The Economic Impact of Tobacco Control Funding:

A Benefit-Cost Analysis

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Abstract

This report examines a study by Chattopadhyay & Pieper (2012) exploring the economic effectiveness of state-level tobacco prevention and control programs in the United States. The study applies econometric modeling techniques to analyze how tobacco control spending influences cigarette demand over time using state-level panel data from 1991 to 2007. It addresses multiple factors, such as addiction, market structures, price elasticities, cross-border sales, and endogeneity in funding allocations. Their findings suggest that while the immediate impact of tobacco control spending on cigarette consumption is quite small, the long-term effects grow significantly. The benefit-cost analysis indicates that aligning state funding with CDC Best Practices recommendations could generate economic benefits around 14 to 20 times the cost. The research shows strong empirical evidence supporting sustained investment in tobacco control programs to maximize both public health improvements, as well as economic efficiency.

I. Introduction

Policy Questions

Tobacco control programs have been an important component of public health policy in the U.S. for several decades. Starting in the early 1990s, state-level initiatives were made to reduce the prevalence of smoking through multiple tactics, such as public education, smoking cessation programs, and policy interventions, such as taxation and advertising restrictions. While these programs have shown to be effective in reducing smoking rates, they have not been funded consistently across states. In many cases, funding has declined over time.

Even while collecting billions of dollars in tobacco tax revenues and settlements from the 1998 Master Settlement Agreement (MSA), many states still allocate only a small fraction of these funds to control programs. This raises two critical policy questions:

1. Does increased spending on tobacco control programs effectively reduce cigarette demand?
2. If so, does this effect persist and grow over time?

The economic significance of these questions is high; smoking is one of the leading causes of preventable death, being linked to serious health conditions like lung cancer, respiratory illness, and heart disease. Having these health consequences generates massive economic costs, such as through direct medical expenses and loss in productivity. According to the Centers for Disease Control and Prevention (CDC), illnesses caused by smoking cost the U.S. economy over $300 billion on an annual basis, with $170 billion being spent on direct medical care, and $156 billion in loss of productivity.

Despite this, Figure 1 in the study shows a major funding gap in what states collect in tobacco-related revenue and what they choose to spend on prevention programs. Some states dedicate a portion of their cigarette tax to public health efforts, but most of them use said funds for general budgetary needs. This leads to a chronic underfunding of tobacco control efforts. Failing to adequately fund said programs only raises concerns about how sustainable and effective they can be in the long term.

Distinct Features of the Cigarette Market

The cigarette market is fundamentally different from most consumer markets due to two main characteristics:

1. Addiction: Cigarette consumption is less responsive to short-term interventions, such as price increases, due to high levels of nicotine dependence. Most goods usually show a reduction in demand with higher prices, but the addictive nature of nicotine means that smokers have a habitual behavior and lower price elasticity in the short run. This shows the need for sustained and long-term interventions over one-time policy shifts.

2. Oligopolistic Structure: The cigarette industry is mainly dominated by a couple of large firms, meaning they hold significant market power. This lets them strategically adjust prices, be more aggressive in marketing, as well as even influence policy decisions to counteract public health initiatives. Due to this, regulatory efforts face resistance from industry lobbying, which shows how crucial it is to understand market dynamics when designing policies to be effective.

These factors make reducing cigarette consumption even more challenging, showing how necessary a comprehensive, well-funded, and sustained policy approach is.

II. Methodology

Econometric Modeling of Addiction

The study uses econometric models to analyze the impacts of tobacco control funding on cigarette demand. Since nicotine addiction creates inertia in consumer behaviors, traditional demand models have been shown to fail to capture the long-term effects that control policies have. To combat this, the study incorporates lagged effects to show how past consumption influences current smoking behavior.

Econometric Modeling of Oligopoly

As the cigarette market is oligopolistic, firms can respond with strategies to policy interventions. For example, when states raise cigarette taxes, companies could lower their pre-tax prices, as well as introduce price promotions to offset the impact. This makes the price a more endogenous variable, meaning it is influenced by internal market dynamics over external policies themselves. To target this, the study replaces price with total tax per pack as the key independent variable, which ensures that demand estimates are not biased by industry price manipulation.

Panel Data Models (FE, RE)

The study uses panel data regression techniques, such as Fixed Effects (FE) and Random Effects (RE) models to control state-specific factors. Some of these include demographics, regulatory environments, as well as even cultural attitudes toward smoking. The FE model has proven to be the most reliable approach, given the high serial correlation in the dataset.

Endogeneity of Tobacco Control Funding

One of the most significant challenges when estimating the impact of tobacco control spending is endogeneity. For example, states with higher smoking rates are more likely to allocate more resources to control programs, which then creates a reverse causality problem. To correct this bias, the study uses instrumental variable techniques, such as smoke-free air law scores, Alciati scores on youth access laws, as well as lagged control funding levels. These variables are valid as they influence tobacco control funding, but are exogenous to cigarette demand.

Accounting for Cross-Border Sales

Another critical factor in cigarette demand is cross-border shopping. Smokers in high-taxed states have been shown to often purchase cigarettes from neighboring and lower-tax states, which reduces the effectiveness of price-based policies. The study accounts for this by including the average price of cigarettes in bordering states, labeling this a substitute good.

III. Data

The study uses an extensive panel dataset from the years of 1991 to 2007 for the entirety of all fifty U.S. states. There are 850 state-year observations (ie. 50 states for 17 years), which lets for a longitudinal analysis on how tobacco control policies have influenced cigarette demand over time. By using economic, demographic, as well as policy-related variables, the study is quite thorough for assessing the long-term effects of control funding.

