ECON 211B: Homework 3

Due: Thursday, March 2, 2017

Carlos E. Dobkin

David Sungho Park

Problem 1

Suppose $T = 2$.

$$\begin{aligned}
\ddot{Y}_{it} &= \ddot{\mathbf{X}}'_{it}\beta + \ddot{\varepsilon}_{it} \\
(Y_{it} - \overline{Y}_i) &= (\mathbf{X}_{it} - \overline{\mathbf{X}}_i)'\beta + (\varepsilon_{it} - \overline{\varepsilon}_i) \\
\Big(Y_{it} - \frac{1}{2}(Y_{i1} + Y_{i2})\Big) &= \Big(\mathbf{X}_{it} - \frac{1}{2}(\mathbf{X}_{i1} + \mathbf{X}_{i2})\Big)'\beta + \Big(\varepsilon_{it} - \frac{1}{2}(\varepsilon_{i1} + \varepsilon_{i2})\Big) \\
\frac{1}{2}(Y_{i2} - Y_{i1}) &= \frac{1}{2}(\mathbf{X}_{i2} - \mathbf{X}_{i1})'\beta + \frac{1}{2}(\varepsilon_{i2} - \varepsilon_{i1}) \\
(Y_{i2} - Y_{i1}) &= (\mathbf{X}_{i2} - \mathbf{X}_{i1})'\beta + (\varepsilon_{i2} - \varepsilon_{i1}) \\
\Delta Y_{it} &= \Delta\mathbf{X}'_{it}\beta + \Delta\varepsilon_{it}.
\end{aligned}$$

Table 1 shows that the two estimators produce identical results, in an arbitrary time period from November to December in 2006.

Table 1: Fixed Effect (Within) and First Difference Estimation

VARIABLES	(1) Within	(2) First Difference
OTC	6.200	
	(8.3)	
cov_unemp_rate	5.507	
	(2.2)	
cov_food__st_person	-0.000	
	(0.0)	
OTC_d		6.200
		(8.3)
cov_unemp_rate_d		5.507
		(2.2)
cov_food__st_person_d		-0.000
		(0.0)
Constant	36.245	
	(40.7)	
Observations	100	50
R-squared	0.172	0.172
Number of state	50	

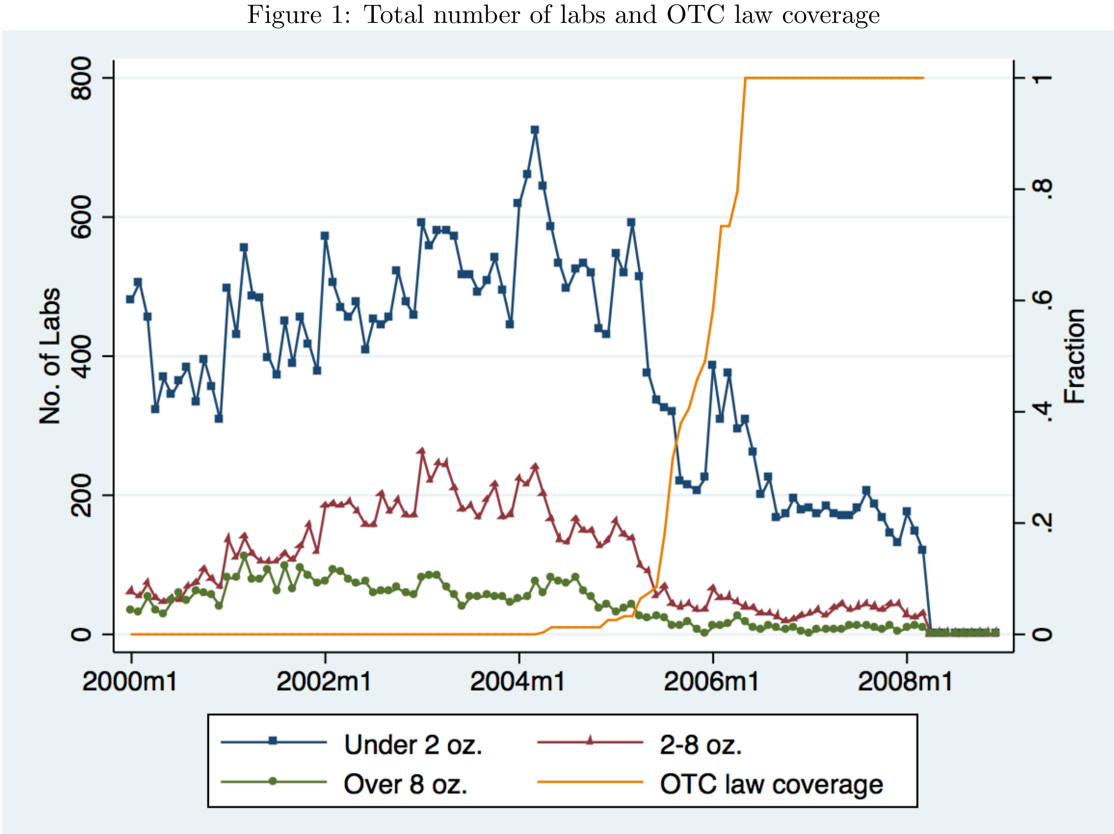
* The standard errors in parentheses below the estimated coefficients.

