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Cigarette pack prices and sales following policy changes in California, 2011-2018

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Abstract

Objective: To estimate the combined effect of California's Tobacco-21 law (enacted June 2016) and $2-per-pack cigarette excise tax increase (enacted April 2017) on cigarette prices and sales, compared with matched comparator states.

Methods: We used synthetic control methods to compare cigarette prices and sales after the policies were enacted, relative to what we would have expected without the policy reforms. To estimate the counterfactual, we matched pre-reform covariates and outcome trends between California and control states to construct a "synthetic" California.

Results: Compared with the synthetic control in 2018, cigarette prices in California were $1.89 higher ($7.86 versus $5.97, $p<0.01$), and cigarette sales were 16.6% lower (19.9 versus 16.6 packs per capita, $p<0.01$). This reduction in sales equates to 153.9 million fewer packs being sold between 2017-2018.

Conclusions: California's new cigarette tax was largely passed on to consumers. The new cigarette tax, combined with the Tobacco-21 law, have contributed to a rapid and substantial reduction in cigarette consumption in California.

Introduction

California has been a national leader in tobacco control since the California Tobacco Control Program was established in 1989. As a result, cigarette pack sales per capita have declined 80% across the state over the past 30 years.[1] Despite this, there were still approximately 3.3 million adult smokers residing in California in 2016.[2]

A 2015 report by the National Academy of Medicine concluded that restricting tobacco sales to those ≥21 years-old would effectively reduce youth and young adult smoking and have a substantial positive impact on future population-level smoking rates.[3] Consequently, in June 2016, California enacted a Tobacco-21 (T21) law.

Shortly afterwards, in April 2017, California enacted a voter-approved tax increase of $2 per pack of cigarettes and an equivalent amount on e-cigarettes and other tobacco products (Proposition 56). In addition to higher pack prices being a disincentive for current and potential smokers, the tax revenues fund tobacco-related law enforcement and medical treatment.[4] However, not all tax initiatives are equally successful. Tax-induced price increases may be circumvented, for example, by introducing cheaper products or setting lower baseline prices for consumers who are most price-sensitive.[5]

Our aim was to evaluate the extent to which Proposition 56 has been passed on to smokers and the combined impact T21 and Proposition 56 have had on cigarette sales.

Methods

We used synthetic control methods to construct a control group that matched pre-reform covariates and outcomes in California. To create the counterfactual, we used longitudinal outcome and covariate data from a weighted combination of 30 comparison states that did not introduce a state-wide under-21 law or tobacco tax between 2011-2018. Supplementary Table 1 shows the excluded states and the reason for their exclusion.

Outcomes and Covariates

We compiled annual state-level data from 2011-2018 on cigarette pack prices (calculated as retail revenue divided by sales) and sales per capita from Orzechowski and Walker's *Tax Burden on Tobacco*.[1] Time-varying, state-level covariates evaluated in the development of our counterfactuals included (for 2011-2018 except as indicated): percentage aged <25

years,[6] percentage male,[6] percentage white race,[6] log-transformed income per capita (2011-2017),[6] over-18 cigarette smoking prevalence,[7] over-18 percentage who drink alcohol,[7] and tobacco control spending per capita (2011-2016).[8] Log-transformed cigarette pack price was also evaluated for the sales model.[1] All dollar values were inflated to 2018 dollars.

Statistical Analysis

We constructed our synthetic California groups as a weighted average of all available control states, with weights selected to find the best match (the minimum mean squared prediction error, or MSPE) to California in outcome and covariate trends prior to policy implementation (2011-2016). We estimated the cigarette pack price and sales separately. After calculating the weights, we compared California and synthetic California in 2017 and 2018. Given the proximity of T21 (June 2016) and Proposition 56 (April 2017) enactment, we assumed that their combined impact on cigarette sales started after 2016 so as our intervention time point aligned in our sales and price analyses. In a sensitivity analysis, however, we assumed their impact on sales started after 2015 to account for the possibility that T21 had an appreciable impact in the second half of 2016. In a further sensitivity analysis, we excluded New York from the donor pool because, even though New York did not enact a tax increase or T21 law during the study period, it implemented several important tobacco control policy and administrative changes during the study period.

We assessed statistical significance using a permutation-based test comparing the treated and synthetic control populations. Specifically, we estimated the "placebo" effect by assuming each state in the control pool had been treated instead of California. We calculated a p-value as the proportion of placebo effects at least as large as California's effect, standardized by how closely the control state resembles California.The estimated reduction in the number of cigarettes packs sold as a result of T21/Proposition 56 was calculated by multiplying the difference in cigarette sales per capita between California and its synthetic control by California's population size in 2017 and 2018 then summing across those years.

Statistical analyses were conducted with Stata 14 (Stata Corp., College Station, Texas) using the user-generated "synth" and "synth_runner" packages.

