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How cigarette excise tax pass-through to prices responds to the uptake and evolution of e-cigarettes (ECs)

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ABSTRACT

Background How excise taxes are passed through to prices determines whether tax policies will be effective in changing smoking behaviours. Though previous literature has documented that cigarette taxes are overly shifted to prices, there is limited evidence on how cigarette tax pass-through to prices is affected by the uptake and evolution of e-cigarettes (ECs) in the US market.

Objective This study investigates how cigarette excise tax pass-through rate varied by price levels (the 25th, 50th, and 75th percentile prices) and the uptake and evolution of ECs.

Methods Tax pass-through rates were assessed using ordinary least squares regressions while controlling for state, year and month fixed effects. Different trends were then tested for the pre-EC uptake era (2006–2011), EC uptake era (2012–2016) and the evolution of nicotine salt-based ECs era (2017 and later).

Findings Cigarette excise taxes were fully shifted to the 25th and 50th percentile prices and overly shifted to the 75th percentile prices at a 1:1.1 rate. While cigarette excise taxes had a continuous impact on raising prices, the tax pass-through rates were lower for lower priced cigarettes, and states imposed lower taxes.

Conclusions Continuing to raise cigarette taxes may be needed to create financial incentives to encourage people who smoke to switch to ECs. In addition, continuing to raise cigarette taxes and additional pricing policies such as price promotion restrictions are needed to increase retail prices and reduce price minimisation opportunities.

INTRODUCTION

Raising excise taxes on tobacco products has long been recognised as a highly effective tobacco control strategy.^{1–2} The effectiveness of tax policies in changing tobacco use behaviours largely depends on the level at which excise taxes are passed through to prices (ie, tax pass-through rate) and thus ensures that the consumer faces increasing prices when taxes are raised. In the case of cigarettes, ample evidence from the 1990s and early 2000s documented that cigarette taxes were over-shifted to prices in the USA, that is, manufacturers intentionally raised cigarette prices on top of the tax increase.^{3–6} This represents a tactic the tobacco industry may employ to continue realising profits while avoiding blame for the price hikes.

Cigarette manufacturers also may strategise tax pass-through based on price levels (eg, 25th vs 75th percentile prices), retaining profits and market share by shifting lower taxes to low-priced brands

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ The effectiveness of raising excise taxes on tobacco products as a public health strategy depends on how taxes are passed through to prices.
- ⇒ The uptake of e-cigarettes (ECs) into the US market and the growth of nicotine salt-based EC market share may impact how manufacturers pass cigarette excise taxes to cigarette prices.
- ⇒ More evidence on cigarette excise tax pass-through is needed to inform the design of a tobacco excise tax system that reflects the relative harms of different tobacco products (eg, cigarettes vs ECs).

WHAT THIS STUDY ADDS

- ⇒ Cigarette excise taxes were fully shifted to the 25th and 50th percentile prices and overly shifted to the 75th percentile prices.
- ⇒ The tax pass-through rate is lower for lower priced cigarettes and in states with lower tax levels, suggesting strategies to keep the price of cheap cigarettes low.
- ⇒ Both current and past cigarette excise tax increases raise contemporaneous cigarette prices, suggesting continuous or long-term impacts of tax hikes on cigarette prices.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ As cigarette excise tax pass-through rates are lower for lower priced cigarettes and for states imposing lower taxes, continuing to raise cigarette taxes and additional pricing policies such as price promotion restrictions are needed to increase retail prices and reduce price minimisation opportunities.
- ⇒ The increase in the pass-through rate on median-priced cigarettes after the EC evolution era may create financial incentives to encourage consumers who consumed median-priced cigarettes to modify their smoking behaviours.

and higher taxes to higher priced brands. Lessons learnt from alcohol taxation studies offer evidence that tax pass-through rates do vary by price level and lower taxes are passed to lower priced products to maintain product affordability.⁷ Such strategies can undermine the public health goals of tax policy and exacerbate income-based substance use



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disparities since low-income consumers are more likely than others to purchase discount products.⁸ While a growing number of studies document cigarette price minimisation behaviours (eg, downshifting to discount cigarettes) in the USA,^{8–11} existing evidence on how manufacturers facilitate such behaviours by passing lower taxes to lower priced cigarettes mostly comes from outside the USA.^{12–15} To the best of our knowledge, there have been no US-specific studies to ascertain whether the cigarette industry manipulates cigarette tax pass-through rates to prices to facilitate price minimisation in the country.

