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The Impact of a Federal Cigarette Minimum Pack Price Policy on Cigarette Use in the U.S

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Abstract

Background—Increasing cigarette prices reduces cigarette use. The United States Food and Drug Administration has the authority to regulate the sale and promotion—and therefore the price—of tobacco products.

Objective—To examine the potential effect of federal minimum price regulation on the sales of cigarettes in the United States.

Method—We used yearly state level data from the Tax Burden on Tobacco and other sources to model per capita cigarette sales as a function of price. We used the fitted model to compare the status quo sales to counterfactual scenarios in which a federal minimum price was set. The minimum price scenarios ranged from $0 to $12.

Results—The estimated price effect in our model was comparable to that found in the literature. Our counterfactual analyses suggested that the impact of a minimum price requirement could range from a minimal effect at the $4 level, to a reduction of 5.7 billion packs sold per year and 10 million smokers at the $10 level.

Conclusion—A federal minimum price policy has the potential to greatly benefit tobacco control and public health by uniformly increasing the price of cigarettes and by eliminating many price reducing strategies currently available to both sellers and consumers.

Keywords

Price; Economics; Advertising and Promotion

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COMPETING INTERESTS

None to report

CONTRIBUTORSHIP STATEMENT

NJD devised the study with the support of MEW and MLB. NJD also retrieved, processed, and analyzed the data, formed an initial draft of the manuscript, and submitted the manuscript. MEW and MLB contributed to the interpretation and writing processes substantially with their extensive expertise in tobacco control and relevant legal matters.

INTRODUCTION

Price is a powerful tobacco control lever.[1] Excise taxation is a commonly used mechanism to increase tobacco prices, particularly for cigarettes.[2] When governments increase an excise tax on cigarettes or other tobacco products, the overall price generally increases.[3,4] Such an increase in price results in a decrease in use and corresponding health care cost savings.[5] Excise taxation also results in revenue for governments, which incentivizes governments to impose them. Thus, despite heavy lobbying against excise taxes by the tobacco industry, excise taxation is often politically feasible and there is evidence that it is supported by the public, especially if revenues are directed towards tobacco control.[6] To counteract increasing taxes, the tobacco industry has the flexibility to adjust what consumers pay for their products, [7–10] which can diminish the beneficial impact of excise taxes. The industry invests heavily in this approach; in 2009 the tobacco industry's spending on price discounts ($6.7 billion) exceeded the total marketing expenditures of the soda and fast food industries combined ($5.4 billion in 2009).[11,12] Tobacco companies have also targeted specific market segments with numerous discount brands, [10] which are disproportionately utilized by older and lower income consumers.[13,14] These strategies can be used to reduce the cigarette pack price by as much as one U.S. dollar per pack, facilitating continued product use by price sensitive consumers.[7–9] While these price reduction strategies can diminish the public health benefits of excise taxes, other consumer strategies such as border state shopping, Indian reservation (i.e., no-tax) shopping, and purchasing smuggled cigarettes can, in addition to reducing the health benefits of taxes, also act to divert and reduce tax revenues.[15–18]

Therefore, in addition to studying excise taxes, it is also valuable to consider alternative or supplemental approaches to manipulating the price of tobacco products to benefit public health.[19,20] Approaches proposed or implemented in other countries—and to a limited degree in the U.S.— include bans on price promotions, non-tax fees (e.g., to offset externalities imposed by tobacco use), and restrictions on tobacco industry profits (e.g., through capping manufacturers' prices).[19,21] The current study examined the effect on cigarette sales of another policy option—a mandatory federal retail *minimum price* for cigarettes. Although state minimum price laws have been examined in the U.S., there has been relatively little research considering the potential impact of a *federal* minimum price regulation in the U.S. Importantly, a federal minimum price is now a viable policy option in the U.S. due to the 2009 Family Smoking Prevention and Tobacco Control Act (TCA), which provided the Food and Drug Administration (FDA) with the authority to regulate retail tobacco sales. In addition to their ability to reduce tobacco use through increased prices, minimum price policies are promising in regard to their pro-equity effect when compared with tax policies that have a similar impact on average price paid by the consumer.[20]

A well designed mandatory federal minimum price can increase cigarette prices and limit industry and consumer flexibility of the final paid price. An effective minimum price policy should set a strict floor price above the market price that cannot be reduced with coupons, promotions, or brand switching. [19,22–27] The regulation should either adjust price consistently depending on pack size (e.g., a per-cigarette minimum price), or should define

fixed legal pack sizes and a minimum price for each. The minimum price should be tied to inflation to ensure the effectiveness of the policy does not diminish with time. A simple minimum price rule that applies to all cigarette brands would facilitate enforcement.

