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# Effect of the Arizona tobacco control program on cigarette consumption and healthcare expenditures

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ABSTRACT

This research investigates the relationship between per capita tobacco control expenditures, cigarette consumption, and healthcare expenditures in the state of Arizona. Arizona's tobacco control program, which was established in 1994, concentrates on youth uptake of smoking and avoids public policy and commentary on the tobacco industry. We use a cointegrating time series analysis using aggregate data on healthcare and tobacco control expenditures, cigarette consumption and prices and other data. We find there is a strong association between per capita healthcare expenditure and per capita cigarette consumption. In the long run, a marginal increase in annual cigarette consumption of one pack per capita increases per capita healthcare expenditure by $19.5 (SE $5.45) in Arizona. A cumulative increase of $1.00 in the difference between control state and Arizona per capita tobacco control expenditures increases the difference in cigarette consumption by 0.190 (SE 0.0780) packs per capita. Between 1996 and 2004, Arizona's tobacco control program was associated with a cumulative reduction in cigarette consumption of 200 million packs (95% CI 39.0 million packs, 364 million packs) worth $500 million (95% CI: $99 million, $896 million) in pre-tax cigarette sales to the tobacco industry. The cumulative healthcare savings was $2.33 billion (95% CI $0.37 billion, $5.00 billion) and the cumulative reduction in cigarette. Arizona's tobacco control expenditures are associated with reduced cigarette consumption and healthcare expenditures, amounting to about 10 times the cost of the program through 2004. This return on investment, while large, was less than the more aggressive California program, which did not limit its focus to youth and included tobacco industry denomalization messages.



## Introduction

Large scale tobacco control programs reduce cigarette consumption (Institute of Medicine, 2007) and tobacco-induced heart disease (Fichtenberg & Glantz, 2000) and cancer (Barnoya & Glantz, 2004; Centers for Disease Control and Prevention, 2007a; Jemal, Cokkinides, et al., 2003). Rapidly increasing healthcare expenditures are a major problem in the United States and around the world. The California Tobacco Control Program was created in 1988 by voter initiative and implemented beginning in 1989 (Glantz & Balbach, 2000) and has been associated with significant reductions in smoking and direct healthcare expenditures, which, over the first 15 years of the program, totaled approximately 50 times what the program cost (Lightwood, Dinno, et al., 2008). Arizona voters established its tobacco control program in 1994, with implementation beginning in 1996 (Bialous & Glantz, 1999; Hendlin, Barnes, et al., 2008). There are substantial differences between the two programs. The California program focuses on adults, reinforces the nonsmoking norm, emphasizes policy change, and uses media focused on secondhand smoke and the manipulative behavior of the tobacco industry (Tobacco Control Section, 1998). The Arizona program concentrates on youth uptake of smoking and avoids public policy and commentary on the tobacco industry. This paper applies and extends our earlier California model (Lightwood, Dinno, et al., 2008) to Arizona to estimate the associations between per capita state tobacco control expenditures, cigarette consumption and healthcare expenditures in Arizona and compares the results to California.

## Methods

### Model

Classical time series regression techniques are not be appropriate for analysis of the relationship between aggregate tobacco control expenditures and healthcare costs because these classical techniques require that the parameters describing the underlying

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processes remain constant over time (ie, the processes are "stationary"). The underlying processes that determine state expenditures on tobacco control programs, smoking behavior, and healthcare costs change with time as does the tobacco industry's promotional efforts, medical technology, costs and the population (i.e., are "nonstationary"). In recent years economists have developed an approach called cointegrating regressions that, if specified mathematical conditions are met, provide consistent and reliable estimates of the relationships between two or more nonstationary processes (Burke & Hunter, 2005; Enders, 2004; Engle & Granger, 1987; Greene, 2000; Maddala & Kim, 1998). The conclusion that these processes are nonstationary comes from strong evidence that the data evolve over time in a way similar to random walks.

The cointegrating regression describes the long run equilibrium statistical relationship between the variables. The stationary residuals describe departures of the observations from the long run equilibrium relationship (Burke & Hunter, 2005; Enders, 2004; Engle & Granger, 1987; Greene, 2000; Maddala & Kim, 1998). A well-specified and identified structural model is required for economic interpretation when a cointegrating regression involves more than two variables (Hsiao, 2001, 2006).

Each cointegrating regression must be accompanied by an error, or equilibrium, correction model (ECM) that describes the dynamic short run relationship between the variables. An ECM describes the behavior of the first difference of the dependent variables in the cointegrating regression as a function of the lagged cointegrating regression residual and lagged first differences of the variables in the cointegrating regression. An ECM corresponding to a cointegrating regression exists if the coefficient of the lagged cointegrating regression residual (the "error correction term") is statistically significant. The error correction term measures the rate at which the cointegrating relationship moves toward long run equilibrium (Burke & Hunter, 2005; Enders, 2004; Engle & Granger, 1987; Greene, 2000; Maddala & Kim, 1998).