** The time periods are November and December 2006.

Problem 2

Figure 1 shows the time series of the fraction of population with OTC restrictions and the total number of methamphetamine laboratories discovered by law enforcement agents. The labs are categorized into three groups depending on the their estimated capacity measured as the amount of methamphetamine that can be produced in a single production cycle. *OTC law coverage* is calculated as a fraction where the numerator is the sum of population in the states with OTC restriction in effect and the denominator is the whole U.S. population. Yet, for the month that the law was enacted in a certain state, the state's population was weighted by the proportion of days with the regulation in effect to the total days of that month. For example, if the law was enacted on February 20, 2003, the weight is calculated as $\frac{28-20}{28}$.
We can visually check that the number of labs decreased as the fraction of population covered by OTC restriction increased. However, the decline of the number of labs began slightly before April 2004, which is the month the OTC restriction was first enacted in the U.S., specifically in Oklahoma.

Figure 1: Total number of labs and OTC law coverage

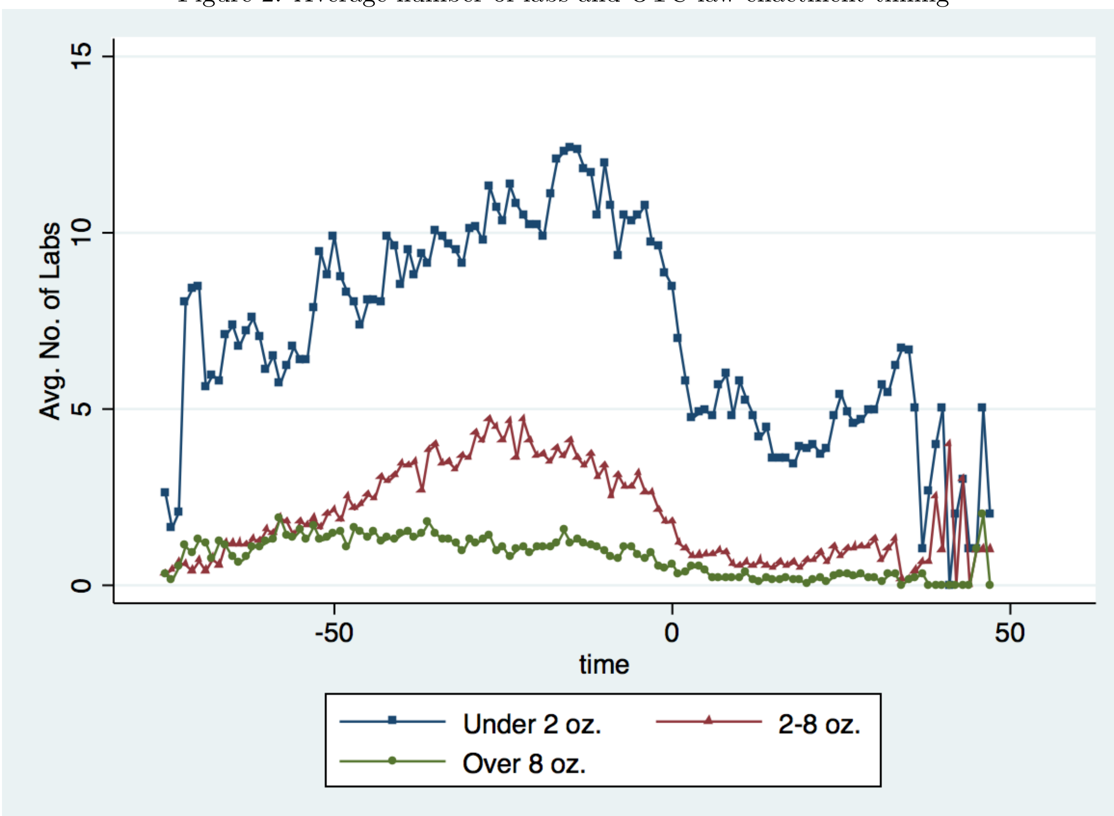


Note: The figure contains the total number of labs in all states discovered for three capacity groups at each month.

Problem 3

Figure 2 displays the average number of labs discovered for each capacity group. The time is centered at the months when the law enactment happened for each state. As in Figure 1, the decline in the number of labs discovered starts well before the law enactment, on average. This tells us the possibility that there may be some spillover effects from the states which the law was in effect earlier than other states and the effects may be persistent across time.

Figure 2: Average number of labs and OTC law enactment timing