The TCA gives the FDA broad authority to "require restrictions on the sale and distribution of a tobacco product, including restrictions on access to, and the advertising and promotion of, the tobacco product" (FSPTCA, 906(d)). Although this section of the law does not specifically reference a minimum price, such a regulation would constitute a "restriction on the sale" of a tobacco product (i.e., the product could not be sold for less than a set price), and therefore would fall within the FDA's authority under this section. Likewise, because price reduction is a well-established form of promotion, setting a minimum price could also be seen as a "restriction on the … promotion of" a given tobacco product. Under this section of the law, the FDA can only issue a regulation if it finds that such a restriction would be a "regulation … appropriate for the protection of the public health," taking into account "the risks and benefits to the population as a whole," including possible impacts on tobacco use initiation and cessation (FSPTCA, 906(d)). Accordingly, research is needed to examine the public health implications of a national minimum price regulation.

Only one recent study has estimated the potential effect of a national, U.S. minimum price regulation, and the results showed considerable benefits of a $10 minimum floor price with a ban on promotions.[28] We build on this work and quantify the expected change in U.S. cigarette sales due to a minimum price regulation for an *array* of minimum prices. We accounted for the impact of tax avoidance and incorporated a price elasticity of demand that increases with price.[29] We report our estimates in terms of pack sales, provide quantitative bounds, and calculate the expected number of smokers who would quit as a measure of public health benefit from a minimum price regulation.

METHODS

Data

The Centers for Disease Control and Prevention (CDC) State Tobacco Activities Tracking and Evaluation (STATE) System compiled much of the data used in this study.[30] We analyzed data from 1996 to 2013, ensuring a current estimate of price effect and sufficient statistical power. We also used price data from the 2013–2014 National Adult Tobacco Survey (NATS) to incorporate within-state pack price variability into our analyses. The NATS is a cell phone survey of non-institutionalized U.S. residents 18 years of age and older designed to provide state (and nationally) representative estimates.[31]

Dependent variable—The dependent variable was the natural log of per capita tax paid cigarette sales for fiscal years ending June 30th. Sales data were available yearly and for each state from The Tax Burden on Tobacco.[32]

Independent variables—The key price-related independent variables included in the model were also drawn from the Tax Burden on Tobacco. *Pack price* was the average cost of a pack of cigarettes in a given state-year, and included generic brands. The Consumer Price Index was used to adjust pack price to 2013 dollars. To account for the effect of price

differences between adjacent states (i.e., via border state shopping behavior) we included *border state relative price difference,* calculated as the state's pack price minus the average of border states' pack price divided by the state's pack price (i.e., a percentage difference). Thus, relatively expensive states will have a proportionally positive value for *border state relative price difference.*

Covariates—Expendable income bears on the amount of tobacco that can be purchased and should therefore be controlled in the analysis. We included state-year *median income* drawn from the Census Bureau. We included four time-varying clean air restriction indicators for restaurants, bars, private workplaces, and government workplaces (restriction=1), which were supplied by the Office on Smoking and Health at the CDC.[30] We also included *tobacco control funding* in the model, a three-year moving sum (i.e., present year plus the previous two years) of per capita funding appropriations for tobacco control from state and federal agencies, sourced from The Health Policy Center at the University of Illinois at Chicago.

Like Yurekli and Zhang, [33] we controlled for long distance cigarette smuggling behavior between low and high price non-adjacent states. Two variables were calculated—*import opportunity* and *export opportunity.* The *import opportunity* variable for a state A is set to the price difference between state A and the least expensive state within a 1000 mile radius, state B, if state B had a lower average pack price than state A, and set to zero otherwise. The *export opportunity* variable is calculated the same, except the difference calculation is with the most expensive state within 1000 miles. We chose 1000 miles to match the distance considered by Yurekli and Zhang. [33]

Model

We built a log-linear model of per capita tax paid cigarette sales regressed on the key predictors *price* and *border state relative price difference,* as well as control covariates. The log-linear form of the model implies that the price elasticity of demand gets stronger as price rises, a model feature supported by the literature.[29,34,35] We also included state and year fixed effects to account for all but the within-state temporal variation in sales data, including unobserved state-specific effects on sales (e.g., a relatively positive sentiment regarding tobacco).