Key Variables in Model

The model includes economic and policy-related factors, such as cigarette demand measured as state tax-paid sales per capita each year. There are also price and tax effects, which is the cigarette price per pack including all taxes, as well as the average price of cigarettes in the bordering states to account for cross-border purchases. Tobacco control funding is the total annual spending on control programs per state, this being adjusted for inflation. There are also macroeconomic indicators, which is the the per capita disposable income to control for purchasing power, as well as the unemployment rate to control for economic conditions. Demographics are also a variable, being used as the percentage of young adults 15-24 years old and percentage of adults 25+ years old, since the younger generation is more susceptible to smoking. There are also policy environments, such as smoke-free air laws and youth access laws, which are more instrumental variables.

Data Sources

The data is sourced from multiple public and government databases, including *Tax Burden on Tobacco* (Orzechowski and Walker, 2008), *Bureau of Labor Statistics, U.S. Census Bureau, ImpacTEEN.org,* as well as the *Centers for Disease Control and Prevention (CDC)*.

Data Adjustments

All the financial data is converted into 2008 constant dollars to combat inflation and ensure more consistency throughout the years. The study also log-transforms certain variables to improve normality, as well as interpret elasticities. Having this dataset shows both the short and long term impacts of tobacco control funding, and makes sure that results are not skewed by neither state-specific factors nor temporal variations.

IV. Empirical Findings

Comparison of Fixed Effects (FE) and Random Effects (RE) Models

The study applies both fixed effects and random effects models in order to account for unobserved heterogeneity across the states. There is a high serial correlation in error terms, suggesting that the FE model is the most reliable. It is able to effectively capture state-specific factors influencing cigarette demand, such as smoking culture, pre-existing policies, and the overall economic conditions.

Price and Tax Elasticities

The study shows that cigarette demand is price elastic, meaning an increase in prices leads to a decline in consumption. The own-price elasticity of demand for the FE model is ~-0.91, meaning that a 1% increase in price results in a 0.91% decrease in sales. However, as many smokers engage in cross-border purchases, the study calculates a full price elasticity of ~-0.67, accounting for consumers buying cigarettes in lower-taxed states. The tax elasticity of demand is ~-0.42, translating to a price elasticity of ~-0.58, which only reinforces the argument that taxation alone is not sufficient without policies complementing them.