Note: Time 0 indicates the month when the OTC restriction was enacted in the state.

Problem 4

We estimate the following regression model:

$$Y_{st} = \beta OTC_{st} + \alpha_s + \gamma_t + \varepsilon_{st},$$

where OTC_{st} is the indicator variable for state s at month t, α_s is the state-specific fixed effect, and γ_t is the time effect. OTC_{st} takes the value of either 1 or 0, except for the observations at the month when the law started to be in effect. It is calculated exactly the same way as for the population weight in Problem 2. Tables 2 and 3 show the estimation results. For each Table, the independent variables are the number of total labs for the first three columns, the number of labs with under-2-ounce capacity for the second three, the number of labs with 2-to-8-ounce capacity for the third three, and the number of labs with over-9-ounce capacity for the last three.

Table 2 has normal standard errors and Table 3 displays clustered standard errors by state. The clustered standard errors are larger than the normal ones by about a factor of 2. The usual formula for OLS standard errors overstates the precision by underestimating the standard errors and thus overestimating the t-statistics.

Table 2: Impact of OTC regulation (usual standard errors)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
OTC	-6.78	-7.05	-6.82	-4.25	-4.44	-4.40	-2.22	-2.27	-2.21	-0.30	-0.33	-0.22
	(0.91)	(0.91)	(0.90)	(0.68)	(0.67)	(0.67)	(0.26)	(0.26)	(0.26)	(0.19)	(0.19)	(0.18)
unemployment		2.20	2.50		1.56	1.62		0.39	0.48		0.24	0.40
		(0.25)	(0.26)		(0.19)	(0.19)		(0.07)	(0.07)		(0.05)	(0.05)
food_stamp			-0.00			-0.00			-0.00			-0.00
			(0.00)			(0.00)			(0.00)			(0.00)
Observations	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937
Number of state	50	50	50	50	50	50	50	50	50	50	50	50

* The standard errors are in the parentheses below the estimated coefficients.

