Economics

Lecture #9

Regression with Panel Data

Outline (Lectures 10 and 11)

1. Panel data – what and why
2. Fixed effects regression
    a. The entity fixed effects regression model
    b. fixed entity effects – estimation
    c. fixed time effects
    d. fixed entity and time effects
3. Standard errors for panel data regression
4. Applications

Example of a panel data set: Traffic deaths and alcohol taxes

Observational unit: a year in a U.S. state

- 48 U.S. states, so n = of entities = 48
- 7 years (1982,…, 1988), so T = # of time periods = 7
- Balanced panel, so total # observations = $7 \times 48 = 336$

Variables:

- Traffic fatality rate (# traffic deaths in that state in that year, per 10,000 state residents)
- Tax on a case of beer
- Other (legal driving age, drunk driving laws, etc.)

Drunk Driving

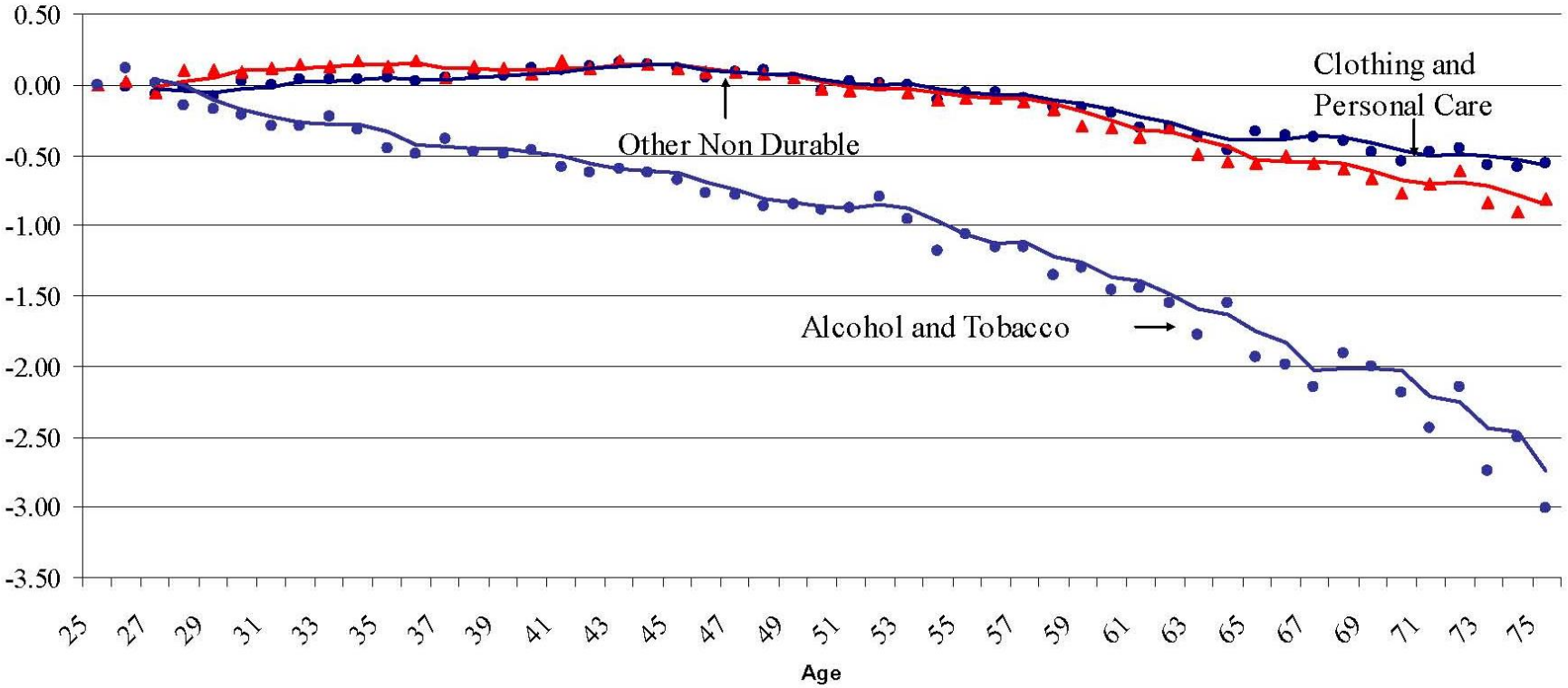
Some Facts

- Approx. 40,000 traffic fatalities annually in the U.S.
- 1/3 of traffic fatalities involve a drinking driver
- 25% of drivers on the road between 1am and 3am have been drinking (estimate)
- A drunk driver is 13 times as likely to cause a fatal crash as a non-drinking driver (estimate)

Policy remedies

- mandatory punishment
- National Drinking Age Act of 1984 (effective national age-21 limit – states made changes 1980-1987)
- economic interventions (alcohol taxes)

Figure 3b: Declining Categories Over the Lifecycle
Percent Deviation from 25 Year Olds