In the USA, how cigarette manufacturers pass cigarette taxes to prices is further complicated by the uptake of e-cigarettes (ECs) and the evolution of nicotine salt-based ECs in the market. Although ECs were first introduced to the USA in 2007, the EC use prevalence in the USA only began to soar around 2011.^{16–19} The prevalence of EC use among high school students has increased markedly from 1.5% in 2011 to 19.6% in 2020. ECs have also become the most popular non-combustible tobacco products for adults, with 3.7% of adults being current EC users as of 2020.^{20,21} The model of ECs has further undergone several rounds of evolution over the past decade, with over 600 brands documented in the market.^{22,23} In 2015, nicotine salt-based ECs, most prominently JUUL pods,^{24,25} were introduced and its sales grew 641% from 2.2 million in 2016 to 16.2 million in 2017, taking the greatest EC market share.^{26–28} Compared with free-base nicotine, nicotine salt products can deliver high concentrations of nicotine, thereby having great potential to be close substitutes for combustible cigarettes.^{29–31}

The rapid growth and evolution of the EC market have prompted policymakers to impose excise taxes on ECs, which has been shown to effectively reduce vaping among youth and adults.^{32–34} The heated debate thus focuses on how to design a tax system where cigarettes and ECs are taxed relative to their harms. While EC excise taxes are at least fully passed to EC prices and the current tax burden is higher on cigarettes than on ECs,^{34,35} it is unclear how cigarette taxes are passed to prices in recent years, especially in the era of ECs. Further evidence on cigarette tax pass-through rates to prices is necessary to ascertain whether the current tax system maintains the financial incentive for transitioning from cigarette smoking to EC use and whether there is room to increase EC taxes to prevent addiction.³⁶

The growing popularity of ECs and their potential roles as substitutes for cigarettes have also motivated the cigarette industry to increasingly invest in the EC market. Lorillard purchased Blu in 2012 and as of 2018, most major tobacco companies, including Reynolds, JTI and Altria, have either purchased EC brands or released their own EC or heated tobacco products.^{28,37} The Food and Drug Administration's requirement of premarket tobacco product applications may have further reduced EC market competition by favouring the traditional cigarette industry which has more resources over small independent EC manufacturers. This trend implies that cigarette companies will have incentives to maximise their profit by setting simultaneously cigarette and EC tax pass-through rates, as demonstrated in recent studies evaluating the tax pass-through rates of heated tobacco products and cigarettes globally.^{36,38} Empirical evidence on cigarette tax pass-through rate to prices in the EC uptake era and evolution era is highly needed to elucidate industry behaviours in the USA.

Revisiting the recent and current pass-through rates of cigarette excise taxes to prices is timely to clarify the impact of the evolving tobacco market on cigarette pricing, including the more recent growth in nicotine salt-based ECs. Understanding the tobacco industry's pricing decisions in response to tax increases

remains essential to designing and enforcing effective tax policies. In this study, we analysed the Nielsen Retail Scanner Data from 2006 to 2020 to evaluate how cigarette excise taxes were passed through to prices for cigarettes at different price levels (25th, 50th and 75th percentile prices) and by state excise tax levels (low, medium and high taxes). We also tested how the cigarette tax pass-through rate to prices varied by different periods, including the pre-EC uptake era (2006–2011), the EC uptake era (2012–2016) and the evolution of the nicotine salt-based ECs era (2017 and later). The findings have the potential to inform the design of the tobacco taxation system.