Various factors, including geography, enforcement, and near-border population size, could bear on the extent of border-state shopping in a given state.[16,36] We modeled this variation by allowing the *border state relative price difference* parameter to vary across states by using a random effect. This simple and parsimonious approach should improve the accuracy of the price effect over not modeling such variation at all, and therefore should improve our estimates of the expected change in sales in our minimum price scenarios discussed below. The dispersion of the varying border state price effect is characterized in the results as the *border state relative price difference variance component*, expressed in standard deviation units. No other parameters in the model were allowed to vary randomly across states.

Finally, because price is theoretically endogenous (i.e., price drives sales and sales drive price), we used an instrumental variables approach to further isolate the causal effect of price on sales. The World Bank Economics of Tobacco Toolkit [37] suggests the use of state cigarette excise tax as an instrument for price in economic models, which others have done. [15] While taxation has a strong effect on price, there is little theoretical reason to believe that sales drive taxation (though the possibility does exist[a]), and even less so after controlling for state-specific effects on sales. We instrument price with state-year cigarette excise tax from the Tax Burden on Tobacco corrected for inflation (to 2013 dollars) with the Consumer Price Index. We adjust for tax changes that occur in the middle of a fiscal year by calculating a weighted average of tax rates that were effective during the year, weighted on the number of weeks each was effective.[15]

We built the model using a Markov chain Monte Carlo sampling software known as Stan. [38] We reported parameter estimates and predicted quantities along with their 95% CI bounds.

Policy Analyses

Once the model was fit to data, we used it to make counterfactual statements about the expected cigarette pack sales under various national minimum prices ranging from $0 to $12. To ensure our counterfactual statements accounted for within-state price variability (e.g., due to generic brands and price promotions), we first estimated the *expected* state average cigarette prices under each minimum price scenario using individual cigarette pack price data from the NATS. For the baseline (no minimum price) scenario, we calculated the state-specific participant-weight-adjusted mean cigarette pack price and generated predictions of per capita cigarette packs sold in 2013. The state predictions were multiplied by state population sizes and summed to calculate total predicted packs sold nationally. For each minimum price scenario, we replaced individual level paid prices in the NATS data with the scenario-specific minimum price if they were below the minimum price. We then recalculated the state level mean prices, recalculated border state relative price differences, and predicted cigarette sales. We reported the differences between the predictions from the baseline scenario and each minimum price scenario with uncertainty bounds in a plot of sales change across minimum prices and reported selected results in the text. Our counterfactual analyses assume that excise taxes are incorporated within the price dictated by the minimum price, rather than being levied on top of the minimum price.

Finally, half of the effect of a price increase on consumption is attributed to quitting, [39,40] therefore we calculated the expected number of smokers who would quit under three of our price scenarios using the equation,

$$q = \frac{.5\,\Delta s}{p}$$

[a]For example, a government could respond to declining cigarette sales by increasing taxes to offset tax revenue losses.

which states that the number of quitters (q) is one half of the change in pack sales per year (Δs) divided by number of packs (p) smoked on average per year by daily smokers.

RESULTS

Model Coefficients

We present descriptive statistics for all variables included in the multivariable log-linear model in Table 1. For brevity, we report model coefficients in-text for key independent variables only; the full set of coefficients and their 95% CIs are presented in Table 2. An increase of one dollar in *price* had a negative impact on state cigarette sales of 12.3% (B=−.123, 95% CI [−.148, −.097]), implying a price elasticity at the mean price in the data ($4.60) of approximately −.566[b], (95% CI [−.681,−.446]). A 0.1 (10%) increase in *border state relative price difference* was associated with a 5.11% drop in sales for the average state (B=−.511, 95% CI [−.693,−.318]). The *border state relative price difference variance component* was estimated to be 0.557 (95% CI [0.431, 0.731]) suggesting considerable variability centered on the average relative border price effect of −.511 across states.

