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Making a Smooth Exit? Menthol Bans and Cigarette Sales in Massachusetts

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Abstract. Public health regulators in the United States are currently advocating for a ban on menthol-flavored cigarettes because they are believed to be more dangerous than traditional nonmenthol cigarettes. However, these bans will have limited benefits if consumers are able to circumvent them. We examine this issue by evaluating the effects of a statewide menthol ban that was instituted by Massachusetts in 2020. An examination of store-level retail sales data from Massachusetts indicates that some demand shifted from menthols to nonmenthols after the ban was instituted, thereby supporting the goals of the ban. However, broadening our analysis to neighboring states shows a sharp increase in menthol sales in areas just outside the Massachusetts border, thereby suggesting that many Massachusetts residents were able to get around the ban by engaging in cross-state shopping for menthol cigarettes. This cross-state shopping is damaging because it reduces the tax revenue for Massachusetts while also not yielding any positive public health benefits among its population. To provide policy makers with guidance regarding the benefits of alternative policies, we develop and estimate a structural model that accounts for heterogeneity in (i) prices across states, (ii) distances from state borders, and (iii) menthol shares across Massachusetts. We show that a statewide menthol tax might be preferable over either a statewide menthol ban or a national ban because it yields sizable reductions in smoking activity while also generating up to 14% in additional tax revenue.

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1. Introduction

Menthol-flavored cigarettes represent over one third of cigarettes sold in the United States (Villanti et al. 2022). Menthol is a chemical additive that adds a cooling, minty sensation to cigarettes when they are smoked. Since 2009, menthol cigarettes have been the only flavored cigarette permitted to be sold in the United States; all other flavors and additives were banned as part of the Tobacco Control Act (U.S. Food and Drug Administration 2009).

The U.S. Food and Drug Administration (FDA) has concluded that menthol cigarettes pose a number of additional dangers compared with nonmenthol cigarettes. The cooling sensation in menthols makes them less harsh to smoke compared with nonmenthols, and this leads to increased smoking initiation among new smokers (U.S. Food and Drug Administration 2013). Furthermore, menthol binds to chemical receptors in the brain, and "the combined effects of menthol and nicotine in the brain are associated with behaviors indicative of greater addiction to nicotine compared to nicotine alone" (U.S. Food and Drug Administration 2022b, p. 26457). Overall, the FDA has concluded that "menthol cigarettes pose a public health risk above that seen with nonmenthol cigarettes" (U.S. Food and Drug Administration 2013).

In response to these public health concerns, over 150 cities and counties in the United States have banned the sale of menthol cigarettes (Bach 2022). A federal ban on menthol cigarettes was proposed by the FDA in early 2022, but this has not yet passed the proposal stage (Jewett 2022). At the state level, the first menthol ban was passed in Massachusetts (MA), followed by California. One challenge with local and state bans is that residents may circumvent the rules by traveling to a neighboring area to purchase menthol cigarettes; these patterns have been documented in other contexts, like alcohol taxes and soda taxes (Asplund et al. 2007, Seiler et al. 2021). In those contexts, people engage in cross-border shopping because it helps them save money relative to buying these items at their local store. In the context of a menthol ban, cross-border shopping is even more enticing because it is the only legal way to buy the products.

In this research, we analyze retail sales data to examine the effect of the Massachusetts menthol ban that started during June 2020. We have two research goals: to evaluate how the Massachusetts menthol ban affected sales and consumption of cigarettes and then, to predict what would have happened if the government had passed an alternative policy instead. This approach allows us to both measure the effects of the policy that was enacted in reality and also, to compare it with other possibilities that have been proposed.

Our initial goal is to understand how the ban affected sales and consumption of cigarettes, and we account for the possibility that Massachusetts residents may be engaging in cross-border shopping. We focus on two outcomes of the ban: the reduction in demand for menthol cigarettes and the overall reduction in demand for cigarettes. Both of these issues are relevant to regulators because of their public health implications, and they were cited by the FDA as two of the key outcomes that their proposed ban on menthol cigarettes was intended to produce (U.S. Food and Drug Administration 2022b).

We model the Massachusetts menthol ban's effect on demand using two empirical approaches: a difference-in-difference model and a synthetic control model. Both of these models yield similar results and takeaways. (1) Some Massachusetts residents switched to nonmenthol cigarettes, so nonmenthol demand rose by about 10%. (2) About half of the pre-ban menthol demand in Massachusetts was diverted to neighboring states after the ban was implemented. (3) Some nonmenthol demand was also diverted to neighboring areas, and (4) total cigarette demand among Massachusetts residents remained relatively stable. These facts indicate that the efficacy of the menthol ban was hampered by cross-border shopping, which was particularly relevant in Massachusetts for two reasons. Massachusetts has much higher cigarette prices and cigarette taxes compared with some of its neighboring states, and Massachusetts is also a geographically small state, in which most residents live within a short drive of a neighboring state.