DATA AND METHODS

Data

Outcome variable: cigarette prices

The historical cigarette price data from 2006 to 2020 were obtained from the Nielsen Retail Scanner Data provided by the Kilts Center for Marketing at The University of Chicago Booth School of Business. Nielsen Retail Scanner Data collects information on prices, sales volume, product name/type, store environment, etc from 90 participating retail chains across all US markets every week. In total, approximately 1876 million price observations were collected from 30 860 stores on average each year from 2006 to 2020. We calculated the 25th, 50th, and 75th percentile cigarette prices per pack of 20 sticks and aggregated them to the monthly level for each state. Out of the 50 states and the District of Columbia, data are available for the years 2006–2020 except for Alaska and Hawaii. These two states only have data for 2018 and 2019. Finally, we obtained 8868 observations on state-year-month price data.

Explanatory variable: federal and state excise taxes

The federal and state excise taxes on cigarettes were obtained from Orzechowski and Walker, *The Tax Burden on Tobacco*.³⁹ We then linked the tax data to the cigarette price data by state, year and month identifiers. We converted cigarette prices and excise taxes to real terms in constant January 2010 dollars using the Consumer Price Index published by the US Bureau of Labor Statistics.⁴⁰

Methods

We first estimated the fixed effects (FE) model as the benchmark framework. The specification of the model can be described as follows:

$$P_{sij} = \alpha_1 + \alpha_2 Tax_{sij} + Y_i + M_j + \varphi_s + \varepsilon_{sij} \quad (1)$$

where P_{sij} and Tax_{sij} denote cigarette prices and federal and state cigarette excise taxes in state s , year i and month j , respectively. Y_i , M_j and φ_s denote year, month and state FE, respectively. ε_{sij} is the error term. The two-way FE model can account for time-invariant state-specific unobservable factors and common trends across states, such as potential differences in EC uptake time by locations. Thereby, the association between taxes and prices could have a causal interpretation. Standard errors (SEs) were clustered at the state level to account for intertemporal correlations within each state.

Given that EC use prevalence started to soar in 2012 and that nicotine salt ECs started to grow significantly in 2017, we then test the difference in tax pass-through rates by different periods: the pre-EC uptake era (2006–2011), the EC uptake era (2012–2016) and the evolution of nicotine salt-based ECs era (2017–2020), to ascertain whether the cigarette tax pass-through rate was impacted by the uptake and evolution of ECs in the market. Specifically, we added two interaction terms between excise taxes

and the EC uptake indicator (coded as 1 from 2012 onward and 0 before 2012) and the EC evolution indicator (coded as 1 from 2017 onward and 0 before 2017) to the estimating equation. The specification of the model can be described as follows:

$$P_{sij} = \alpha_1 + \alpha_2 Tax_{sij} + \alpha_3 Tax_{sij} \times EC_uptake + \alpha_4 Tax_{sij} \times EC_evolution + Y_i + M_j + \varphi_s + \varepsilon_{sij} \quad (2)$$

Throughout the analysis, we also conducted seemingly unrelated regressions (SUR) to simultaneously estimate equations for cigarette prices at different price levels (the 25th, 50th, and 75th percentile prices). SUR allows the error terms of estimating equations for different price levels to be correlated, further allowing for a direct test of whether the estimated coefficients from equations for different price levels are statistically significant from each other. Following existing literature, we classify tax pass-through rates into undershifting (rate < 0.9), fully-shifting (rate = 0.9–1.1) and overshifting (rate > 1.1).^{7,41}

Two sensitivity analyses were performed to examine the validity of these estimates. First, we examined a dynamic model with one lag ($t-12$) and one lead ($t+12$) of excise taxes entering the equation along with contemporaneous (t) taxes. Lag ($t-12$) and lead ($t+12$) denote the excise taxes 1 year before and after. As described in the review article by Nelson and Moran, the lag and lead effects of taxes are often tested in existing research on tax pass-through rates.⁴² This dynamic framework tests whether the market reactions to tax change are lagged and/or proactive if a tax increase is anticipated. Second, we added a linear state-specific year trend to the benchmark model to control for state differences in antismoking sentiment, price elasticity, market concentration, evolutions of other tobacco products, socioeconomic changes, etc that may influence tax pass-through rates to prices.