Minimum Price Scenarios

Figure 1 depicts the expected state and national average prices under various minimum price scenarios. Moving left to right, as the increasing minimum price affects the lowest priced cigarettes within a state, the expected average price begins curving upwards. Each curve in the plot (state and national) eventually meets the diagonal minimum price line when all individual pack prices in the state or nation are impacted by the minimum price regulation. It is also notable that among-state price variation reduces as minimum price increases.

Figure 2 depicts the expected reduction in sales across the range of minimum prices. The plot shows a curvilinear relationship between minimum price and expected sales change. While a $4 minimum price is below all state average prices in the status quo, it nevertheless resulted in a small expected change in sales due to its effect on average prices—raising the 2013 national average of $5.98 up to $6.03. As the minimum price increased to $5 and beyond, the effect became mostly linear and sharply negative.

At a relatively low minimum price of $5, the expected average price rose to $6.20, and the expected reduction in sales was 549 million packs (95%CI [445 m, 654 m]) per year nationally, corresponding to an approximate 4.0% reduction in sales. For a minimum price of $7, the expected average price was $7.37, and the expected reduction in sales was 2.5 billion packs (95%CI [2.02 b, 2.95 b]), or about 18.0% of current sales. For a minimum price of $10, the expected average price was $10.06, and the expected reduction in sales was 5.7 billion packs (95% CI [4.75 b, 6.60 b]), or about 41.1% of current sales.

With the assumption that half of a reduction in consumption due to price is the result of smoking cessation, we calculated the expected number of current smokers who would quit in

[b]Price elasticity at the mean price was calculated by multiplying the price coefficient by the mean price found in the data set, as described in the World Bank Economics of Tobacco Toolkit [37] for log-linear models. Elasticity at other prices can be calculated in the same way. The 95% CIs for price elasticity were calculated by transforming the price coefficient 95% CI bounds in the same way.

the three scenarios described above assuming the average daily smoker smokes 14.6 cigarettes per day or 266.6 packs per year—a recent estimate by the CDC.[41] According to our model, minimum prices of $5, $7, and $10 would be expected to result in approximately 1.0 million, 4.7 million, and 10.7 million fewer smokers, respectively, due to cessation.

DISCUSSION

The aim of this study was to estimate the expected effect of a federal minimum price regulation on cigarette sales in the United States across a range of minimum price points, and to determine how minimum price regulation could potentially benefit public health. To do so, we constructed a model similar to those found in the economics of tobacco control literature using state level and time-varying sales and price data from the Tax Burden on Tobacco, as well as individual level pack price data from the most recent National Adult Tobacco Survey. The price elasticity identified in our model agrees with other published estimates.[29,42,43] We found that a national minimum price regulation could have a significant impact on sales that could translate to significant benefits for public health. For example, we estimated that a $10 minimum price could reduce sales by over 5 billion packs per year and induce cessation by over 10 million smokers.

We also examined the expected effect of a range of minimum prices. Our policy scenarios suggested that minimum prices greater than $5 produce the strongest returns for each additional increment in minimum price. Therefore, the best overall effectiveness of a minimum price policy is likely to be achieved when the price is above this point. However, while our results show that a minimum price of $4 is unlikely to have a substantial impact on overall sales and smoking participation, our analysis indicates that it would still impact sales through its impact on the price of low-cost brands and on the ability to minimize price with price promotions, both of which are industry price tools that are targeted towards [44] and utilized by low income consumers.[45,46] Given that low income consumers react more strongly than their counterparts to increasing prices by reducing use or by quitting, [40,43] even low minimum prices could have an equity producing effect with respect to disparate cigarette use by low socioeconomic status groups.

As minimum price increases, the variability in average price across states decreases. Minimum price regulation can therefore equalize prices among states and limit the incentive to shop in a border state. This can have a positive effect on public health by reinforcing the effect of increasing prices. It can also benefit state sales and tax revenues as residents are not incentivized to take their tax dollars to a lower price jurisdiction. As such, the argument against raising taxes due to lost sales may be substantially weakened under some minimum price regulations. Notably, Indian reservations would be subject to a federal minimum price regulation (even though they are not always subject to *state* minimum price laws), which would eliminate another method by which consumers minimize their costs and avoid taxes.[8] However, a minimum price regulation could encourage smuggling from other countries into the U.S., a reason for enhanced border enforcement for any national policy that increases prices. Our model did not include prices across national borders, so the potential effect of efforts to find lower prices in other countries was not incorporated into our counterfactual scenarios.