Source: Aguiar and Hurst, "Decomposing Life Cycle Expenditure," manuscript, University of Chicago (2007) (not all charts are in published version)

Figure 3c: Increasing Categories Over the Lifecycle
Percent Deviation from 25 Year Olds

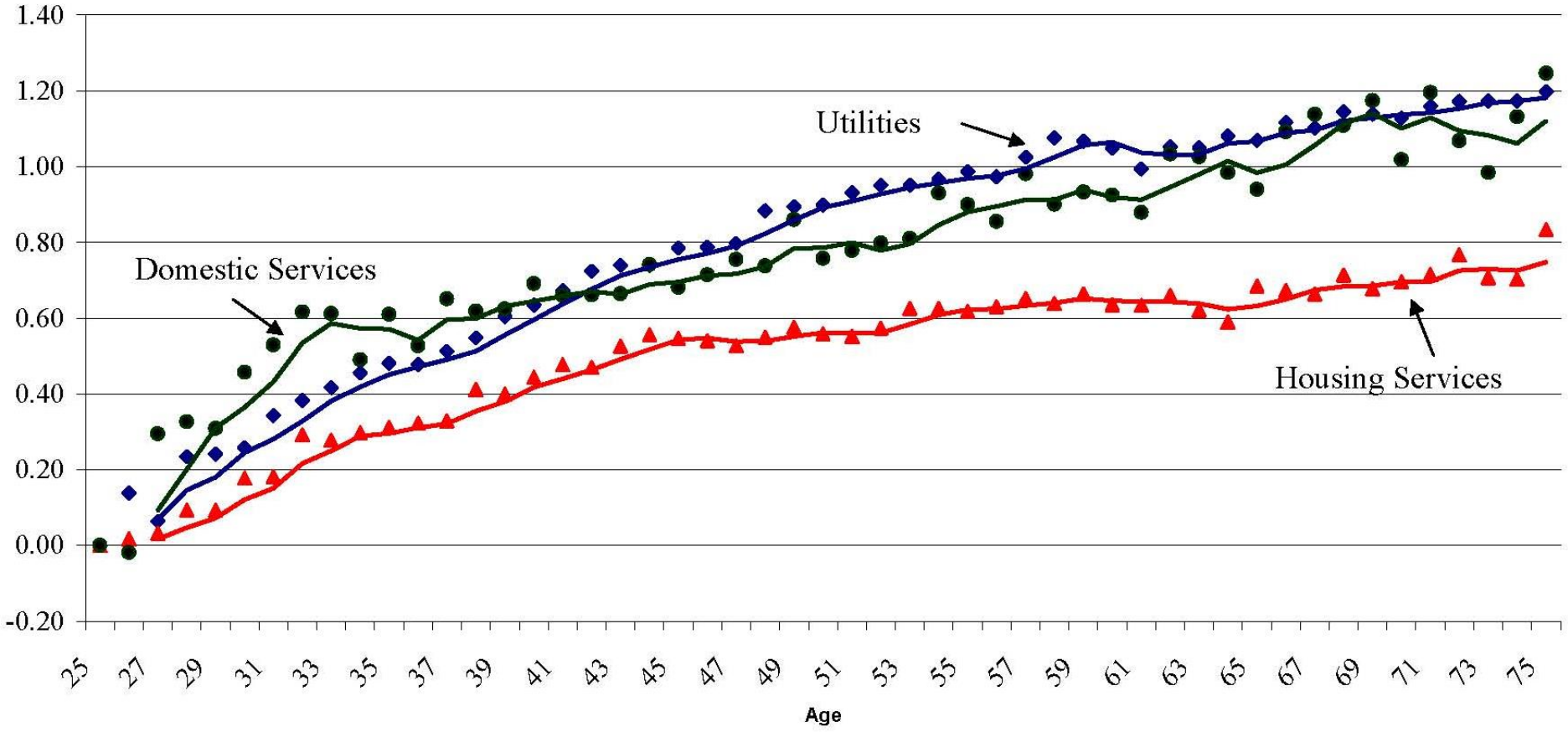
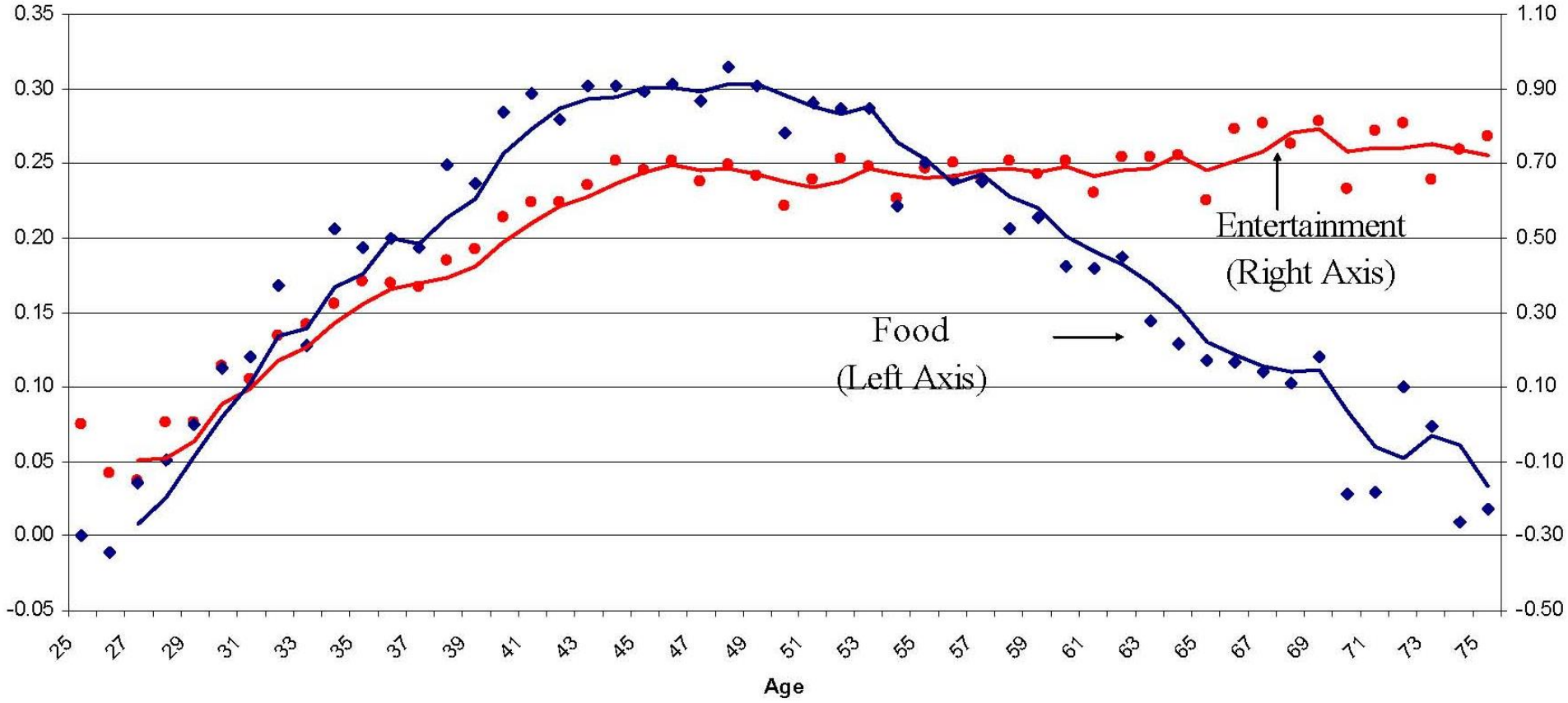