Cigarette excise taxes varied significantly across states, with the lowest rate recorded at \$0.07 per pack in South Carolina from 2006 to June 2010, while the highest rate reached \$5 per pack in the District of Columbia from October 2020 to December 2020. To assess whether the tax pass-through rates differ by state excise tax levels, we categorised states into three groups, low, medium

and high-tax states, according to the average tax rate between 2006 and 2020, and conducted stratified analysis by the groups.

RESULTS

Figure 1 depicts the trends in real cigarette prices at different levels and the total excise taxes between 2006 and 2020. Overall, cigarette prices at all levels exhibit an upward sloping trend. The price gaps between 75th percentile prices and 50th percentile prices remain stable throughout the study period. However, the price gaps between 50th percentile prices and 25th percentile prices increased significantly after 2009. The total cigarette excise taxes increased slightly between 2008 and 2010 and remained stable after 2010. Table 1 reports the summary statistics of the analytical sample. On average, a pack of cigarettes at the 25th, 50th, and 75th percentiles costs \$4.74, \$5.25, and \$5.62, respectively. The minimum, average, and maximum federal and state excise taxes are \$0.45, \$2.15, and \$5.32, respectively.

During the study period, the cigarette tax pass-through rates to the 25th, 50th, and 75th percentile prices were 1.08, 1.07, and 1.13, respectively (as shown in table 2). This finding suggests that cigarette excise taxes fully shifted to the 25th and 50th percentile prices and overshifted to the 75th percentile price. The SUR test showed that the tax pass-through rates to prices at the 25th and 50th percentiles were not statistically different. However, the tax pass-through rate to the 75th percentile price was significantly higher than that to the 25th and 50th percentile prices ($p < 0.001$). We further examine the tax pass-through rates to cigarette prices by three different eras: pre-EC uptake (2006–2011), the uptake of ECs (2012–2016) and the evolution of nicotine salt-based ECs (2017 and later). We found that the tax pass-through rate for cigarettes at the 50th percentile price was significantly higher after the evolution era compared with the pre-EC uptake era and EC uptake era (a \$1 increase in taxes leads to \$0.11 higher prices after the evolution era compared with the pre-EC uptake era and \$0.07 higher prices compared with the EC uptake era). However, for cigarettes at the 25th and 75th percentile prices, the tax pass-through rates after the

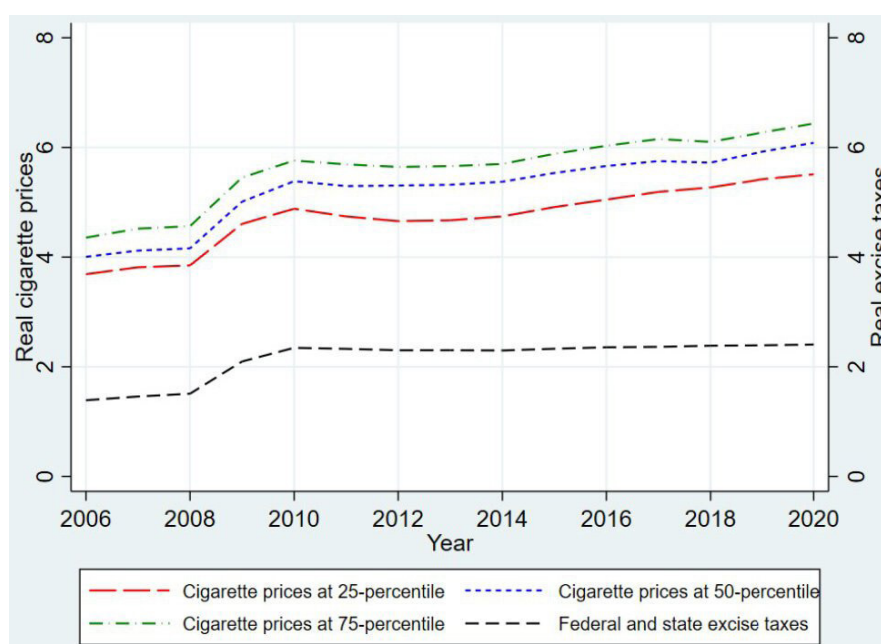


Figure 1 Trend in cigarette prices and excise taxes, 2006–2020.