Reducing tobacco use improves our nation's health, and quitting has immediate and major health benefits for individuals. Previous research suggests that half of the price effect on sales that we estimated would be due to quitting. The remaining reduction in sales is assumed to be the result of consumers adapting by cutting back or switching products. During this period of adaptation, it is crucially important to increase funding for cessation treatment and awareness, which may render quitting a viable alternative for these consumers, and therefore further decrease smoking prevalence. It should also be noted that from a public health perspective, never starting to smoke is the best outcome of all. Our model focuses on the potential effects of minimum prices on current smokers, but it is important to note that adolescents who are considering smoking or are smoking experimentally are among the most price-sensitive consumers.[43] A sufficiently high minimum price could substantially reduce initiation, leading to even lower smoking rates in the longer term.

Although it is apparent to us that the TCA provides the FDA with the ability to implement a national minimum price regulation, the statutory authorization for a minimum price policy is not entirely explicit. For this reason, the FDA may be disinclined to pursue such a strategy, especially since any such regulation would certainly be challenged by the tobacco industry in court. However, as this paper suggests, the public health benefits of a national minimum price could be substantial, which would be a strong reason to consider this option despite potential legal and political challenges.

From an economic perspective, a minimum price regulation does not solve some of the market failures apparent in the tobacco marketplace.[21] Prominent manufacturers might welcome the anti-competitive nature of a moderate minimum price.[47] This is likely one reason the industry supported a Malaysian minimum price policy, [24] which was unable to significantly increase the price of cigarettes because the price was too low and because of the presence of an excessive illicit cigarette trade.[24] More research is needed to understand the potential ramifications of a minimum price regulation on the U.S. cigarette market.

Our statistical model resulted in one unexpected finding—tobacco control funding was positively related to cigarette sales. While the reason for this is unclear, one possibility is that the tobacco industry successfully counteracts increases in state tobacco control funding with increases in marketing and promotion efforts. Additional research is needed to explain this result.

Our model is, by necessity, a simplification and cannot capture the complex social, political, and economic mechanisms at play. For two important reasons we believe our estimates are a lower bound of what should be expected under such a realized regulation. First, as the prevalence of smoking decreases in the population, smoking becomes less acceptable, resulting in less adoption of the behavior—including by youth [48]—and greater motivation to quit, above and beyond the influence of price. Second, it is not clear from our model what the full demand curve for cigarettes looks like; the data we used do not allow us to obtain a precise estimate of the demand curve at higher prices. While sensitivity could drop at higher prices, [49] experimental work utilizing cigarette purchase tasks and other approaches to studying demand curves for tobacco products suggest that sensitivity increases as price

increases.[29,34,35] Tauras and colleagues [29] estimate that elasticity could be as high as −1.7 at a price of $10, whereas our estimate at $10 is approximately −1.23. Therefore, we believe that our estimate that 10 million smokers would quit under a $10 minimum price regulation may be an underestimate of the full beneficial impact of a minimum price regulation.

In conclusion, this report presents broad stroke expectations for the impact of a federal regulation that sets a strict minimum price on cigarettes. Such a regulation by the FDA could be a highly effective tobacco control mechanism if the price is set at a sufficiently high level, and it could also serve to promote health equity. In addition to reducing consumption, a national minimum price could also reduce state-to-state disparities in price, thereby reducing the incentive to cross-border purchase and smuggle products between states. Future work should consider a model that incorporates price sensitivity estimates that vary by age and income, as well as features that model initiation, cessation, aging, death, and social mechanisms such as denormalization. Future work could employ system dynamics or agent based models to more fully capture system complexity, such as potential market complications or unexpected health benefits.