Table 3: Impact of OTC regulation (clustered standard errors)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
OTC	-6.78	-7.05	-6.82	-4.25	-4.44	-4.40	-2.22	-2.27	-2.21	-0.30	-0.33	-0.22
	(1.82)	(1.81)	(1.90)	(1.18)	(1.18)	(1.21)	(0.52)	(0.52)	(0.52)	(0.33)	(0.32)	(0.36)
unemployment		2.20	2.50		1.56	1.62		0.39	0.48		0.24	0.40
		(0.90)	(1.00)		(0.67)	(0.71)		(0.18)	(0.20)		(0.13)	(0.18)
food_stamp			-0.00			-0.00			-0.00			-0.00
			(0.00)			(0.00)			(0.00)			(0.00)
Observations	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937	4,937
Number of state	50	50	50	50	50	50	50	50	50	50	50	50

* The standard errors in the parentheses are clustered by state.

Problem 5

For FE estimator to be unbiased, we need strict exogeneity:

$$E[\varepsilon_{st}|X_{s1}, ..., X_{sT}, \alpha_s] = 0.$$

This means the expected value of the error term conditional on past, current, and future values of the regressors is zero. This assumption is basically ruling out the cases in which the independent variables have persistent effect on the dependent variable across time. And it is difficult to believe that this is true in our case, especially because a restriction on OTC drugs will not directly, immediately, or fully affect the methamphetamine production.

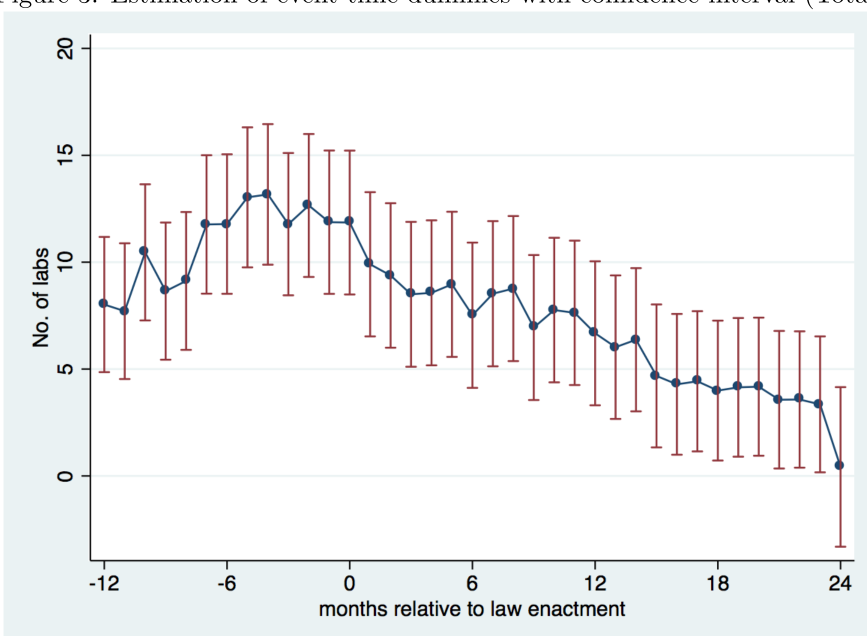
Problem 6

As mentioned in Problem 5, the strict exogeneity assumption rules out the cases in which the treatment has persistent effects across time periods. The specification in Problem 7 allows us to see how the enactment of OTC restrictions affect the number of labs discovered across time.