Table 1 Summary statistics of the analytical sample

Variables	Mean (%)	SD	Min	Max
Outcome variables				
Cigarette prices at 25th percentile	4.736	1.222	2.435	9.225
Cigarette prices at 50th percentile	5.246	1.267	2.866	9.549
Cigarette prices at 75th percentile	5.617	1.296	3.060	10.501
Explanatory variable				
Federal and state excise taxes	2.152	0.946	0.453	5.324
State tax changes: During the study period, the following states did not have any changes in their state taxes: AK, GA, HI, ID, ME, MI, MO, MT, NE, ND, VA, and WY. The following states increased their cigarette excise taxes once during the study period: AL, AZ, AR, CA, CO, FL, IN, IA, KS, MD, MS, NV, OH, OK, SC, SD, TN, TX, UT, WA, and WV. IL, KY, LA, MA, NJ, NM, NY, NC, PA, and WI increased cigarette excise taxes two times during the study period. DE increased cigarette excise taxes three times during the study period. MN, NH, OR, and RI increased cigarette taxes four times during the study period. CT and VT increased cigarette excise taxes five times during the study period. DC increased cigarette excise taxes 10 times during the study period. NH decreased cigarette excise taxes once during the study period. The federal cigarette excise tax increased from \$0.39 to \$1.01 per pack in April 2009. AK, Alaska; AL, Alabama; AR, Arkansas; AZ, Arizona; CA, California; CO, Colorado; CT, Connecticut; DC, District of Columbia; DE, Delaware; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Mexico; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.				

evolution era were not statistically different from the EC uptake era.

Table 3 shows the results of the dynamic model which controlled for the excise taxes of the past and lead 12 months in addition to the contemporaneous excise taxes. The pass-through from contemporaneous excise taxes to the 25th, 50th, and 75th percentile prices was 1.03, 1.08, and 1.12, respectively. The past excise taxes were positively associated with current prices. The past excise taxes raised the current 25th, 50th, and 75th percentile prices by \$0.13, \$0.10, and \$0.17, respectively, suggesting that cigarette tax increases continue to raise prices for at least 12 months. As expected, the price of cigarettes did not respond to future tax hikes, indicating that the tobacco industry either did not foresee tax increases or did not take proactive action to respond to anticipated tax hikes.

Table 4 shows the tax pass-through rates after controlling for the linear state-specific year trend. The tax pass-through rates to the 25th, 50th, and 75th percentile prices were 1.00, 1.00,

Table 3 Pass-through rates of past, contemporaneous and lead excise taxes to cigarette prices

	Cigarette prices at 25%	Cigarette prices at 50%	Cigarette prices at 75%
Excise taxes (t)	1.034*** (<0.001)	1.082*** (<0.001)	1.117*** (<0.001)
Excise taxes (t-12)	0.129† (0.090)	0.095** (0.003)	0.165* (0.020)
Excise taxes (t+12)	-0.017 (0.510)	-0.042 (0.189)	-0.071 (0.140)
*P<0.05; **p<0.01; ***p<0.001. †P<0.1.			

and 1.10, respectively. The amount or the extent of tax pass-through to prices did not vary significantly by the EC uptake and evolution of nicotine salt-based ECs. This finding suggests that excise taxes were fully shifted to cigarette prices at all levels after controlling for state-specific year trends.

Table 5 shows the tax pass-through rates stratified by high versus medium versus low excise tax states. Our results show that taxes were fully shifted to prices in all states during the pre-EC uptake era except the 75th percentile prices in high-tax states. However, taxes were undershifted or fully shifted to prices during the EC uptake era and evolution era in low-tax and medium-tax states. In contrast, in high-tax states, taxes were mostly overshifted to prices during the EC uptake era and evolution era. Given less variation in taxes in stratified analyses than in pooled analyses, we may not have statistical power to detect trend differences in stratified regressions.