Results

The covariates and pre-reform outcome data used in our price analysis to construct synthetic California were percentage aged <25 years, log-transformed income per capita, percentage aged ≥18 years who drink alcohol, and cigarette pack price for 2011, 2013, 2014 and 2016. For our cigarette sales analysis, synthetic California was constructed using log-transformed cigarette pack price, percentage aged <25 years, log-transformed income per capita, and cigarette sales for 2011, 2013, and 2015. States with a non-zero weight contribution are listed in Supplementary Table 2. The MSPE was 0.0006 for our price model and 0.0115 for our sales model, indicating our synthetic control groups were an excellent fit for the pre-reform California data. The balance of our predictor variables are shown in Supplementary Tables 3 and 4.

Figure 1A compares average cigarette pack prices over time between California and synthetic California. Proposition 56 resulted in consumers paying $1.89 more for a pack of cigarettes in 2018 than they would have paid without this policy ($7.86 versus $5.97, standardized $p<0.01$). Our permutation tests indicated that none of the 30 potential control states had a price trend that diverged this much from their synthetic control (Supplementary Figure 1).

Figure 1B compares cigarette pack sales over time between California and synthetic California. The T21 and Proposition 56 laws reduced 2018 cigarette sales in California by 16.6% (19.9 versus 16.6 packs per capita, standardized $p<0.01$). This accounted for 61.1% of the total decline in sales between 2016 (22.0 packs per capita) and 2018 (16.6 packs per capita). Permutation testing indicated that none of the 30 potential control states had a sales trend that diverged this much from their synthetic control (Supplementary Figure 2). Based on these findings, we estimate that the policies resulted in 22.6 million and 131.3 million fewer packs of cigarettes being sold in 2017 and 2018, respectively.

In our sensitivity analysis assuming the intervention effect on cigarette sales started after 2015, our findings were very similar to the main model; a decline of 3.4 packs per capita (Supplementary Figure 3). When we excluded New York from the donor pool in our other sensitivity analysis, our price model was unchanged as New York did not contribute to the main analysis, and our sales model produced the same effect size as the main analysis; a decline of 3.3 packs per capita (Supplementary Figure 4).

Discussion

We estimated that 95% of the Proposition 56 cigarette tax was passed on to consumers. This builds upon a recent study of retail audit data which found over-shifting of Proposition 56 (i.e., greater than $2) for four major cigarette brands but under-shifting for several demographic groups and a significantly greater likelihood of stores offering discounts after implementation of the new tax.[9] The price increase we observed, in conjunction with the similarly timed T21 law, contributed to a reduction in cigarette pack sales in 2017 and 2018. This is consistent with a large prior literature on cigarette taxes,[4] and recent data on restricting tobacco sales to those ≥21 years-old.[10]

Abadie et al [11] used similar methods to ours to estimate the impact of a $0.51 ($0.25 in 1989 dollars) tax increase on cigarettes introduced in California in 1989. This equated to a 28% increase in retail price (assuming it was all passed on to consumers) and resulted in pack sales dropping by approximately 10% (9 packs per capita) in the first two years of the intervention. Abadie's estimates suggest a price elasticity of demand of -0.36, or a 10% increase in cigarette price producing a 3.6% decrease in cigarette consumption.. We found that Proposition 56 increased cigarette pack prices by 31.7% (from $5.97 to $7.86). If we assume that the T21 law contributed 2% to the reduction in cigarette sales we observed up to 2018, in line with national impact estimates,[12] then Proposition 56 resulted in a 14.6% decline in pack sales in the first two years. This equates to a price elasticity of demand of -0.46, or a 10% increase in cigarette price producing a 4.6% decrease in cigarette consumption. Ours and Abadie's price elasticities are consistent with other studies from the US, although estimates vary widely.[13] Encouragingly, this indicates that cigarette price increases in the modern era may still be an effective policy tool.

There are three main limitations to this study. First, we were not able to disaggregate our results by population sub-groups nor by individual policy. Further research should evaluate the extent to which youth, low-income earners, and minority groups have been impacted by T21 and Proposition 56. Second, the post-intervention period is short. Abadie et al [11] showed that cigarette sales were still in decline more than ten years after the 1989 tax increase in California suggesting our findings may be the beginning of a larger decline. Finally, we have assumed no residual confounding. Cigarette sales data are particularly vulnerable to changes in demand for other tobacco products and cigarette smuggling across jurisdictions. Importantly, synthetic control methods appear better able to account for time-

varying unobserved confounding than standard approaches.[14] Moreover, Proposition 56 applied to both cigarettes and e-cigarettes, and, in an assessment of California Department of Tax and Fee Administration monthly data we found no evidence that the number of cigarette packs or tobacco products seized or the dollar value of tobacco products seized changed following implementation of the Proposition 56 tax.