We developed a system of two cointegrating regressions that describes the relationship between tobacco control program expenditures and healthcare costs that meet these mathematical conditions:

- The first cointegrating regression equation describes annual per capita healthcare expenditures in Arizona modeled as a function of corresponding heath care expenditures in 38 control states that did not have substantial tobacco control programs and the difference in annual per capita cigarette consumption between Arizona and the control states, controlled for per capita personal income and population age structure. This specification controlled for common national trends in per capita healthcare expenditures and smoking over time (e.g., trends in medical practice, insurance status, access to care, medical cost inflation, and demographic changes).
- The second cointegrating regression equation describes the difference between Arizona and control states' per capita cigarette consumption modeled as a function of the difference in cumulative per capita Arizona and control states' tobacco control expenditures and cigarette prices.

Thus, as in our California (Lightwood, Dinno, et al., 2008) study, two equation systems were estimated for the main results: 1) a cointegrating and ECM regression for real per capita healthcare expenditures as a function of the level of cigarette smoking and other variables, and 2) a similar system for per capita cigarette consumption as a function of cumulative state tobacco control education expenditures and other variables. Both the Arizona and California analyses use the same 38 control states that did not have substantial tobacco control programs or tobacco tax increases of 50 cents per pack or more over the sample period (Alabama, Arkansas, Colorado, Connecticut, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Wisconsin and Wyoming) (Abadie, Diamond, et al., 2007).

The model used for Arizona has the same structure as for California, with the addition of the proportion of the population that was elderly (≥65 years old) and per capita personal income. (These two variables were explored in our sensitivity analysis of the California model, but were not statistically significant in that model and their presence or absence did not affect the results (Lightwood, Dinno, et al., 2008).) Annual per capita all-payer total healthcare expenditures in Arizona is modeled as a function of corresponding healthcare expenditures in the control states and the difference in annual per capita cigarette consumption between Arizona and the control states:

$$h_{AZ,t} = \alpha_0 + \alpha_1 h_{c,t} + \alpha_2 (s_{c,t} - s_{AZ,t}) + \alpha_3 (A_{c,t} - A_{AZ,t}) + \alpha_4 \left(y_{c,t} - y_{AZ,t}\right) + v_{1.t} \quad (1)$$

where

$h_{i,t}$ = per capita real total all-payer direct healthcare expenditures in $i$ (Arizona = AZ; control states = c) in year $t$ in 2004 dollars,

$s_{i,t}$ = per capita cigarette consumption in $i$, in year $t$,

$A_{i,t}$ = proportion of elderly (age ≥ 65) in the population $i$, in year $t$,

$y_{i,t}$ = real per capita income in $i$ in year $t$ in 2004 dollars,

$t$ = year ($t_0$ = 1975),

$v_{1,t}$ = stationary regression residuals, in year $t$.

Per capita healthcare expenditure in the control states controls for common time trends in healthcare expenditures in both populations, such as technological progress, changes in standards of and access to care, and insurance coverage. The additional explanatory variables model determinants of healthcare expenditures that do not follow a common time trend in the two populations: the difference in per capita cigarette consumption, $(s_{c,t} - s_{AZ,t})$, difference in real per capita income, $(y_{c,t} - y_{AZ,t})$, and difference in proportion of the population that is elderly, $(A_{c,t} - A_{AZ,t})$, between the control states and Arizona. These variables are expressed as differences, but this specification is not necessary for structural interpretation of the coefficients and the use of differences between control and intervention populations as explanatory variables should be considered restrictions that indicate the control state and Arizona variables have the approximately the same effect on healthcare costs. The coefficient of interest is $\alpha_2$, which measures the effect of differences in the level of per capita cigarette consumption between Arizona and control states on per capita healthcare expenditures in Arizona.

The cointegrating regression for the difference between per capita cigarette consumption (demand) in Arizona and the 38 control states is:

$$(s_{c,t} - s_{AZ,t}) = \beta_0 + \beta_1 (E_{AZ,t} - E_{c,t}) + \beta_2 \left(p_{c,t} - p_{AZ,t}\right) + \beta_3 y_{AZ,t} + \beta_4 (t - t_0) + v_{2.t} \quad (2)$$

where

$E_{i,t}$ = per capita real cumulative tobacco control education expenditures in $i$ (Arizona = AZ or control states = c) in year $t$ in 2004 dollars,

$p_{i,t}$ = real price of cigarette per pack in $i$, in year $t$ in 2004 dollars,

$v_{2,t}$ = a stationary regression residuals, in year $t$.

The difference between per capita cigarette consumption in Arizona and the 38 control states, $(s_{c,t} - s_{AZ,t})$, is a function of the differences in cumulative per capita tobacco control expenditures,