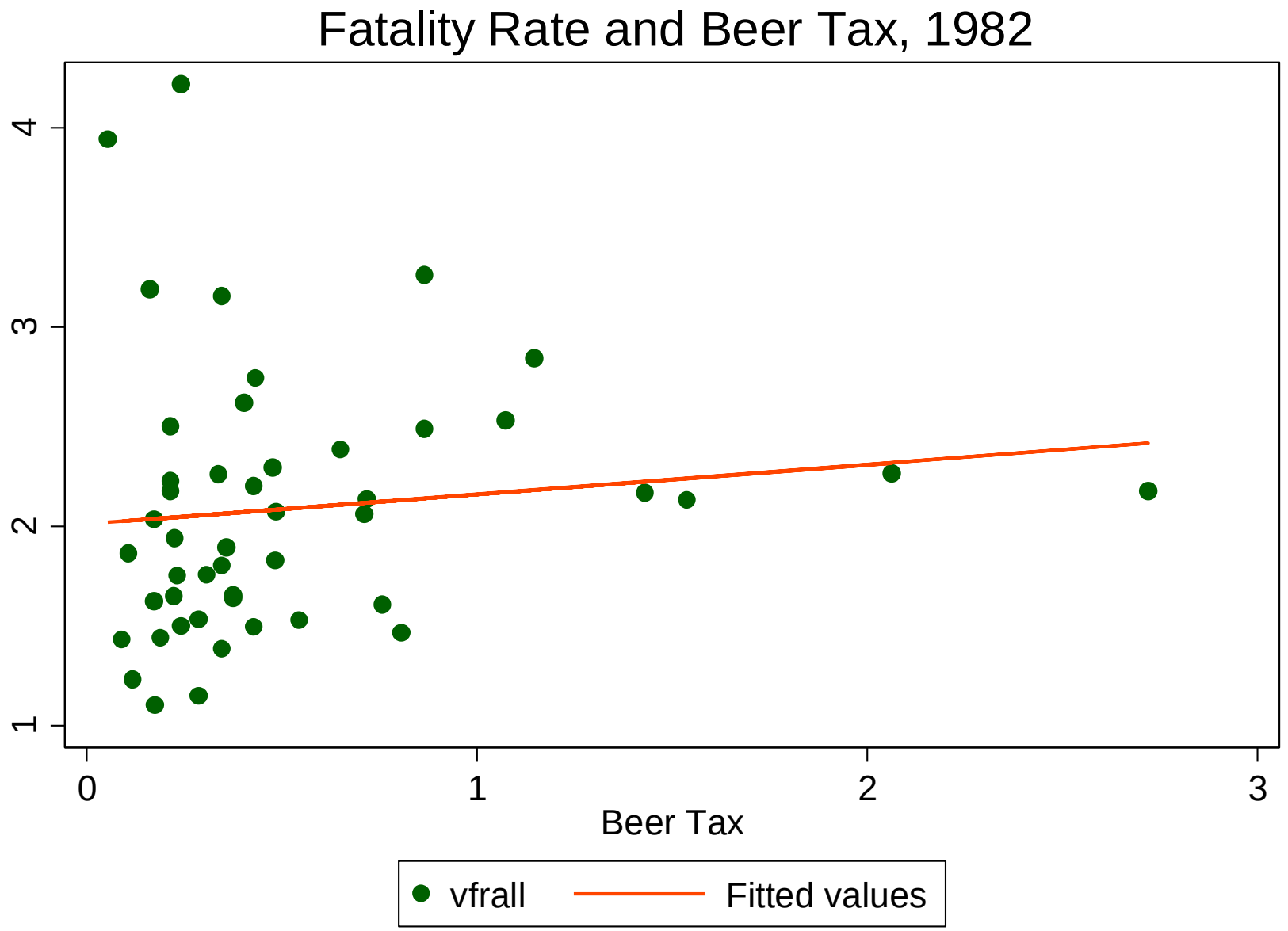
Figure 2b: Entertainment vs Food Over the Lifecycle
Percentage Deviation from 25 Year Olds