Public Health Implications

California's T21 law and Proposition 56 have reduced cigarette consumption and are likely to continue doing so for several years. Tobacco control initiatives should continue to consider age restrictions and tax increases to reduce the burden of tobacco-attributable illness.

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Contributor Statement

D. C. Boettiger conceived of the study design, planned and performed the data analyses, interpreted the findings, and prepared the initial draft of the article. J.S. White conceived of the study design, planned the data analyses, interpreted the findings, and critically revised the article. All authors approved the final version of the article and have agreed to be accountable for the accuracy and integrity of the work.

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None

Human Participant Protection

This study used deidentified public data sets, and ethical approval was not required.

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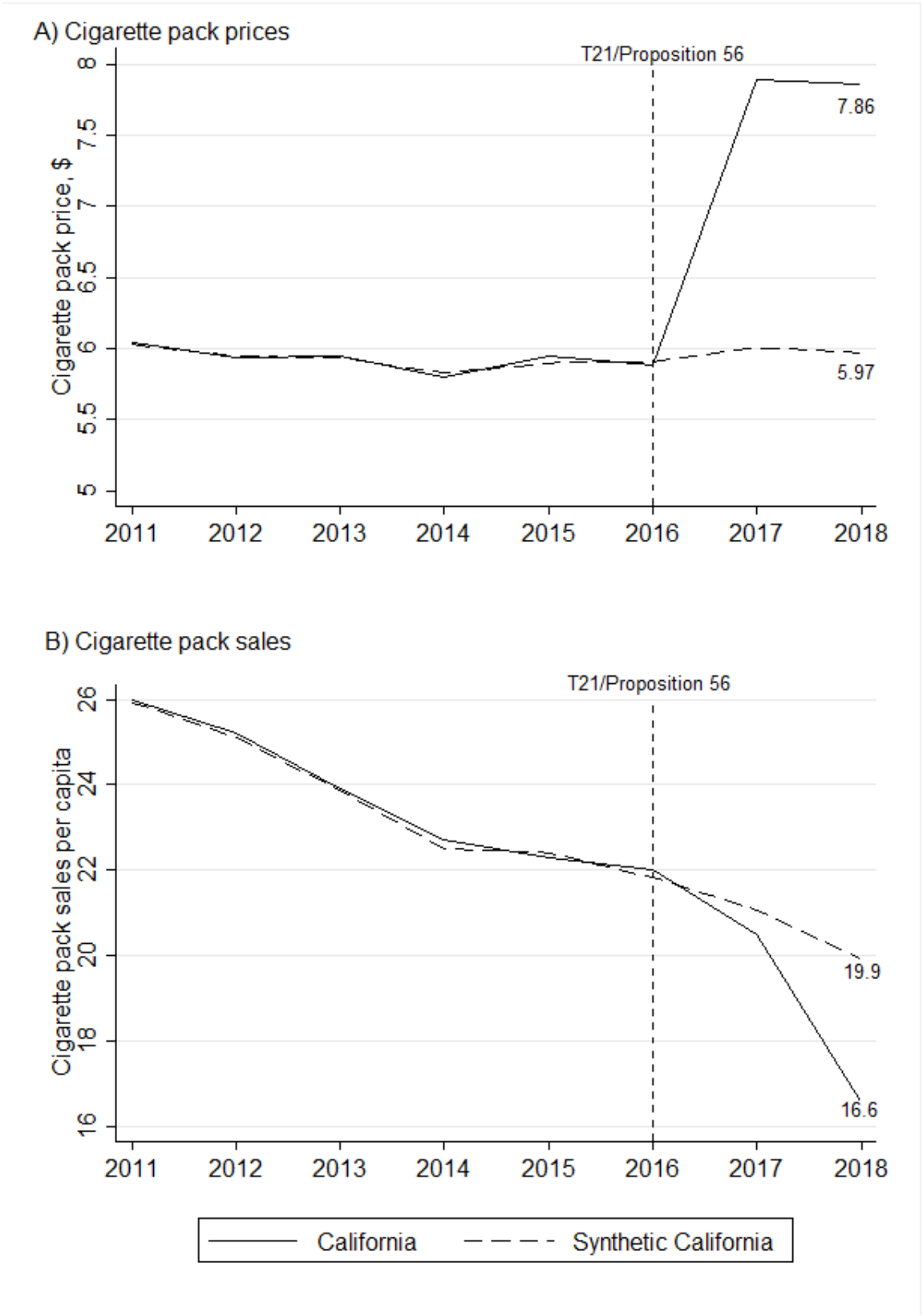
Figure 1. Annual cigarette prices and sales before and after implementation of T21/Proposition 56 for California and synthetic California



Note: Cigarette pack prices are in 2018 dollars. The vertical dashed line indicates when one of the policies was first implemented.