Problem 7

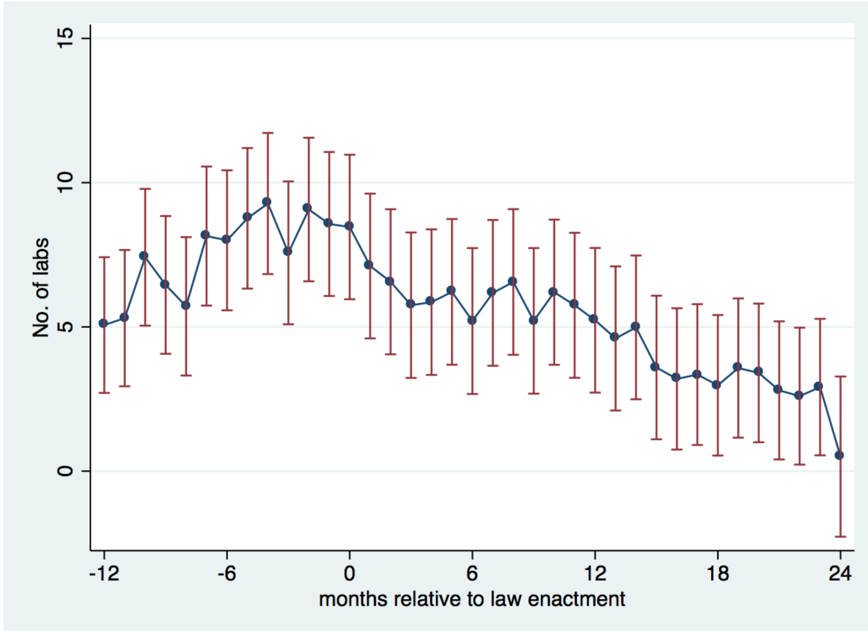
Figures 3 to 6 show the estimates of event time dummies and their confidence intervals. The effect is not immediate but gradual across time. In Figure 1, we can't see the precise timings of when the number of labs decrease by state, since the enactment dates are different across states. Yet in Figures 3 to 6, we can see that the number of labs are decreasing in relative to the timing of law enactment. However, the starting point of decline is on average about three months before the law enactment. From this, we may tell there is possibility of spill over effects from other states which had the OTC restriction in effect earlier than others.

Figure 3: Estimation of event time dummies with confidence interval (Total)



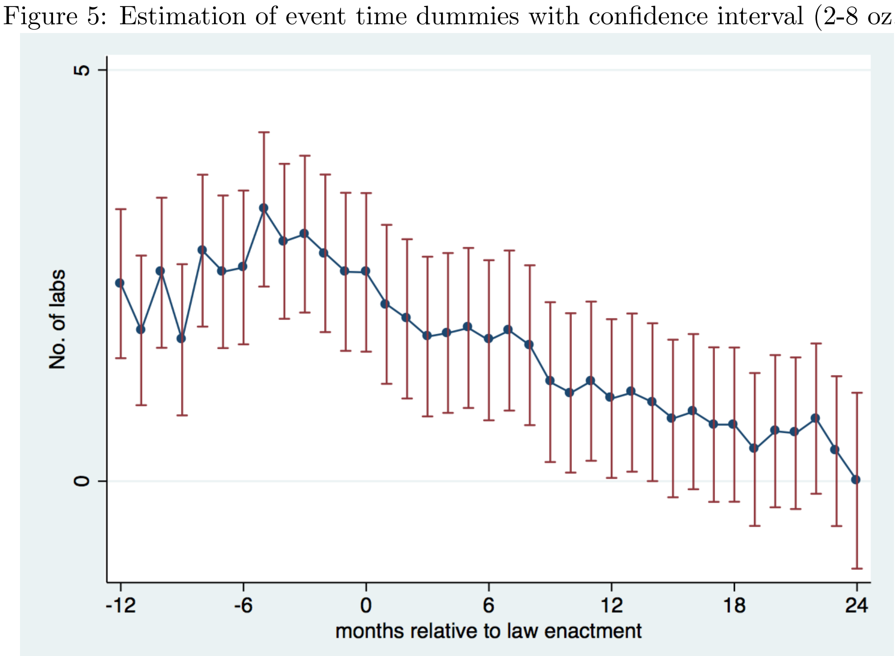
Note: The graph contains OLS estimates of the coefficients on the indicators corresponding to the number of months since any OTC restriction went into effect. The vertical bars represent 95% confidence intervals, using normal standard errors.

Figure 4: Estimation of event time dummies with confidence interval (under 2 oz.)