DISCUSSION AND CONCLUSION

ECs, a less harmful alternative to cigarettes, have demonstrated potential in recent years in helping smoking cessation.^{43 44} However, their prevalence increased among youth and young adults as the preferred nicotine salt-based ECs complicate efforts to prevent nicotine addiction. This shift in popularity towards ECs has sparked an intense debate on the appropriate design of an excise taxation system that mirrors the relative harms of various tobacco products.

The desired tax structure should leverage EC taxes to discourage use among young people while simultaneously ensuring that cigarettes bear a higher tax burden than ECs. This strategy would provide an economic incentive for existing smokers to fully transition to ECs. In this context, the key factor lies in understanding how cigarette taxes are passed to retail prices and identifying if this pass-through alters with the uptake and evolving forms of ECs in the US market. Such insights are

Table 2 Pass-through rates using the real prices and taxes

	Cigarette prices at 25%		Cigarette prices at 50%		Cigarette prices at 75%	
	(1)	(2)	(3)	(4)	(5)	(6)
Federal and state excise taxes	1.079*** (<0.001)	1.032*** (<0.001)	1.073*** (<0.001)	1.006*** (<0.001)	1.125*** (<0.001)	1.069*** (<0.001)
Tax*EC uptake		0.043 (0.429)		0.035 (0.111)		0.059 (0.278)
Tax*nicotine salt evolution		0.022 (0.475)		0.073*** (0.001)		0.011 (0.853)
Pass-through rates						
2006–2011	–	1.032*** (<0.001)	–	1.006*** (<0.001)	–	1.069*** (<0.001)
2012–2016	–	1.074*** (<0.001)	–	1.041*** (<0.001)	–	1.128*** (<0.001)
2017 and later	–	1.096*** (<0.001)	–	1.114*** (<0.001)	–	1.139*** (<0.001)
*P<0.05; **p<0.01; ***p<0.001. †P<0.1. EC, e-cigarette.						

Table 4 Tax pass-through rates controlling for state-specific year trend

	Cigarette prices at 25%		Cigarette prices at 50%		Cigarette prices at 75%	
	(1)	(2)	(3)	(4)	(5)	(6)
Federal and state excise taxes	1.000*** (<0.001)	1.010*** (<0.001)	0.997*** (<0.001)	1.017*** (<0.001)	1.098*** (<0.001)	1.096*** (<0.001)
Tax*EC uptake		-0.019 (0.778)		-0.042 (0.305)		0.004 (0.947)
Tax*nicotine salt evolution		-0.031 (0.506)		0.020 (0.658)		-0.016 (0.814)
Pass-through rates						
2006–2011	–	1.010*** (<0.001)	–	1.017*** (<0.001)	–	1.096*** (<0.001)
2012–2016	–	0.991*** (<0.001)	–	0.976*** (<0.001)	–	1.100*** (<0.001)
2017 and later	–	0.960*** (<0.001)	–	0.995*** (<0.001)	–	1.084*** (<0.001)

*P<0.05; **p<0.01; ***p<0.001.
†P<0.1.
EC, e-cigarette.