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WHAT THIS PAPER ADDS

- Price has a powerful effect on tobacco use, and should be included in comprehensive tobacco control efforts.
- In the U.S., the Food and Drug Administration has the power to regulate the sale and promotion of tobacco products, and thus the price.
- This study examines the potential public health benefit of minimum cigarette price regulation.
- Only one published study estimates the expected change in smoking given a single national floor price on cigarettes.
- This study adds estimates of the sales and smoking prevalence effects of a range of federal minimum floor prices for cigarettes.

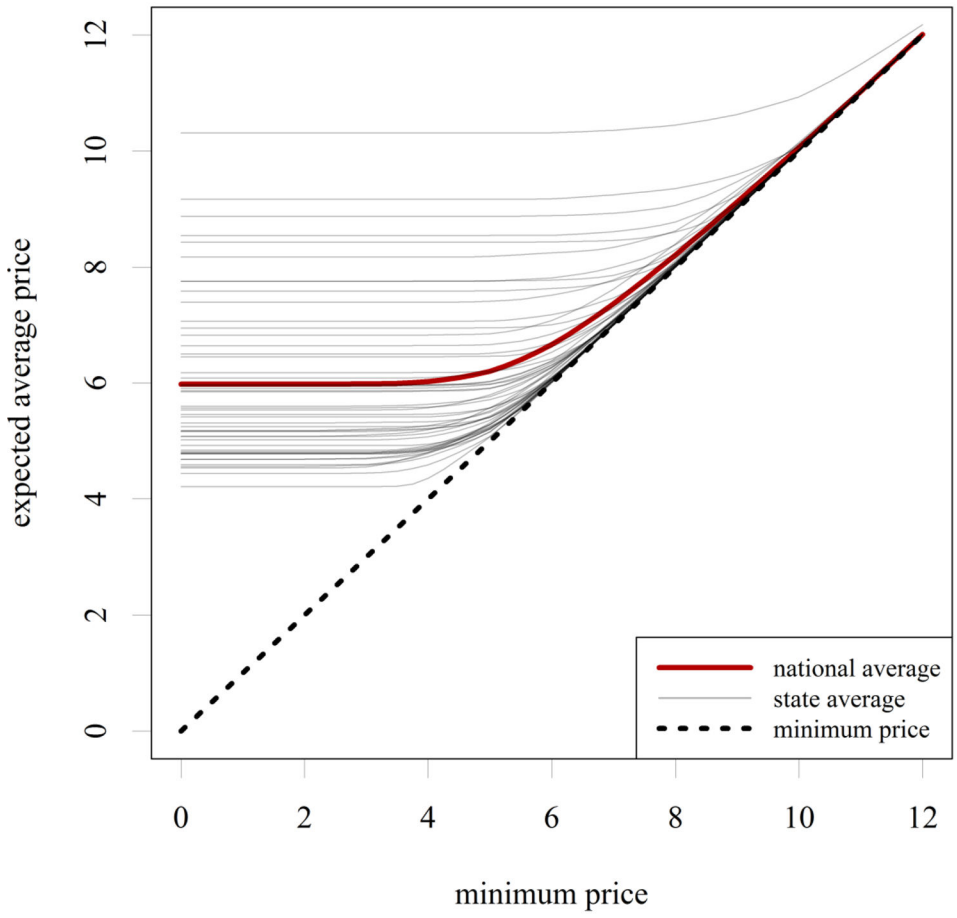

Figure 1.

Expected state (fine solid gray lines) and national (thick solid line) average cigarette pack prices for minimum price scenarios ranging from $0 to $12. A dashed black diagonal line representing the minimum price is also included for reference.