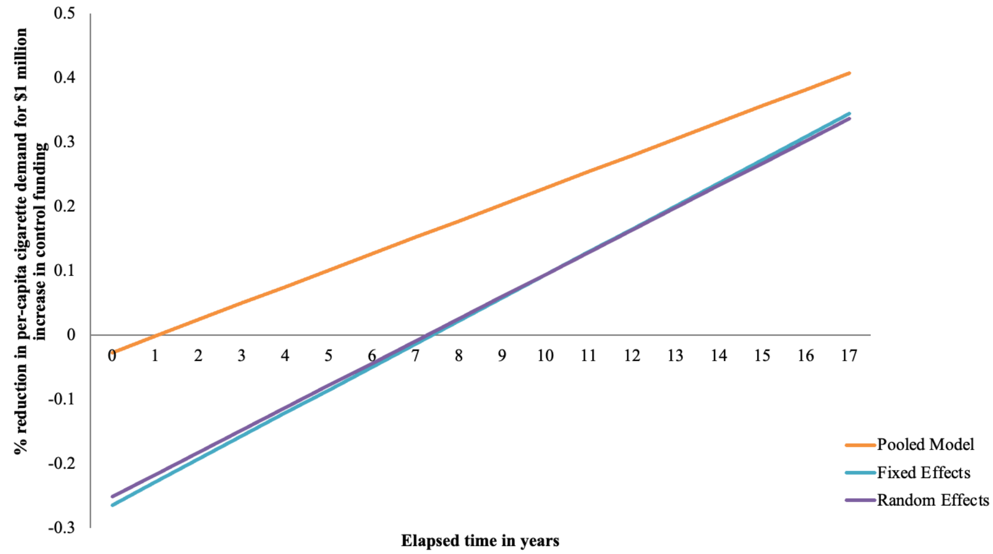


Figure 2: Control funding effect size over time

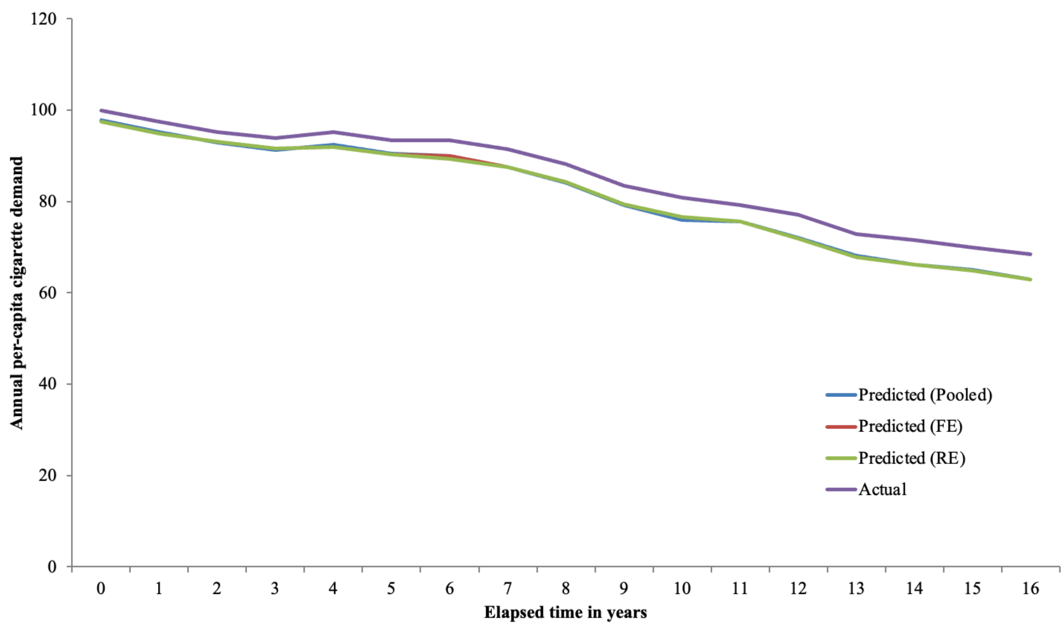


Figure 3: Time Path of Per-capita Cigarette Demand

Impact of Control Funding on Cigarette Demand

One of the most critical findings in the study is that the immediate impact of control funding on cigarette demand may be small, but the long-term effects grow significantly. Contemporaneous effects, or short-term impacts, are either weak or negligible. This hints at the idea that funding programs need more time to take effect before significantly reducing consumption. Elapsed time effects, or the long-term impacts, are strong and highly significant, showing that more time passing increases the effectiveness of tobacco control funding. This dynamic can be seen in Figure 2 of the study, showing that control funding begins to have a statistically significant impact after ~7 years. This only emphasized the importance of long-term policy commitments, as reducing funding can not undo years of progress. We can also see in Figure 3 that the predicted cigarette consumption follows said observed trends, which validates the model. FE and RE models are closely aligned, showing the estimation methods are reliable.

V. Benefit-Cost Analysis

Estimating Economic Benefits

To quantify the economic impacts of reduced smoking, the study estimates cost savings from the three following major areas:

1. Medical Cost Savings: These are the healthcare expenditures avoided from a reduction in smoking-related illnesses.
2. Productivity Gains: This is the increased workforce efficiency, as fewer workers in the labor force suffer from smoking-related illnesses.
3. Reduced Medicaid Expenditures: There is lower government spending on smoking-related health treatments, especially for lower-income populations.

TABLE 4

Total Costs and Benefits under Various Levels of Control Funding (Fixed Effects Model)

Additional Funding in a State in 2008 (Million Dollar)	Predicted Per-Capita Packs Reduction in a State in 2008	Average Pack Reduction in a State in 2008 (Million)	Medical Cost Avoided (Million Dollar)	Productivity Cost Avoided (Million Dollar)	Medicaid Cost Avoided (Million Dollar)	Total Cost Avoided (Million Dollars)
1	0.19	1.4	7.0	6.8	2.1	15.9
10	1.9	14.0	68.8	66.8	21.1	157
20	3.75	27.5	135	132	42	309
50	8.97	65.1	324	314	99	737
59.832	10.57	76.5	382	371	117	869

TABLE 5
Summary of Aggregate Benefits in a State and the Benefit-Cost Ratios

Additional Funding in 2008 (Million Dollar)	Total Cost Avoided (Million Dollars)			Benefit-Cost Ratios		
	Pooled Model	Fixed Effects	Random Effects	Pooled Model	Fixed Effects	Random Effects
1	19.7	15.9	15.6	19.7	15.9	15.6
10	194	157	154	19.4	15.7	15.4
20	380	309	303	19.0	15.4	15.1
50	898	737	724	17.9	14.7	14.5
59.832	1055	869	853	17.6	14.5	14.3

Projected Cost Savings and Effectiveness of Tobacco Control Funding

If all the states followed the *CDC Best Practices* (2007) by increasing annual spending to the recommended $73.72 million per state, the estimated benefits would range from $853 million to $1.05 billion on an annual basis. According to the CDC, the per-pack economic cost of smoking estimates are $5.31 in medical expenses per pack avoided, $5.16 in lost productivity per pack avoided, as well as $1.63 in Medicaid costs per pack avoided. A $1 million increase in control funding leads to a 0.022% reduction in cigarette demand (1999) and 0.308% (2007), showing increasing effectiveness with time. For every dollar spent on tobacco control, states could generate anywhere between $14 to $20 in economic benefits. This is an exceptionally high-return public health investment.

Policy Implications

These results indicate that reducing funding for tobacco control would be a costly mistake, as it leads to higher future healthcare costs, higher productivity losses from smoking-related illnesses, as well as higher Medicaid expenditures for smoking-related diseases. Policymakers should prioritized sustained investment in tobacco control programs in order to maximize both health and economic benefits.

VI. Conclusion

The findings of this study provides strong empirical support for increasing state-level tobacco control funding. These results confirm that tobacco control spending significantly reduces cigarette demand, especially overtime. The impact of spending grows steadily, which only reinforced the necessity for sustained investment. Increasing funding is a highly efficient public health intervention, and the economic benefits will far outweigh program costs. Despite these clear benefits, most states still continue to underfund tobacco control programs, and instead divert tobacco tax revenues and settlement funds into completely unrelated expenditures. This is a short-term budgeting strategy that cotninues to undermine long-term public health goals, as well as increasing future healthcare costs. To achieve maximum impact, states should fully fund their tobacco control programs in accordance with CDC recommendations, as well as implement multi-year funding commitments to ensure long-term effectiveness. This should be complemented with taxation policies with comprehensive prevention and cessation programs.

Reducing smoking rates is not just a public health priority, but also an economic necessity. Making these long-term invesmtnets in prevention and control efforts will generate substantial economic returns, all while improving the health of millions of Americans.

References

Chattopadhyay, S., & Pieper, D. R. (2012). Does spending more on tobacco control programs make economic sense? An incremental benefit-cost analysis using panel data. *Contemporary Economic Policy, 30*(3), 430–447.