Table 5 Tax pass-through rates by state tax level

	Cigarette prices at 25%	Cigarette prices at 50%	Cigarette prices at 75%
Low-tax states (AL, CO, GA, ID, KY, LA, MO, MS, NC, ND, NE, SC, TN, VA, WV, WY)			
Federal and state excise taxes	0.891*** (<0.001)	0.922*** (<0.001)	0.857*** (<0.001)
Tax*EC uptake	-0.049 (0.745)	-0.171 (0.119)	0.074 (0.610)
Tax*nicotine salt evolution	-0.305 (0.195)	-0.230 (0.383)	-0.306 (0.200)
Pass-through rates			
2006–2011	0.891*** (<0.001)	0.907*** (<0.001)	0.960*** (<0.001)
2012–2016	0.842*** (<0.001)	0.751*** (<0.001)	0.930*** (<0.001)
2017 and later	0.537† (0.093)	0.521 (0.133)	0.625† (0.084)
Medium-tax states (AR, CA, DE, FL, IA, IN, KS, NH, NM, NV, OH, OK, OR, SD, TX, UT)			
Federal and state excise taxes	1.052*** (<0.001)	1.079*** (<0.001)	0.990*** (<0.001)
Tax*EC uptake	-0.034 (0.803)	-0.035 (0.772)	0.058 (0.675)
Tax*nicotine salt evolution	-0.266 (0.346)	-0.304 (0.335)	-0.216 (0.503)
Pass-through rates			
2006–2011	1.052*** (<0.001)	1.079*** (<0.001)	0.990*** (<0.001)
2012–2016	1.018*** (<0.001)	1.044*** (<0.001)	1.049*** (<0.001)
2017 and later	0.753* (0.012)	0.740* (0.016)	0.832* (0.015)
High-tax states (AK, AZ, CT, DC, HI, IL, MA, MD, ME, MI, MN, MT, NJ, NY, PA, RI, VT, WA, WI)			
Federal and state excise taxes	1.010*** (<0.001)	1.054*** (<0.001)	1.227*** (<0.001)
Tax*EC uptake	0.164 (0.210)	0.041 (0.435)	0.109 (0.432)
Tax*nicotine salt evolution	-0.030 (0.721)	0.112† (0.059)	-0.078 (0.560)
Pass-through rates			
2006–2011	1.010*** (<0.001)	1.054*** (<0.001)	1.227*** (<0.001)
2012–2016	1.174*** (<0.001)	1.094*** (<0.001)	1.336*** (<0.001)
2017 and later	1.145*** (<0.001)	1.206* (0.016)	1.258*** (<0.001)

*P<0.05; **p<0.01; ***p<0.001.
†P<0.1.
AK, Alaska; AL, Alabama; AR, Arkansas; AZ, Arizona; CA, California; CO, Colorado; CT, Connecticut; DC, District of Columbia; DE, Delaware; EC, e-cigarette; FL, Florida; GA, Georgia; HI, Hawaii; IA, Iowa; ID, Idaho; IL, Illinois; IN, Indiana; KS, Kansas; KY, Kentucky; LA, Louisiana; MA, Massachusetts; MD, Maryland; ME, Maine; MI, Michigan; MN, Minnesota; MO, Missouri; MS, Mississippi; MT, Montana; NC, North Carolina; ND, North Dakota; NE, Nebraska; NH, New Hampshire; NJ, New Jersey; NM, New Mexico; NV, Nevada; NY, New York; OH, Ohio; OK, Oklahoma; OR, Oregon; PA, Pennsylvania; RI, Rhode Island; SC, South Carolina; SD, South Dakota; TN, Tennessee; TX, Texas; UT, Utah; VA, Virginia; VT, Vermont; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

vital for sculpting an effective tobacco excise taxation system and determining appropriate tax levels for ECs.

In this study, we examined cigarette excise tax pass-through rate to prices and how it varied by price levels (the 25th, 50th, and 75th percentile prices) and the uptake and evolution of ECs (2006–2011, 2012–2016, and 2017 and later). Consistent with existing literature,^{3 20 21 23 24} we found that cigarette excise taxes were fully shifted or overshifted to prices, with the tax pass-through rate higher for higher priced cigarettes. This finding held true after we controlled for the linear state-specific year trend. This suggests that manufacturers have strategised to generate profits from higher priced or premium cigarettes while keeping the prices of cheap or discount cigarettes low. This discovery is also consistent with previous literature demonstrating that people who smoke and have a low socioeconomic status are more likely to engage in price minimisation behaviours (eg, downshifting to discount prices).^{8 10} Eliminating cheap cigarette products through raising tax pass-through rates to lower priced cigarettes and the adoption of other policies such as price promotion restrictions may be needed to encourage quitting smoking.