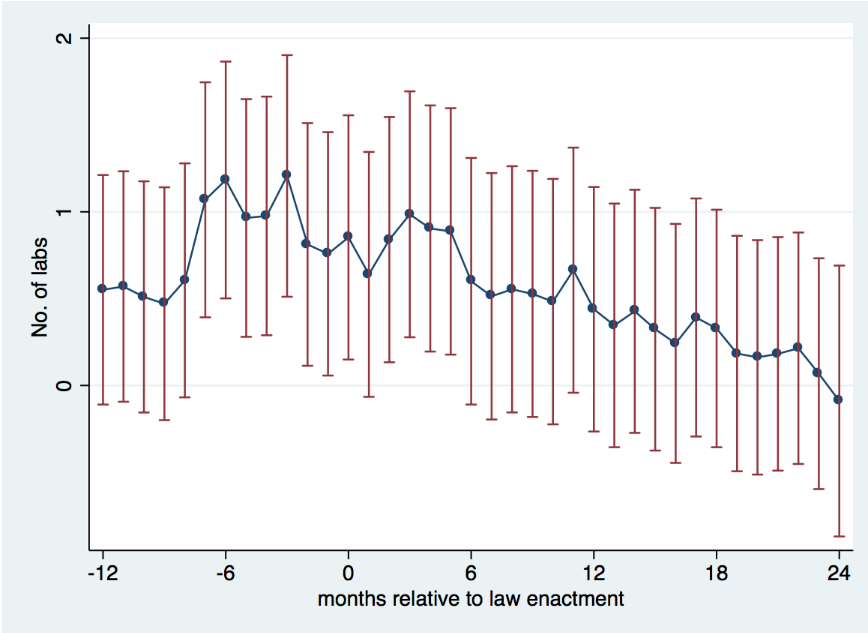
Note: The graph contains OLS estimates of the coefficients on the indicators corresponding to the number of months since any OTC restriction went into effect. The vertical bars represent 95% confidence intervals, using normal standard errors.

Figure 5: Estimation of event time dummies with confidence interval (2-8 oz.)



Note: The graph contains OLS estimates of the coefficients on the indicators corresponding to the number of months since any OTC restriction went into effect. The vertical bars represent 95% confidence intervals, using normal standard errors.

Figure 6: Estimation of event time dummies with confidence interval (over 9 oz.)



Note: The graph contains OLS estimates of the coefficients on the indicators corresponding to the number of months since any OTC restriction went into effect. The vertical bars represent 95% confidence intervals, using normal standard errors.