Appendix

```
. use "C:\Users\923606369\Desktop\Tobacco-Data-690.dta", cle
> ar

. gen lqpc=log(qpc)

. gen lpreal=log(preal)

. gen lpricesub=log(pricesub)

. gen lpopul=log(popul)

. gen lpcpdireal=log(pcpdireal)

. gen ltottaxreal=log(tottaxreal)

. gen ltaxsub=log(taxsub)

. gen totfundreal1=totfundreal[_n-1]
(1 missing value generated)

. replace totfundreal1=totfundreal if t==0
(50 real changes made)

. gen timefund = t*totfundreal

. regress totfundreal airscore youthscore totfundreal1
```

Source	SS	df	MS			
				Number of obs	=	850
				F(3, 846)	=	941.40
Model	309993.334	3	103331.111	Prob > F	=	0.0000
Residual	92860.1165	846	109.763731	R-squared	=	0.7695
				Adj R-squared	=	0.7687
Total	402853.45	849	474.503475	Root MSE	=	10.477

totfundreal	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
airscore	.0137435	.0369321	0.37	0.710	-.0587458	.0862328
youthscore	.0469427	.055802	0.84	0.400	-.0625838	.1564693
totfundreal1	.883919	.0171702	51.48	0.000	.8502178	.9176202
_cons	.9483597	.8804543	1.08	0.282	-.7797715	2.676491

```
. predict totfundrealhat
(option xb assumed; fitted values)

. gen timefundhat=t* totfundrealhat
```

```
. regress lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 lpreal lpricesub lpopul lpcpdirea
> l totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, robust

Linear regression                               Number of obs     =        850
                                                F(26, 823)        =      84.17
                                                Prob > F          =     0.0000
                                                R-squared         =     0.7043
                                                Root MSE          =     .18928
```

lqpc	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
d2	.0227965	.030819	0.74	0.460	-.0376965	.0832895
d3	-.0240683	.0294439	-0.82	0.414	-.0818622	.0337257
d4	-.1324222	.0318987	-4.15	0.000	-.1950347	-.0698098
d5	-.0930591	.0318235	-2.92	0.004	-.155524	-.0305943
d6	-.093822	.0333573	-2.81	0.005	-.1592975	-.0283466
d7	-.079113	.0346178	-2.29	0.023	-.1470626	-.0111634
d8	-.0155109	.0382576	-0.41	0.685	-.0906049	.0595831
d9	.1609725	.0402517	4.00	0.000	.0819645	.2399805
d10	.3259246	.0496902	6.56	0.000	.2283902	.423459
d11	.3175405	.0522417	6.08	0.000	.2149978	.4200832
d12	.3750074	.0552738	6.78	0.000	.2665131	.4835016
d13	.3880559	.0589908	6.58	0.000	.2722657	.5038461
d14	.3346913	.0633176	5.29	0.000	.2104083	.4589744
d15	.2939257	.0611539	4.81	0.000	.1738897	.4139616
d16	.2649023	.0621857	4.26	0.000	.1428409	.3869636
d17	.2193363	.0613181	3.58	0.000	.0989781	.3396945
lpreal	-1.532264	.090024	-17.02	0.000	-1.708967	-1.35556
lpricesub	.2964316	.1123163	2.64	0.008	.0759714	.5168918
lpopul	-.0457603	.0082895	-5.52	0.000	-.0620313	-.0294893
lpcpdireal	.3708487	.1062991	3.49	0.001	.1621995	.5794978
totfundrealhat	.0020588	.0010676	1.93	0.054	-.0000367	.0041543
timefundhat	-.0003735	.0001175	-3.18	0.002	-.0006042	-.0001428
pcgr	-.0208422	.0021468	-9.71	0.000	-.0250561	-.0166283
pcnt1524	-.0341607	.0143581	-2.38	0.018	-.0623435	-.0059779
pcnt25	.0273491	.0067222	4.07	0.000	.0141543	.0405438
unemprate	.0127407	.0065432	1.95	0.052	-.0001025	.025584
_cons	1.144746	1.229844	0.93	0.352	-1.269254	3.558747

```
. xtreg lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 lpreal lpricesub lpopul lpcpdireal
> totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, fe robust

Fixed-effects (within) regression               Number of obs     =        850
Group variable: state1                          Number of groups  =         50

R-squared:                                      Obs per group:
     Within  = 0.7782                                         min =         17
     Between = 0.1318                                         avg =       17.0
     Overall = 0.1953                                         max =         17

                                                F(26, 49)         =      49.08
corr(u_i, Xb) = -0.7555                         Prob > F          =     0.0000
```

(Std. err. adjusted for 50 clusters in **state1**)

lqpc	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
d2	.0200613	.0175044	1.15	0.257	-.015115	.0552377
d3	-.0153965	.0133679	-1.15	0.255	-.0422604	.0114673
d4	-.0819747	.0200941	-4.08	0.000	-.1223553	-.0415941
d5	-.0595152	.0233008	-2.55	0.014	-.1063399	-.0126905
d6	-.0560963	.0280006	-2.00	0.051	-.1123656	.000173
d7	-.0444779	.031326	-1.42	0.162	-.1074299	.018474
d8	-.0111122	.0372083	-0.30	0.766	-.0858851	.0636607
d9	.0692337	.059304	1.17	0.249	-.049942	.1884095
d10	.1522405	.0987408	1.54	0.130	-.0461866	.3506676
d11	.1531512	.1071952	1.43	0.159	-.0622656	.368568
d12	.1958512	.1220482	1.60	0.115	-.0494139	.4411163
d13	.1937308	.1334215	1.45	0.153	-.0743898	.4618513
d14	.1481979	.1314835	1.13	0.265	-.1160281	.4124239
d15	.1211289	.1314754	0.92	0.361	-.1430808	.3853386
d16	.1077579	.1329625	0.81	0.422	-.1594402	.374956
d17	.0838694	.1353912	0.62	0.538	-.1882094	.3559481
lpreal	-.9112639	.1974258	-4.62	0.000	-1.308006	-.5145219
lpricesub	.240897	.2583001	0.93	0.356	-.2781764	.7599705
lpopul	-.429696	.1355902	-3.17	0.003	-.7021747	-.1572172
lpcpdireal	-.1573025	.2278561	-0.69	0.493	-.6151965	.3005915
totfundrealhat	.0037525	.0006214	6.04	0.000	.0025037	.0050012
timefundhat	-.0004424	.000069	-6.41	0.000	-.0005811	-.0003037
pcgr	-.0057325	.0033042	-1.73	0.089	-.0123725	.0009075
pcnt1524	-.0156382	.0121819	-1.28	0.205	-.0401186	.0088422
pcnt25	.0060673	.0027173	2.23	0.030	.0006066	.011528
unemprate	-.0037102	.0124421	-0.30	0.767	-.0287136	.0212932
_cons	7.279982	2.349451	3.10	0.003	2.558583	12.00138
sigma_u	.45535708					
sigma_e	.08883782					
rho	.9633336	(fraction of variance due to u_i)				

```
. xtreg lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 lpreal lpricesub lpopul lpcpdireal
> totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, re robust

Random-effects GLS regression                 Number of obs     =        850
Group variable: state1                        Number of groups  =         50

R-squared:                                    Obs per group:
     Within  = 0.7711                                       min =         17
     Between = 0.5663                                       avg =       17.0
     Overall = 0.5982                                       max =         17

                                              Wald chi2(26)     =    1463.64
corr(u_i, X) = 0 (assumed)                    Prob > chi2       =     0.0000
```