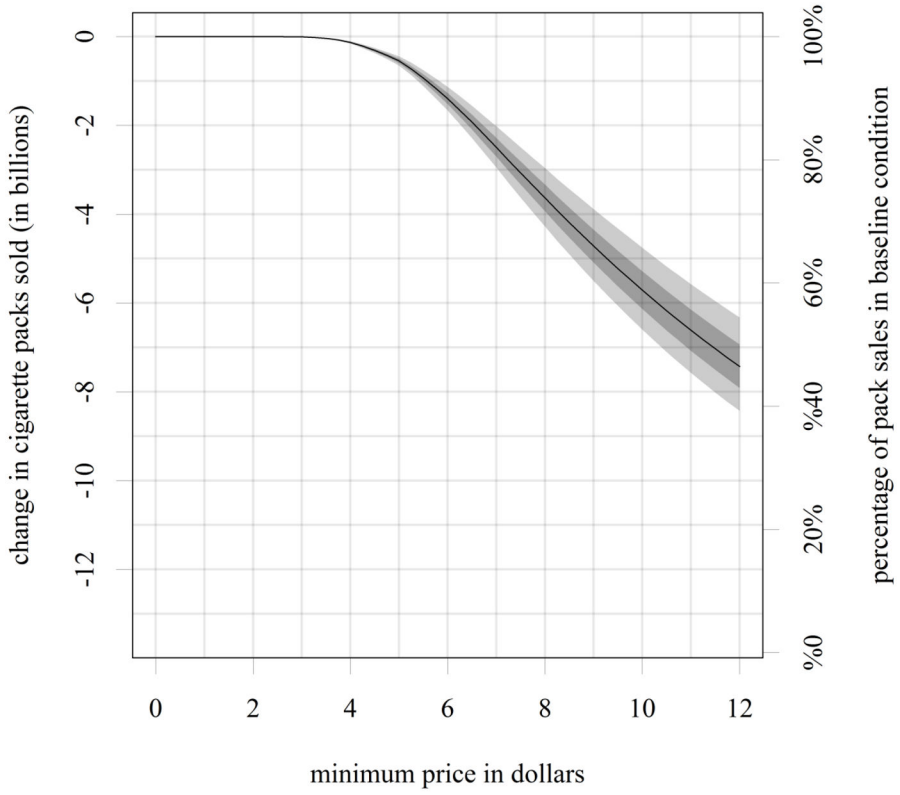

Figure 2.

Expected change in packs sold nationally under various minimum price scenarios. The plot includes 68% (inner dark gray) and 95% (outer light gray) confidence intervals. The right axis identifies the percentage of sales in the baseline no-minimum-price scenario that remain in the minimum price scenario represented on the X-axis.

Table 1

Descriptive statistics for variables included in the multivariable model across all years (1996–2013).

				Percentiles					
Continuous Variables	**mean**	**sd**	**min**	**10th**	**25th**	**median**	**75th**	**90th**	**max**
Median Household Income	5.443	0.834	3.772	4.417	4.812	5.328	6.016	6.655	7.639
Per Capita Tobacco Control Funding	9.525	10.472	0.045	0.729	1.775	6.403	13.088	24.650	57.924
LD Export Opportunity	1.553	1.321	0.000	0.000	0.598	1.233	2.193	3.320	5.615
LD Import Opportunity	0.930	0.912	0.000	0.056	0.299	0.621	1.285	2.206	5.615
Average Price	4.596	1.374	2.137	2.794	3.784	4.416	5.358	6.293	10.312
Border State Relative Price Difference	−0.001	0.116	−0.362	−0.143	−0.070	−0.003	0.062	0.150	0.336
Dichotomous Variables (Clean Air)	proportion								
Private Workplace Air Restriction	0.272	-	-	-	-	-	-	-	-
Government Workplace Air Restriction	0.421	-	-	-	-	-	-	-	-
Restaurant Air Restriction	0.273	-	-	-	-	-	-	-	-
Bar Air Restriction	0.203	-	-	-	-	-	-	-	-

Table 2

Coefficients and 95% confidence intervals of the fitted model.

		95% CI	
Variable	**Estimate**	**2.50%**	**97.50%**
Private Workplace Air Restriction	0.001	−0.030	0.031
Government Workplace Air Restriction	−0.024 *	−0.047	0.000
Restaurant Air Restriction	−0.007	−0.041	0.026
Bar Air Restriction	−0.011	−0.044	0.024
Median Household Income	0.027 *	0.000	0.056
Per Capita Tobacco Control Funding	0.002 *	0.001	0.003
LD Export Opportunity	0.002	−0.008	0.012
LD Import Opportunity	−0.008	−0.024	0.009
Average Price	−0.123 *	−0.148	−0.097
Border State Relative Price Difference	−0.511 *	−0.693	−0.318
Border State Rel. Price Diff. Variance	0.557 *	0.431	0.731

The model also includes state and year fixed effects.

* 95% CI does not include zero (i.e., “statistically significant”)