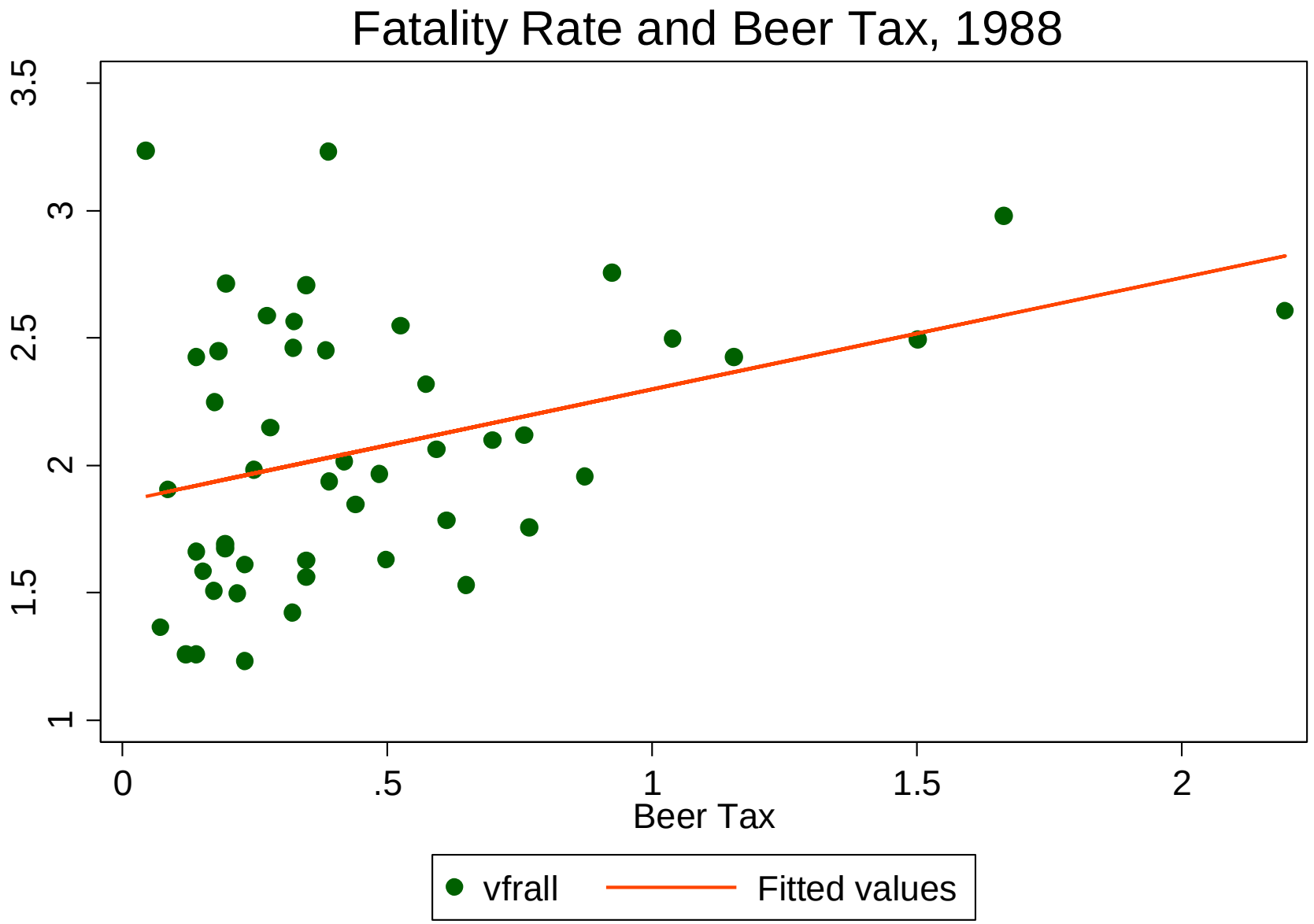
```
. list state year vfrall vmilespd beertax

     +-----------------------------------------------+
     | state   year    vfrall   vmilespd    beertax |
     |-----------------------------------------------|
  1. |    AL   1982   2.12836   7.233887   1.539379 |
  2. |    AL   1983   2.34848   7.836348   1.788991 |
  3. |    AL   1984   2.33643    8.26299   1.714286 |
  4. |    AL   1985   2.19348   8.726917   1.652542 |
  5. |    AL   1986   2.66914   8.952853   1.609907 |
     |-----------------------------------------------|
  6. |    AL   1987   2.71859   9.166302       1.56 |
  7. |    AL   1988   2.49391   9.674323   1.501444 |
  8. |    AZ   1982   2.49914   6.810157   .2147971 |
  9. |    AZ   1983   2.26738   6.587495    .206422 |
 10. |    AZ   1984   2.82878    6.70997   .2967033 |
     |-----------------------------------------------|
 11. |    AZ   1985   2.80201   6.771263   .3813559 |
 12. |    AZ   1986   3.07106   8.129007    .371517 |
 13. |    AZ   1987   2.76728   9.370654        .36 |
 14. |    AZ   1988   2.70565   9.815721    .346487 |
 15. |    AR   1982   2.38405     7.2085    .650358 |
     |-----------------------------------------------|
 16. |    AR   1983    2.3957   7.175917   .6754587 |
 17. |    AR   1984   2.23785    7.08482   .5989011 |
 18. |    AR   1985   2.26367   7.253918   .5773305 |
 19. |    AR   1986   2.54323   7.468999   .5624355 |
 20. |    AR   1987   2.67588   7.665831       .545 |
```