(Std. err. adjusted for 50 clusters in **state1**)

lqpc	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]

d2	.0138427	.0152642	0.91	0.364	-.0160745	.0437599
d3	-.0265143	.0098857	-2.68	0.007	-.0458899	-.0071387
d4	-.0972243	.0179562	-5.41	0.000	-.1324178	-.0620309
d5	-.0790339	.0210176	-3.76	0.000	-.1202277	-.0378402
d6	-.0808701	.0247951	-3.26	0.001	-.1294675	-.0322727
d7	-.0729102	.0275144	-2.65	0.008	-.1268374	-.0189829
d8	-.0421069	.0307113	-1.37	0.170	-.1022998	.0180861
d9	.0354946	.045996	0.77	0.440	-.0546559	.1256451
d10	.1068975	.0784906	1.36	0.173	-.0469413	.2607362
d11	.1003809	.0841355	1.19	0.233	-.0645217	.2652835
d12	.1388136	.0964953	1.44	0.150	-.0503137	.3279409
d13	.1336396	.1049345	1.27	0.203	-.0720281	.3393074
d14	.082863	.1039406	0.80	0.425	-.1208567	.2865827
d15	.0502931	.1027068	0.49	0.624	-.1510085	.2515947
d16	.0327123	.1030396	0.32	0.751	-.1692416	.2346663
d17	.0026744	.1043568	0.03	0.980	-.2018611	.2072099
lpreal	-.9153558	.1930471	-4.74	0.000	-1.293721	-.5369904
lpricesub	.2487038	.2512691	0.99	0.322	-.2437747	.7411822
lpopul	-.0670995	.0258621	-2.59	0.009	-.1177882	-.0164107
lpcpdireal	-.1528424	.1859739	-0.82	0.411	-.5173447	.2116598
totfundrealhat	.0035796	.0006353	5.63	0.000	.0023344	.0048247
timefundhat	-.000429	.0000719	-5.97	0.000	-.00057	-.0002881
pcgr	-.0064743	.0030243	-2.14	0.032	-.0124019	-.0005468
pcnt1524	-.0172492	.0105307	-1.64	0.101	-.0378891	.0033906
pcnt25	.0124219	.0019576	6.35	0.000	.0085851	.0162587
unemprate	-.0029862	.0121312	-0.25	0.806	-.026763	.0207906
_cons	6.452937	1.911201	3.38	0.001	2.707053	10.19882

sigma_u	.15932571	
sigma_e	.08883782	
rho	.76283331	(fraction of variance due to u_i)

```
. regress lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 ltottaxreal ltaxsub lpopul lpcpdi
> real totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, robust
```

Linear regression

Number of obs	=	850
F(26, 823)	=	101.55
Prob > F	=	0.0000
R-squared	=	0.7169
Root MSE	=	.18522

lqpc	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
d2	-.0252654	.029936	-0.84	0.399	-.0840253	.0334945
d3	-.0405346	.0292033	-1.39	0.166	-.0978563	.0167872
d4	-.0341588	.031603	-1.08	0.280	-.0961909	.0278732
d5	-.0071522	.0319658	-0.22	0.823	-.0698963	.0555918
d6	-.0269201	.0320307	-0.84	0.401	-.0897917	.0359515
d7	-.0403535	.0331444	-1.22	0.224	-.105411	.024704
d8	-.0420835	.0373499	-1.13	0.260	-.1153958	.0312288
d9	-.0584153	.0384429	-1.52	0.129	-.1338729	.0170423
d10	-.0788519	.040125	-1.97	0.050	-.1576112	-.0000926
d11	-.0892345	.0410582	-2.17	0.030	-.1698256	-.0086433

d12	-.0620732	.0420394	-1.48	0.140	-.1445902	.0204438
d13	-.0393337	.0448706	-0.88	0.381	-.127408	.0487406
d14	-.0686758	.047625	-1.44	0.150	-.1621565	.024805
d15	-.0870663	.0476833	-1.83	0.068	-.1806615	.0065289
d16	-.1007371	.0503159	-2.00	0.046	-.1994997	-.0019745
d17	-.1526907	.0491092	-3.11	0.002	-.2490847	-.0562966
ltottaxreal	-.5694809	.0291519	-19.53	0.000	-.6267018	-.5122601
ltaxsub	.1784308	.0458446	3.89	0.000	.0884447	.2684169
lpopul	-.0365868	.0076541	-4.78	0.000	-.0516107	-.0215629
lpcpdireal	.2404433	.098193	2.45	0.015	.047705	.4331815
totfundrealhat	.0002729	.0006369	0.43	0.668	-.0009772	.0015231
timefundhat	-.0002556	.0000909	-2.81	0.005	-.0004341	-.0000771
pcgr	-.0221352	.0021083	-10.50	0.000	-.0262734	-.0179969
pcnt1524	-.0365387	.0170922	-2.14	0.033	-.0700882	-.0029892
pcnt25	.0289421	.0082813	3.49	0.000	.0126872	.045197
unemprate	.0004518	.0057868	0.08	0.938	-.0109069	.0118104
_cons	1.1662	1.298621	0.90	0.369	-1.382799	3.7152

```
. xtreg lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 ltottaxreal ltaxsub lpopul lpcpdire
> al totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, fe robust

Fixed-effects (within) regression               Number of obs     =        850
Group variable: state1                          Number of groups  =         50


R-squared:                                      Obs per group:
     Within  = 0.8107                                         min =         17
     Between = 0.1819                                         avg =       17.0
     Overall = 0.2630                                         max =         17

                                                F(26, 49)         =     131.32
corr(u_i, Xb) = -0.6760                         Prob > F          =     0.0000

                                  (Std. err. adjusted for 50 clusters in state1)
```