Stata Codes

```
* Change working directory
cd "/Users/DSP/Dropbox/UCSC (2016- )/1stYear_2Q/211B/Homeworks/HW3"

* Open original DTA file
use "meth_otc", replace

* Generate date variables
gen MMM = date(event_date,"DMY")
gen NNN = date(any_law,"MDY")
drop event_date any_law

* Calculate days in month
gen dd = day(MMM)
gen mm = month(MMM)
gen yyyy = year(MMM)
gen mm1=mm+1 if mm<12
replace mm1=1 if mm==12
replace yyyy=yyyy+1 if mm==12
gen dpm = day(mdy(mm1,1,yyyy)-1)
drop dd mm mm1 yyyy

* Generate OTC variable
gen OTC = 0
replace OTC = (MMM - NNN)/dpm if mofd(MMM)==mofd(NNN) & MMM > NNN
replace OTC = 1 if mofd(MMM)!= mofd(NNN) & MMM > NNN
drop dpm

* Clean up date variables
gen event_date = mofd(MMM)
gen any_law = mofd(NNN)
format %tm event_date any_law
drop MMM NNN

* Arrange ID variable for panel
encode state_ab, gen(state)
drop state_ab

* Declare panel dataset
xtset state event_date, monthly

* Clean up dummies
```

```
gen cap_9_oz_or_more = cap_9_oz_1_lb + cap_2_9_lb + cap_10_19_lb + cap_20_lb_or_greater
drop cap_9_oz_1_lb cap_2_9_lb cap_10_19_lb cap_20_lb_or_greater

* Order variables (for convenience)
order state event_date any_law tot_labs cap_under_2_oz cap_2_8_oz cap_9_oz_or_more OTC,
first

* Save file
save "211b_hw3_meth_otc.dta", replace


************************************** Problem 1 **************************************
use "211b_hw3_meth_otc", replace

* First difference variables
local list "tot_labs OTC cov_unemp_rate cov_food__st_person"
foreach x of local list {
    gen ‘x’_d = ‘x’ - ‘x’[_n-1]
    }

* Time period of our interest
global ttt = 552

* Within estimator
xtreg tot_labs OTC cov_unemp_rate cov_food__st_person if event_date==$ttt-1 |
event_date==$ttt, fe
outreg2 using "hw3_reg1.tex", tex(fr) replace se bdec(3) sdec(1) noaster nonote
ctitle("Within")

* First difference estimator
reg tot_labs_d OTC_d cov_unemp_rate_d cov_food__st_person_d if event_date==$ttt, noconstant
outreg2 using "hw3_reg1.tex", tex(fr) append se bdec(3) sdec(1) noaster nonote
ctitle("First Difference")


************************************** Problem 2 **************************************
use "211b_hw3_meth_otc", replace

* Generate time-series of proportion of population in states with OTC
gen OTC_pop = OTC * pop_all_fitted
collapse (sum) OTC_pop (sum) pop_all_fitted (sum) cap_under_2_oz cap_2_8_oz
cap_9_oz_or_more, by(event_date)
gen Fraction = OTC_pop/pop_all_fitted
```

```
save "211b_hw3_p2.dta", replace

* Plot
#delimit ;
twoway (connected cap_under_2_oz event_date, msize(vsmall) msymbol(square) yaxis(1))
(connected cap_2_8_oz event_date, msize(vsmall) msymbol(triangle) yaxis(1))
(connected cap_9_oz_or_more event_date, msize(vsmall) msymbol(circle) yaxis(1))
(line Fraction event_date, yaxis(2)),
legend(on order(1 "Under 2 oz." 2 "2-8 oz." 3 "Over 8 oz." 4 "OTC law coverage"));
#delimit cr
ytitle(No. of Labs) xtitle("")

graph export "time_series_plot.png", replace


************************************** Problem 3 **************************************
use "211b_hw3_meth_otc", replace

* Center time at 0
gen time = event_date - any_law

* Average number of labs
collapse (mean) cap_under_2_oz cap_2_8_oz cap_9_oz_or_more, by(time)

* Plot
#delimit ;
twoway (connected cap_under_2_oz time, msize(vsmall) msymbol(square))
(connected cap_2_8_oz time, msize(vsmall) msymbol(triangle))
(connected cap_9_oz_or_more time, msize(vsmall) msymbol(circle)),
legend(on order(1 "Under 2 oz." 2 "2-8 oz." 3 "Over 8 oz."))
ytitle(Avg. No. of Labs) xtitle(time) xscale(range(-80 60)) xlabel(-50(50)50);
#delimit cr
graph export "avg_labs_plot.png", replace