21.	AR	1988	2.54697	8.024626	.5245429
.					
.					
.					
323.	WI	1982	1.62242	6.909823	.173031
324.	WI	1983	1.52728	7.184746	.1662844
325.	WI	1984	1.72617	7.426941	.1593406
326.	WI	1985	1.55812	7.681489	.1536017
327.	WI	1986	1.56178	8.036372	.1496388
328.	WI	1987	1.658	8.361979	.145
329.	WI	1988	1.6622	8.745191	.1395573
330.	WY	1982	3.94118	10.35491	.0536993
331.	WY	1983	3.35271	9.804255	.0516055
332.	WY	1984	3.06043	9.994155	.0494506
333.	WY	1985	2.98625	10.61101	.0476695
334.	WY	1986	3.31361	10.61933	.0464396
335.	WY	1987	2.63265	10.95305	.045
336.	WY	1988	3.23591	11.81212	.0433109

U.S. traffic death data for 1982:



U.S. traffic death data for 1988



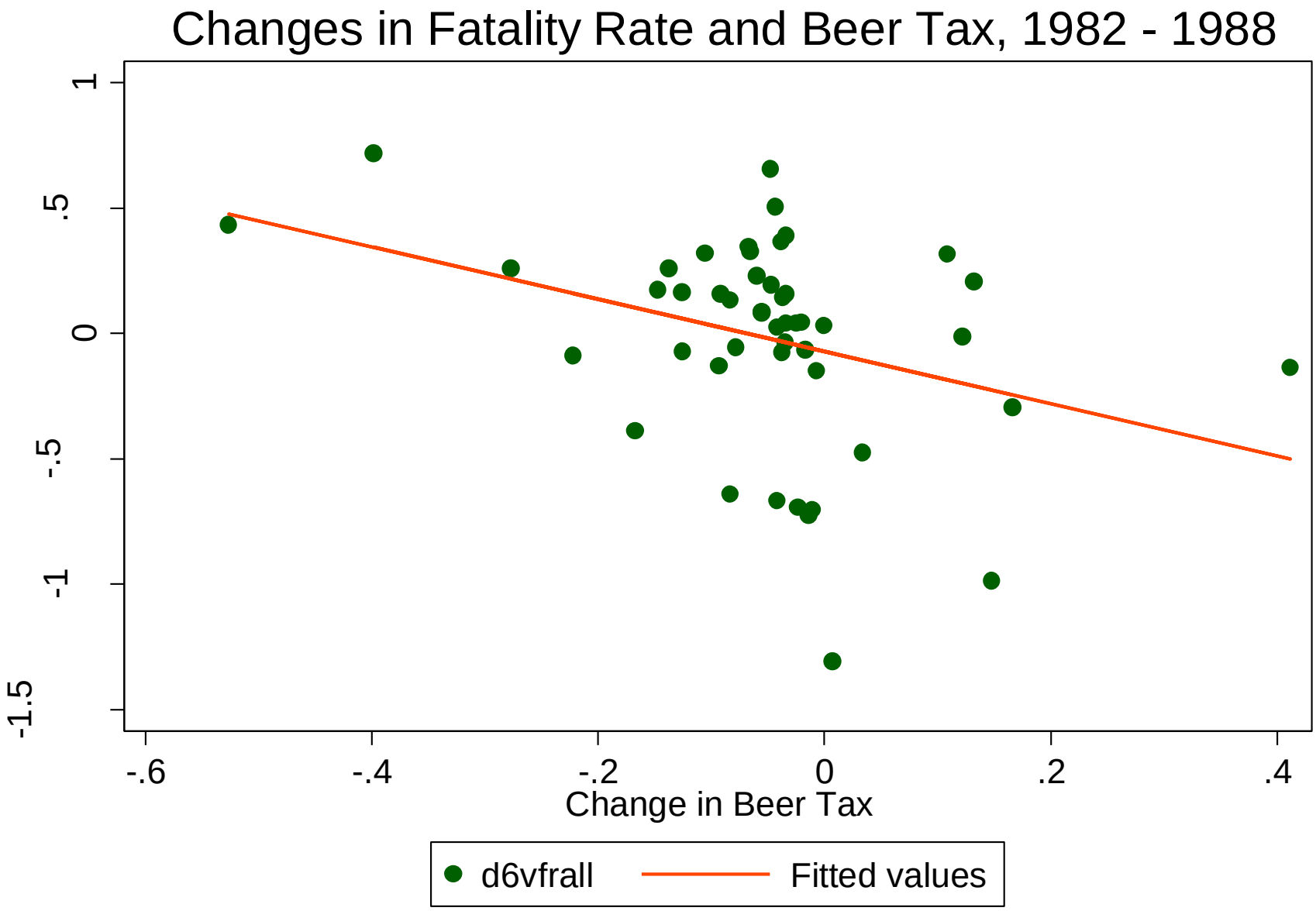
```
. reg vfrall beertax if (year==1982), r

Linear regression                               Number of obs =      48
                                                F(  1,    46) =    1.25
                                                Prob > F      =  0.2687
                                                R-squared     =  0.0133
                                                Root MSE      =  .67048

------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   .1484603   .1326054     1.12   0.269    -.1184604    .4153811
       _cons |   2.010381   .1495728    13.44   0.000     1.709307    2.311456
------------------------------------------------------------------------------
```

```
. reg vfrall beertax if (year==1988), r

Linear regression                               Number of obs =      48
                                                F(  1,    46) =   11.77
                                                Prob > F      =  0.0013
                                                R-squared     =  0.1340
                                                Root MSE      =  .49025

------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   .4387546   .1278649     3.43   0.001     .1813758    .6961334
       _cons |   1.859073   .1146124    16.22   0.000      1.62837    2.089776
------------------------------------------------------------------------------
```

Differences regression: 1998 - 1982

```
. gen d6vfrall = vfrall-vfrall[_n-6]
. gen d6beertax = beertax-beertax[_n-6]

. reg d6vfrall d6beertax if year==1988, r

Linear regression                               Number of obs =      48
                                                F(  1,    46) =    8.60
                                                Prob > F      =  0.0052
                                                R-squared     =  0.1192
                                                Root MSE      =  .39402

------------------------------------------------------------------------------
             |               Robust
    d6vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   d6beertax |  -1.040973   .3550062    -2.93   0.005    -1.755563   -.3263822
       _cons |  -.0720371   .0653552    -1.10   0.276    -.2035903    .0595161
------------------------------------------------------------------------------

.  predict t3
(option xb assumed; fitted values)

. twoway scatter d6vfrall t3 d6beertax if year==1988, s(O i) c(. l) ///
>  title("Changes in Fatality Rate and Beer Tax, 1982 - 1988") ///
>  ytitle("Change in Fatality Rate") xtitle("Change in Beer Tax")
```

$\Delta FatalityRate$ v. $\Delta BeerTax$:



Fixed effects regression: Traffic deaths and beer taxes in STATA

Two period example (1982 & 1988)