lqpc	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
d2	-.0076747	.0118463	-0.65	0.520	-.0314808	.0161314
d3	-.0228945	.0109608	-2.09	0.042	-.044921	-.0008681
d4	-.0242013	.0176068	-1.37	0.176	-.0595836	.0111809
d5	-.0084686	.0190285	-0.45	0.658	-.0467079	.0297707
d6	-.0174485	.0209233	-0.83	0.408	-.0594955	.0245984
d7	-.023917	.0231911	-1.03	0.307	-.0705212	.0226872
d8	-.0280585	.0252872	-1.11	0.273	-.078875	.022758
d9	-.0539558	.0293266	-1.84	0.072	-.1128899	.0049782
d10	-.0712568	.0335511	-2.12	0.039	-.1386803	-.0038333
d11	-.0749262	.0389803	-1.92	0.060	-.15326	.0034077
d12	-.0526986	.0485352	-1.09	0.283	-.1502339	.0448366
d13	-.0435526	.0618794	-0.70	0.485	-.1679039	.0807987
d14	-.0732268	.0645374	-1.13	0.262	-.2029196	.0564659
d15	-.0859312	.068586	-1.25	0.216	-.2237599	.0518975
d16	-.0888984	.0722969	-1.23	0.225	-.2341846	.0563877

d17	-.1178282	.0748522	-1.57	0.122	-.2682494	.0325929
ltottaxreal	-.4183044	.0491275	-8.51	0.000	-.5170297	-.319579
ltaxsub	.1441635	.1143438	1.26	0.213	-.085619	.3739459
lpopul	-.3563724	.1287501	-2.77	0.008	-.6151054	-.0976394
lpcpdireal	-.1219102	.2028316	-0.60	0.551	-.5295155	.2856951
totfundrealhat	.0026458	.000453	5.84	0.000	.0017355	.0035561
timefundhat	-.0003578	.0000728	-4.92	0.000	-.0005041	-.0002115
pcgr	-.0067532	.003082	-2.19	0.033	-.0129468	-.0005597
pcnt1524	-.0109377	.0110293	-0.99	0.326	-.033102	.0112266
pcnt25	.009543	.0024433	3.91	0.000	.0046331	.014453
unemprate	-.007539	.0126645	-0.60	0.554	-.0329892	.0179112
_cons	5.843831	2.130235	2.74	0.008	1.562963	10.1247
sigma_u	.38852296					
sigma_e	.08208388					
rho	.95727151	(fraction of variance due to u_i)				

```
. xtreg lqpc d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 ltottaxreal ltaxsub lpopul lpcpdire
> al totfundrealhat timefundhat pcgr pcnt1524 pcnt25 unemprate, re robust

Random-effects GLS regression                   Number of obs     =        850
Group variable: state1                          Number of groups  =         50

R-squared:                                      Obs per group:
     Within  = 0.8061                                         min =         17
     Between = 0.5777                                         avg =       17.0
     Overall = 0.6275                                         max =         17
```

```
                                              Wald chi2(26)    =    2870.91
corr(u_i, X) = 0 (assumed)                    Prob > chi2      =     0.0000

                              (Std. err. adjusted for 50 clusters in state1)
```

lqpc	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
d2	-.0121829	.0106639	-1.14	0.253	-.0330838	.0087179
d3	-.0311253	.0086716	-3.59	0.000	-.0481213	-.0141293
d4	-.0357956	.0156248	-2.29	0.022	-.0664197	-.0051714
d5	-.0237012	.0176436	-1.34	0.179	-.058282	.0108796
d6	-.0369571	.0179394	-2.06	0.039	-.0721176	-.0017965
d7	-.0465376	.0197849	-2.35	0.019	-.0853153	-.0077599
d8	-.0526531	.0226681	-2.32	0.020	-.0970817	-.0082245
d9	-.0806088	.026337	-3.06	0.002	-.1322283	-.0289893
d10	-.1063702	.0292067	-3.64	0.000	-.1636143	-.049126
d11	-.1155791	.0319045	-3.62	0.000	-.1781107	-.0530475
d12	-.0966689	.0404901	-2.39	0.017	-.176028	-.0173098
d13	-.0887899	.0523471	-1.70	0.090	-.1913883	.0138086
d14	-.1221526	.0558104	-2.19	0.029	-.2315389	-.0127664
d15	-.1389708	.0587049	-2.37	0.018	-.2540304	-.0239112
d16	-.1451471	.0620266	-2.34	0.019	-.266717	-.0235771
d17	-.1787459	.0639334	-2.80	0.005	-.304053	-.0534388
ltottaxreal	-.4205687	.049383	-8.52	0.000	-.5173577	-.3237798
ltaxsub	.139296	.1134822	1.23	0.220	-.0831251	.3617171
lpopul	-.0669391	.0257074	-2.60	0.009	-.1173246	-.0165535
lpcpdireal	-.1138533	.1820897	-0.63	0.532	-.4707426	.243036
totfundrealhat	.0025189	.0004585	5.49	0.000	.0016202	.0034176
timefundhat	-.000346	.0000757	-4.57	0.000	-.0004944	-.0001976
pcgr	-.0071238	.0030308	-2.35	0.019	-.013064	-.0011836
pcnt1524	-.0120981	.0099603	-1.21	0.225	-.03162	.0074237
pcnt25	.0144801	.0020337	7.12	0.000	.0104942	.018466
unemprate	-.0070747	.0123477	-0.57	0.567	-.0312757	.0171264
_cons	5.140241	1.866945	2.75	0.006	1.481096	8.799386
sigma_u	.1719725					
sigma_e	.08208388					
rho	.81444957	(fraction of variance due to u_i)				

.

