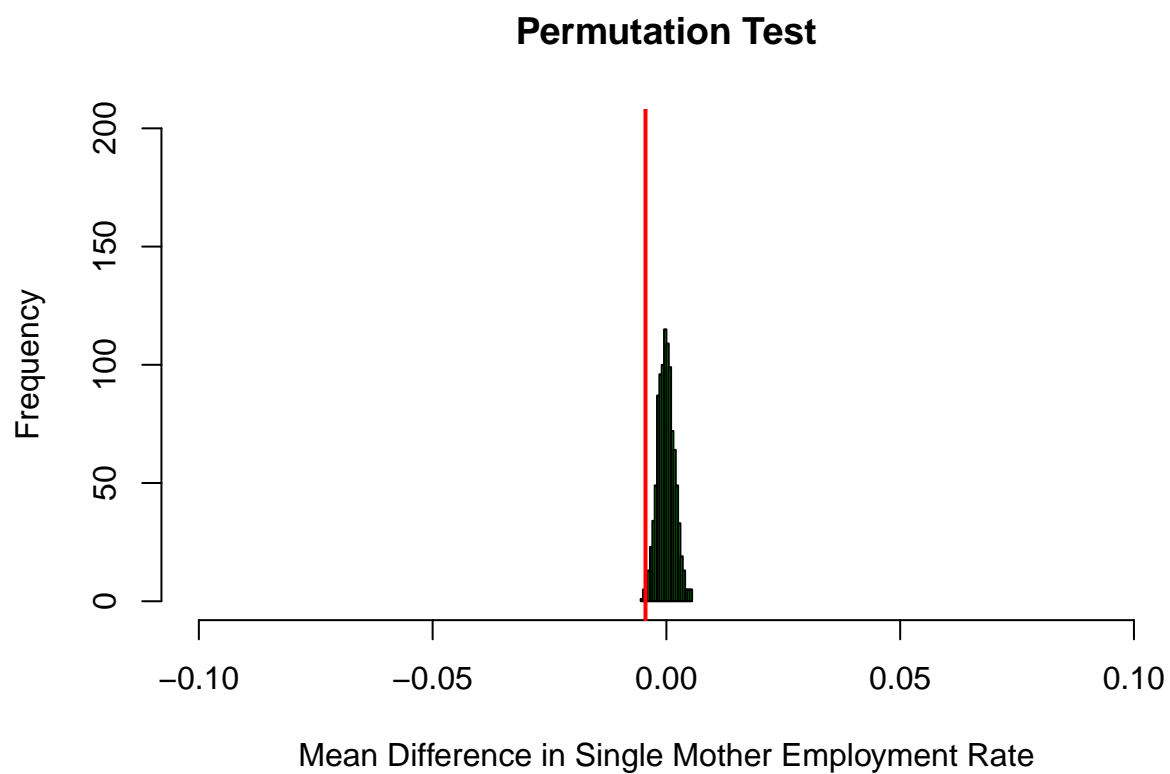
Add one certain color on each permutation test.

```
# Plot histogram of null distribution for ncp_emp_rate  
hist(null_dist, breaks=30, col="blue", xlab="Mean Difference in NCP Employment Rate", main="Permutation  
abline(v=t, col="red", lwd=2)
```

Permutation Test



```
# Plot histogram of null distribution for smon_emp_rate
hist(null_dist1, breaks=30, col="green", xlab="Mean Difference in Single Mother Employment Rate", main=
abline(v=t1, col="red", lwd=2)
```



```
# Plot histogram of null distribution for ncp_wdebt  
hist(null_dist2, breaks=30, col="orange", xlab="Mean Difference in NCP Debt Fraction", main="Permutation  
abline(v=t2, col="red", lwd=2)
```

Permutation Test