(a) "changes" (differences) specification

```
. xtset state year
. reg d6vfrall d6beertax if year==1988, noconstant r

Linear regression                               Number of obs =      48
                                                F(  1,    47) =   10.46
                                                Prob > F      =  0.0022
                                                R-squared     =  0.0942
                                                Root MSE      =  .39574

------------------------------------------------------------------------------
             |               Robust
    d6vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   d6beertax |   -.8689216   .2687029    -3.23   0.002    -1.409482   -.3283611
------------------------------------------------------------------------------
```

(b) Fixed effects specification

```
. xtreg vfrall beertax if (year==1982)|(year==1988), fe vce(cluster state)

Fixed-effects (within) regression               Number of obs      =        96
Group variable: state                           Number of groups   =        48

R-sq:  within  = 0.0942                         Obs per group: min =         2
       between = 0.0622                                        avg =       2.0
       overall = 0.0462                                        max =         2

                                                F(1,47)            =     10.35
corr(u_i, Xb)  = -0.7038                        Prob > F           =    0.0023

                                  (Std. Err. adjusted for 48 clusters in state)
------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   -.8689216   .2701284    -3.22   0.002     -1.41235   -.3254934
       _cons |    2.518194   .1364268    18.46   0.000     2.243739    2.792649
-------------+----------------------------------------------------------------
     sigma_u |   .77501678
     sigma_e |   .27983322
         rho |   .88466639   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Fixed effects regression, multiple time periods

```
. xtset state year
. xtreg vfrall beertax, fe vce(cluster state)

Fixed-effects (within) regression               Number of obs      =       336
Group variable: state                           Number of groups   =        48

R-sq:  within  = 0.0407  IGNORE R-sq            Obs per group: min =         7
       between = 0.1101                                        avg =       7.0
       overall = 0.0934                                        max =         7

                                                F(1,47)            =      5.05
corr(u_i, Xb)  = -0.6885                        Prob > F           =    0.0294

                                  (Std. Err. adjusted for 48 clusters in state)
------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |  -.6558736   .2918556    -2.25   0.029    -1.243011   -.0687358
       _cons |   2.377075   .1497966    15.87   0.000     2.075723    2.678427
-------------+----------------------------------------------------------------
     sigma_u |   .7147146
     sigma_e |  .18985942
         rho |  .93408484   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

- `xtreg` with `,fe` does fixed entity effects estimation
- the estimate is obtained by subtracting entity means
- the reported intercept is arbitrary

***Example*, ctd.** For $n = 48$, $T = 7$:

$$FatalityRate = -.66BeerTax + State\ fixed\ effects$$
$$(.20)$$

- Should you report the intercept?
- Compare slope, standard error to the estimate for the 1988 v. 1982 "changes" specification ($T = 2$, $n = 48$) (*note that this includes an intercept – return to this below*):

$$FR_{1988} - FR_{1982} = -.072 - 1.04(BeerTax_{1988} - BeerTax_{1982})$$
$$(.065) \quad (.36)$$

Alternative way to run this regression: include state dummies

```
. reg vfrall beertax i.state, vce(cluster state)

Linear regression                               Number of obs =     336
                                                F(  0,    47) =       .
                                                Prob > F      =       .
                                                R-squared     =  0.9050
                                                Root MSE      =  .18986

                                   (Std. Err. adjusted for 48 clusters in state)
------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   -.6558736   .3148476    -2.08   0.043    -1.289265    -.022482
             |
       state |
          AZ |   -.5677268   .4133169    -1.37   0.176    -1.399213    .2637596
          AR |   -.6549515    .325306    -2.01   0.050    -1.309383   -.0005202
          CA |   -1.509469   .4809161    -3.14   0.003    -2.476947   -.5419903
          CO |    -1.48428    .450585    -3.29   0.002     -2.39074   -.5778202
          CT |   -1.862257   .4383458    -4.25   0.000    -2.744095   -.9804191
          DE |   -1.307602   .4623804    -2.83   0.007    -2.237791   -.3774125
          FL |   -.2681302   .1599991    -1.68   0.100    -.5900068    .0537465
          GA |    .5246029   .2571406     2.04   0.047     .0073028    1.041903
          ID |   -.6690224   .3975056    -1.68   0.099      -1.4687    .1306557
          IL |   -1.961622   .4579993    -4.28   0.000    -2.882998   -1.040247
          IN |   -1.461542   .4239432    -3.45   0.001    -2.314405   -.6086779
```