. sum qpc if year==1991

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	99.9635	21.05541	52.48482	169.1395

. sum qpc if year==1992

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	97.44765	21.37079	50.00322	164.4944

. sum qpc if year==1993

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	95.20128	21.33246	50.53775	162.9887

. sum qpc if year==1994

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	93.94424	22.30474	42.84851	164.8089

. sum qpc if year==1995

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	95.19581	24.37534	45.74372	172.6478

. sum qpc if year==1996

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	93.44806	24.71376	51.58582	177.1943

. sum qpc if year==1997

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	93.44863	27.05952	48.85136	185.6792

. sum qpc if year==1998

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	91.43396	27.16776	35.28012	170.2615

. sum qpc if year==1999

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	88.23525	26.90126	32.56018	167.6749

```
. sum qpc if year==2000
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	83.40345	25.55514	32.9999	154.1366

```
. sum qpc if year==2001
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	80.82464	24.85774	37.29292	151.6631

```
. sum qpc if year==2002
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	79.14517	23.91169	35.29487	140.7355

```
. sum qpc if year==2003
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	77.03059	30.67739	33.7342	179.3778

```
. sum qpc if year==2004
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	72.80522	30.75924	33.03384	173.4256

```
. sum qpc if year==2005
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	71.48799	31.21384	32.42856	180.4522

```
. sum qpc if year==2006
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	69.94525	29.75866	32.20938	182.1569

```
. sum qpc if year==2007
```

Variable	Obs	Mean	Std. dev.	Min	Max
qpc	50	68.49615	30.86138	31.39841	183.4207