************************************** Problem 4 **************************************
use "211b_hw3_meth_otc", replace

* Rename to table-friendly variable names
rename (cov_unemp_rate) (unemployment)
rename (cov_food__st_person) (food_stamp)

* FE estimation (normal s.e.)
```

```
order cap_9_oz_or_more cap_2_8_oz cap_under_2_oz tot_labs, before(OTC)
local y_list "tot_labs cap_under_2_oz cap_2_8_oz cap_9_oz_or_more"
local x_list "OTC unemployment food_stamp"
foreach y of local y_list {
    foreach x of local x_list{
        xtreg ‘y’-‘x’ i.state i.event_date
        outreg2 using "hw3_reg2_FE.tex", tex(fr) append se bdec(2) sdec(2) noaster nonote
        ctitle(" ") keep(OTC unemployment food_stamp) nocons
        }
    order ‘y’, after(any_law)
    }

* FE estimation (clustered s.e.)
order cap_9_oz_or_more cap_2_8_oz cap_under_2_oz tot_labs, before(OTC)
local y_list "tot_labs cap_under_2_oz cap_2_8_oz cap_9_oz_or_more"
local x_list "OTC unemployment food_stamp"
foreach y of local y_list {
    foreach x of local x_list{
        xtreg ‘y’-‘x’ i.state i.event_date, vce(cluster state)
        outreg2 using "hw3_reg3_FE_cluster.tex", tex(fr) append se bdec(2) sdec(2) noaster
        nonote ctitle(" ") keep(OTC unemployment food_stamp) nocons
        }
    order ‘y’, after(any_law)
    }

************************************** Problem 7 **************************************
use "211b_hw3_meth_otc", replace

* Center time at 0
gen time = event_date - any_law

* Generate event time dummies (positive)
forval i= 0/24 {
    gen pi_‘i’ = 0
    replace pi_‘i’ = 1 if time==‘i’
    }

* Generate event time dummies (negative)
forval i= 1/12 {
    gen pi_n‘i’ = 0
    replace pi_n‘i’ = 1 if time==-‘i’
    order pi_n‘i’, after(time)
    }
```

```
* Save file
save "211b_hw3_prob7.dta", replace


* Estimation (total labs)
use "211b_hw3_prob7", replace
reg tot_labs i.state i.event_date pi_*
regsave pi_*, ci
gen id = 0
forval i=1/37 {
    replace id = -13 + ‘i’ in ‘i’
    }
twoway (connected coef id, msize(small)) (rcap ci_upper ci_lower id), ytitle(No. of labs)
ylabel(none) yscale(range(0 20)) xtitle(months relative to law enactment)
xscale(range(-12 24)) xlabel(-12(6)24) ylabel(0(5)18) legend(off)
graph export "CI_plot_total.png", replace

* Estimation (under 2 oz)
use "211b_hw3_prob7", replace
reg cap_under_2_oz i.state i.event_date pi_*
regsave pi_*, ci
gen id = 0
forval i=1/37 {
    replace id = -13 + ‘i’ in ‘i’
    }
twoway (connected coef id, msize(small)) (rcap ci_upper ci_lower id), ytitle(No. of labs)
ylabel(none) xtitle(months relative to law enactment) xscale(range(-12 24)) xlabel(-12(6)24)
ylabel(0(5)15) yscale(range(0 15)) legend(off)
graph export "CI_plot_under2.png", replace

* Estimation (under 2-8 oz)
use "211b_hw3_prob7", replace
reg cap_2_8_oz i.state i.event_date pi_*
regsave pi_*, ci
gen id = 0
forval i=1/37 {
    replace id = -13 + ‘i’ in ‘i’
    }
twoway (connected coef id, msize(small)) (rcap ci_upper ci_lower id), ytitle(No. of labs)
ylabel(none) xtitle(months relative to law enactment) xscale(range(-12 24)) xlabel(-12(6)24)
ylabel(0(5)5) yscale(range(0 5)) legend(off)
graph export "CI_plot_2-8.png", replace
```

```
* Estimation (under over 9 oz)
use "211b_hw3_prob7", replace
reg cap_9_oz_or_more i.state i.event_date pi_*
regsave pi_*, ci
gen id = 0
forval i=1/37 {
    replace id = -13 + ‘i’ in ‘i’
    }
twoway (connected coef id, msize(small)) (rcap ci_upper ci_lower id), ytitle(No. of labs)
ylabel(none) xtitle(months relative to law enactment) xscale(range(-12 24)) xlabel(-12(6)24)
ylabel(0(1)2) yscale(range(0 2)) legend(off)
graph export "CI_plot_over9.png", replace
```