IA	-1.543932	.3892425	-3.97	0.000	-2.326987	-.7608771
KS	-1.223216	.374555	-3.27	0.002	-1.976724	-.4697084
KY	-1.217517	.450248	-2.70	0.010	-2.123299	-.3117347
LA	-.8471161	.2665763	-3.18	0.003	-1.383399	-.3108337
ME	-1.107947	.2714404	-4.08	0.000	-1.654015	-.5618797
MD	-1.70644	.4431707	-3.85	0.000	-2.597984	-.814895
MA	-2.109746	.4303643	-4.90	0.000	-2.975527	-1.243965
MI	-1.484527	.3571457	-4.16	0.000	-2.203011	-.7660424
MN	-1.897213	.4104499	-4.62	0.000	-2.722932	-1.071494
MS	-.0290797	.1815995	-0.16	0.873	-.3944107	.3362513
MO	-1.296262	.4133583	-3.14	0.003	-2.127831	-.464692
MT	-.3603914	.4084138	-0.88	0.382	-1.182014	.4612311
NE	-1.522178	.3816167	-3.99	0.000	-2.289892	-.754464
NV	-.6007748	.4480759	-1.34	0.186	-1.502187	.3006376
NH	-1.254454	.3075403	-4.08	0.000	-1.873145	-.6357631
NJ	-2.105749	.4859713	-4.33	0.000	-3.083397	-1.128101
NM	.4263751	.3908486	1.09	0.281	-.359911	1.212661
NY	-2.18667	.4712218	-4.64	0.000	-3.134646	-1.238694
NC	-.290465	.1068326	-2.72	0.009	-.5053844	-.0755456
ND	-1.623439	.3899228	-4.16	0.000	-2.407863	-.8390157
OH	-1.674419	.3899228	-4.29	0.000	-2.458843	-.8899957
OK	-.5450609	.2267549	-2.40	0.020	-1.001233	-.0888888
OR	-1.168	.4476496	-2.61	0.012	-2.068555	-.2674449
PA	-1.767466	.4303643	-4.11	0.000	-2.633247	-.9016849
RI	-2.265054	.4620434	-4.90	0.000	-3.194566	-1.335543
SC	.5571736	.0711099	7.84	0.000	.414119	.7002282
SD	-1.003721	.3074117	-3.27	0.002	-1.622153	-.3852882
TN	-.8756585	.4157639	-2.11	0.041	-1.712068	-.0392494
TX	-.9174733	.3747774	-2.45	0.018	-1.671428	-.1635185
UT	-1.16395	.2818616	-4.13	0.000	-1.730983	-.5969181

```
          VT  |  -.9660438   .3103037    -3.11   0.003    -1.590294   -.3417933
          VA  |  -1.290183   .2969075    -4.35   0.000    -1.887484   -.6928824
          WA  |  -1.659524   .4436116    -3.74   0.000    -2.551955   -.7670922
          WV  |  -.8967539   .3767143    -2.38   0.021    -1.654605   -.1389025
          WI  |  -1.759266   .4623804    -3.80   0.000    -2.689456   -.8290767
          WY  |  -.2285036   .4960816    -0.46   0.647    -1.226491    .7694839
              |
       _cons  |    3.47763   .5112472     6.80   0.000     2.449133    4.506127
------------------------------------------------------------------------------
```

Regression with entity and time fixed effects: entity de-meaning and time dummy variables

```
. gen y83=(year==1983)
. gen y84=(year==1984)
. gen y85=(year==1985)
. gen y86=(year==1986)
. gen y87=(year==1987)
. gen y88=(year==1988)
. global yeardum "y83 y84 y85 y86 y87 y88"
```

```
. xtreg vfrall beertax $yeardum, fe vce(cluster state)

Fixed-effects (within) regression               Number of obs      =       336
Group variable: state                           Number of groups   =        48

R-sq:  within  = 0.0803                         Obs per group: min =         7
       between = 0.1101                                        avg =       7.0
       overall = 0.0876                                        max =         7

                                                F(7,47)            =      4.36
corr(u_i, Xb)  = -0.6781                        Prob > F           =    0.0009

                                    (Std. Err. adjusted for 48 clusters in state)
------------------------------------------------------------------------------
             |               Robust
      vfrall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   -.6399799   .3570783    -1.79   0.080    -1.358329    .0783691
         y83 |   -.0799029   .0350861    -2.28   0.027    -.1504869   -.0093188
         y84 |   -.0724206   .0438809    -1.65   0.106    -.1606975    .0158564
         y85 |   -.1239763   .0460559    -2.69   0.010    -.2166288   -.0313238
         y86 |   -.0378645   .0570604    -0.66   0.510    -.1526552    .0769262
         y87 |   -.0509021   .0636084    -0.80   0.428    -.1788656    .0770615
         y88 |   -.0518038   .0644023    -0.80   0.425    -.1813645    .0777568
       _cons |     2.42847   .2016885    12.04   0.000     2.022725    2.834215
-------------+----------------------------------------------------------------
     sigma_u |  .70945965
     sigma_e |  .18788295
         rho |  .93446372   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
.  test $yeardum

 ( 1)  y83 = 0
 ( 2)  y84 = 0
 ( 3)  y85 = 0
 ( 4)  y86 = 0
 ( 5)  y87 = 0
 ( 6)  y88 = 0

       F(  6,    47) =    4.22
            Prob > F =    0.0018
```