Interestingly, we found that the pass-through effect was considerably higher for cigarettes at the 50th percentile price compared with those at the 25th and 75th percentiles after the evolution of nicotine salt-based ECs. However, the effect of EC evolution on tax pass-through rates was not significant after we controlled for the state-specific year trend. Therefore, this estimate should be viewed with caution. This finding suggests that imposing excise taxes on median-priced cigarettes may create financial incentives (ie, cost differences) between ECs and cigarettes for individuals who smoke, motivating them to modify their smoking behaviours (ie, downshifting, switching to ECs, etc). This is in line with the knowledge that cigarettes are very profitable and the cigarette industry's competing interests in promoting ECs.²⁸ With increasing taxes on median-priced cigarettes, there will be room for increasing EC taxes to prevent nicotine addiction among populations who would otherwise not use any nicotine or tobacco products.^{45 46}

Our sensitivity analyses further explored how contemporary cigarette prices respond to past and future cigarette excise taxes. The findings show that the tobacco industry raised contemporary prices in response to both current taxes and tax hikes that were imposed 12 months ago, showing the long-term or continuous impacts of cigarette excise taxes. If we combine the effects of past and current taxes on current cigarette prices, the overall tax pass-through rate is well above 1.1, suggesting an overshifting of taxes across the price distribution. In addition, contemporary or current prices did not respond to future taxes, showing that the

tobacco industry did not proactively respond to future tax hikes or that they did not foresee future tax hikes.

We also examined the tax pass-through rates to prices by groups of states with varying tax levels (high, medium, and low). We discovered that in states with relatively lower excise taxes, taxes are undershifted to prices. These low prices further bolster the availability of relatively cheap cigarettes and provide price minimisation opportunities. Therefore, low tax pass-through rates may perpetuate smoking disparities. In contrast, in states with relatively higher excise taxes, taxes are fully shifted or overshifted to cigarette prices. These states raised excise taxes more frequently or to a greater extent than their counterparts. This is consistent with prior observation that when state governments significantly raised cigarette excise taxes in the 1990s and early 2000s, the tobacco industry overshifted taxes to prices to reap more profits and bolster their financial gains as cigarette consumption decreases less than price increases.^{6 47 48}

Our study does have certain limitations. First, we did not control for state-level smoke-free air laws, policies regulating other tobacco products (eg, prices) or market concentration (Herfindahl–Hirschman Index), which may influence cigarette tax pass-through rates to prices. For example, manufacturers may respond to the prices of other tobacco products by altering the prices of cigarettes. However, we did control for state-specific year trends to adjust for time-varying state factors. Second, we used arbitrary cut-offs to categorise undershifting, fully shifting and overshifting of taxes to prices based on the existing literature. However, our conclusions and categorisation of tax pass-through rates largely remain if we use one as the cut-off (rate >1 would be considered as overshifting and <1 would be considered as undershifting). Third, the timeline of the EC uptake and evolution may differ by state, and responses to cigarette prices may substantially vary, which may undermine the causality interpretation of our results. However, Cotti *et al* examined the impact of cigarette taxes on EC prices and found no significant associations.³⁴ Therefore, it is unlikely that cigarette taxes or prices impact where ECs were first introduced. Nonetheless, future research with data on differential EC uptake and evolution by states and localities will be able to improve this study.

This study contributes insights into how the tobacco industry adjusts its pricing strategy in response to increases in cigarette excise taxes, particularly after the EC uptake and the evolution of nicotine salt-based ECs. Our results suggest that increasing excise taxes on combustible cigarettes remains a viable policy strategy to raise cigarette prices and thus reduce cigarette smoking. As cigarette excise tax pass-through rates are lower for lower priced cigarettes and for states imposing lower taxes, continuing to raise cigarette taxes and additional pricing policies such as price promotion restrictions are needed to increase retail prices and reduce price minimisation opportunities. Further research to monitor tobacco industry pricing strategies in response to increases in excise taxes is merited as the tobacco marketplace continues to evolve.

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