```
.
```

SIMULATION: DATA FOR ESTIMATING THE BENEFIT-COST RATIOS

Per-capita Quantity by Year (Predicted: tax-based regression)

t	OLS	FE	RE
0	-0.02729	-0.264580	-0.25189
1	-0.00173	-0.228800	-0.21729
2	0.02383	-0.193020	-0.18269
3	0.04939	-0.157240	-0.14809
4	0.07495	-0.121460	-0.11349
5	0.10051	-0.085680	-0.07889
6	0.12607	-0.049900	-0.04429
7	0.15163	-0.014120	-0.00969
8	0.17719	0.021660	0.02491
9	0.20275	0.057440	0.05951
10	0.22831	0.093220	0.09411
11	0.25387	0.129000	0.12871
12	0.27943	0.164780	0.16331
13	0.30499	0.200560	0.19791
14	0.33055	0.236340	0.23251
15	0.35611	0.272120	0.26711
16	0.38167	0.307900	0.30171
17	0.40723	0.343680	0.33631

Figure 2: Control funding effect size over time

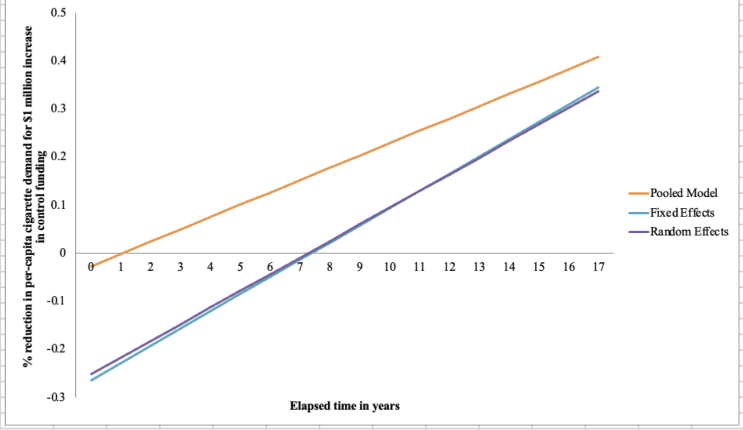
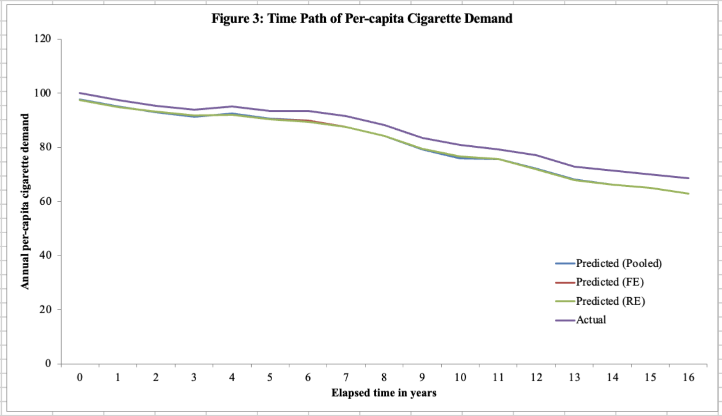


Figure-3: Graph Showing Predicted Average Per Capita and Actual Cigarette Demand

Per-capita Quantity by Year (Predicted: tax-based regression)

	t	Predicted (F	Predicted (F	Predicted (F	Actual
1991	0	97.733227	97.477114	97.490932	99.9635
1992	1	95.133965	94.857638	94.871763	97.44765
1993	2	92.867645	93.08175	93.071668	95.20128
1994	3	91.233538	91.680846	91.661131	93.94424
1995	4	92.358508	91.906517	91.924952	95.19581
1996	5	90.540679	90.306005	90.314673	93.44806
1997	6	89.985258	89.899249	89.288931	93.44863
1998	7	87.585984	87.453869	87.457512	91.43396
1999	8	84.075944	84.212319	84.209561	88.23525
2000	9	79.271124	79.456353	79.453797	83.40345
2001	10	75.888188	76.617612	76.612868	80.82464
2002	11	75.587232	75.615437	75.615274	79.14517
2003	12	72.016209	71.963279	71.962684	77.03059
2004	13	68.10072	67.883723	67.878287	72.80522
2005	14	66.236966	66.175397	66.172958	71.48799
2006	15	64.991273	64.933308	64.929916	69.94525
2007	16	62.845725	62.846349	62.846458	68.49615

Figure 3: Time Path of Per-capita Cigarette Demand



SIMULATION: DATA FOR ESTIMATING THE BENEFIT-COST RATIOS

Per-capita Quantity by Year (Predicted: tax-based regression)

		OLS	FE	RE		
Year	t	avgqpc	avgqpc	avgqpc	Actual	
1991	0	97.733227	97.477114	97.490932		1991
1992	1	95.133965	94.857638	94.871763		1992
1993	2	92.867645	93.08175	93.071668		1993
1994	3	91.233538	91.680846	91.661131		1994
1995	4	92.358508	91.906517	91.924952		1995
1996	5	90.540679	90.306005	90.314673		1996
1997	6	89.985258	89.899249	89.288931		1997
1998	7	87.585984	87.453869	87.457512		1998
1999	8	84.075944	84.212319	84.209561		1999
2000	9	79.271124	79.456353	79.453797		2000
2001	10	75.888188	76.617612	76.612868		2001
2002	11	75.587232	75.615437	75.615274		2002
2003	12	72.016209	71.963279	71.962684		2003
2004	13	68.10072	67.883723	67.878287		2004
2005	14	66.236966	66.175397	66.172958		2005
2006	15	64.991273	64.933308	64.929916		2006
2007	16	62.845725	62.846349	62.846458		2007

Medical cost per pack (2004):	**5.31**
productivity cost per pack (2004):	**5.16**
Medicaid cost per pack (2004):	**1.63**
Total cost per pack (2004):	**12.1**
Medical cost per pack (2008):	**6.0521913**
Productivity cost per pack (2008):	**5.8812254**
Medicaid cost per pack (2008):	**1.857829**
Total cost per pack (2008):	**13.791246**

	Avg. fund in 2007	Predicted per-capita cigarette 2007	Additional per-capita funding 2008	Predicted per-capita cigarette 2008	Per-capita pack reduction 2008	Avg State population	Avg # pack reduction	Medical cost avoided	Prod. Cost avoided	Medicaid cost avoided	Total cost avoided		B/C
	13.88656	62.845725	1	62.606318	0.2394061	**5,961,955**	1427328.577	8638465.55	8394441.1	2651732.36	19684639	$19.7m	19.684639
	13.88656	62.845725	10	60.492289	2.3534353	**5,961,955**	14031076.24	84918757.1	82519922.1	26067339.7	193506018.9	$194m	19.350602
OLS (Final): tax based	13.88656	62.845725	20	58.226985	4.6187396	**5,961,955**	27536719.28	166657492	161949653	51158514.5	379765659.5	$380m	18.988283
	13.88656	62.845725	50	51.927468	10.918256	**5,961,955**	65094155.89	393962282	382833404	120933808	897729493.1	$898m	17.95459
	13.88656	62.845725	59.832	50.014958	12.830767	**5,961,955**	76496460.13	462971208	449892925	142117339	1054981472	$1.05b	17.632395

	Avg. fund in 2007	Predicted per-capita cigarette 2007	Additional per-capita funding 2008	Predicted per-capita cigarette 2008	Per-capita pack reduction 2008	Avg State population	Avg # pack reduction	Medical cost avoided	Prod. Cost avoided	Medicaid cost avoided	Total cost avoided		B/C
	13.88656	62.846349	1	62.6531	0.1932063	**5,961,955**	1151887.435	6971443.07	6774509.65	2140009.83	15885962.55		15.885963
	13.88656	62.846349	10	60.9408	1.9055526	**5,961,955**	11360819.43	68757852.1	66815539.9	21106459.3	156679851.3		15.667985
FE (Final): tax based	13.88656	62.846349	20	59.093	3.7533272	**5,961,955**	22377169.54	135430910	131605178	41572953.6	308609041.7		15.430452
	13.88656	62.846349	50	53.8791	8.9672386	**5,961,955**	53462276.08	323563920	314423697	99323764.6	737311381.5		14.746228
	13.88656	62.846349	59.832	52.2725	10.573865	**5,961,955**	63040911.51	381535654	370757811	117119231	869412695.6		14.530898

	Avg. fund in 2007	Predicted per-capita cigarette 2007	Additional per-capita funding 2008	Predicted per-capita cigarette 2008	Per-capita pack reduction 2008	Avg State population	Avg # pack reduction	Medical cost avoided	Prod. Cost avoided	Medicaid cost avoided	Total cost avoided		B/C
	13.88656	62.846458	1	62.65713	0.1893283	**5,961,955**	1128766.844	6831512.83	6638532.24	2097055.73	15567100.8		15.567101
	13.88656	62.846458	10	60.978637	1.8678218	**5,961,955**	11135870.12	67396415.9	65492562.3	20688542	153577520.1		15.357752
RE (Final): tax based	13.88656	62.846458	20	59.166327	3.6801312	**5,961,955**	21940777.74	132789783	129038660	40762212.2	302590655.2		15.129533
	13.88656	62.846458	50	54.046219	8.8002396	**5,961,955**	52466635.98	317538116	308568113	97474035.6	723580264.3		14.471605
	13.88656	62.846458	59.832	52.466531	10.379928	**5,961,955**	61884665.55	374537832	363957668	114971124	853466623.6		14.264384