Cross-border shopping leads to two downsides of the Massachusetts menthol ban. Massachusetts lost out on a significant amount of tax revenue while also not fully eliminating menthol cigarette usage among Massachusetts residents. Every menthol sale that was diverted out of the state had negative financial implications for Massachusetts while also not yielding any public health benefits for Massachusetts residents. To examine this issue further, we estimate a structural model using store sales data, in which consumers' cigarette purchasing decisions are modeled as a function of their preferences between menthols and nonmenthols, their price sensitivities, and their willingness to incur travel costs to buy cigarettes at stores that are out of state. Given the paucity of information on the portion of cigarettes consumed in Massachusetts that were purchased out of state in the pre-ban period, we augment our structural model by leveraging additional ancillary data on cigarette consumption and taxes in a manner similar to Petrin (2002) and Albuquerque and Bronnenberg (2009).

This structural model allows us to estimate the effect of two alternative policies that could be used to reduce menthol consumption: a national ban on menthol sales and a Massachusetts menthol tax rather than a ban. First, we find that the national ban would lead to substantially better outcomes than the state-specific ban in terms of menthol consumption and total cigarette consumption. Second, we show that a Massachusetts menthol tax (above and beyond the standard cigarette tax) would be able to reduce menthol consumption in the state while also increasing the state's tax revenue compared with the pre-ban status quo. For instance, a \$6 menthol tax would increase tax revenues by about 14% while leading to a 28% reduction in menthol consumption. Third, we find that the effects of the statewide Massachusetts menthol ban varied across different demographic groups. Prior research has shown that Black consumers have received the bulk of advertising for menthol cigarettes and also provide the majority of sales for menthol cigarettes in the United States (Kaplan 2021, Food and Drug Administration 2022a, Jewett 2022, Ferré-Sadurni 2023), and we find that the Massachusetts menthol ban had a disproportionate effect on Black consumers by causing them to change their buying habits more and to incur larger travel costs compared with non-Black smokers.

This research is part of the literature on how menthol bans affect the demand for cigarettes. Survey data have indicated that menthol bans that apply to smaller geographic areas are less effective at reducing menthol consumption. For instance, Yang et al. (2020) shows that 70% of San Francisco menthol smokers continued to smoke menthol cigarettes after a citywide ban on menthol sales was instituted, but those prevalence numbers drop to 44% and 20% when looking at data from similar menthol bans in England and Canada, respectively (Chung-Hall et al. 2022, East et al. 2022). These patterns underline the importance of measuring cross-border shopping, as menthol bans applied to smaller geographic areas enable a higher percentage of menthol smokers to circumvent a retail sales ban in their local area.

Prior research has shown that menthol smokers have lower rates of smoking cessation compared with nonmenthol smokers (Lewis et al. 2014, Levine 2022). Given these patterns, a related stream of research examines to what extent menthol smokers respond to menthol bans by switching to nonmenthol cigarettes versus stopping smoking entirely. Canada instituted a series of province-specific menthol bans in the mid-2010s followed by a national ban in 2017; recent research has come to conflicting conclusions regarding whether this led to a reduction in overall smoking activity (Chaiton et al. 2020, Carpenter and Nguyen 2021, Fong et al. 2022).

More closely related to our research, there are four papers in the public health literature that use retail sales data to evaluate the 2020 Massachusetts menthol ban and its effects on tobacco use. Kingsley et al. (2022) find limited evidence of cross-border shopping by looking at aggregate time trends in retail sales. However, the fact that they do not use an econometric model means that their research suffers from a few limitations. They do not have a control group in their analysis, they do not account for time trends or seasonality, and they measure cross-border shopping by looking at sales outcomes for entire states rather than for specific regions neighboring Massachusetts. These limitations make it much harder to correctly estimate the impact of cross-border shopping. Ali et al. (2022) use a difference-in-differences model, and they find that there is no evidence for cross-border shopping. However, we believe that this result is driven by using statewide sales data rather than more granular store-level data, which dilute the effect and make the result indistinguishable from zero. Asare et al. (2022) use monthly retail data and a difference-in-differences model comparing sales in Massachusetts with sales in other states, and they find that total cigarette sales in Massachusetts declined substantially after the ban was enforced. One drawback of the analysis of Asare et al. (2022) is that they did not account for cross-border shopping. This limitation is partially addressed in an unpublished paper by Rich (2022). However, unlike us, Rich (2022) finds a substantial increase in menthol consumption after the ban was implemented (i.e., the menthol ban backfired and caused Massachusetts residents to consume more menthol cigarettes than before). We believe that this implausible result is likely because of limitations caused by the data and the modeling approach used by Rich (2022), and we provide a more detailed examination in Section A in the online appendix.

More broadly, our research contributes to the marketing literature on how to reduce smoking activity. Prior research has examined a wide range of possible interventions, including the following: removing all brand logos and design elements from cigarette packages (Freeman et al. 2008, Bonfrer et al. 2020), reducing the number of retail stores that sell cigarettes (Polinski et al. 2017, Goli and Chintagunta 2021), restricting the advertising of e-cigarettes (Tuchman 2019), banning television product placement for cigarette brands (Goli et al. 2022), increasing cigarette excise taxes (Gordon and Sun 2015, Wang et al. 2016, Chen and Rao 2020), and limiting cigarette use in public areas (Wang et al. 2021). We add to this literature by now examining how banning or taxing menthol cigarettes affects menthol consumption and overall cigarette consumption more broadly.

2. Data

We use NielsenIQ weekly retail scanner data for 2019 and 2020. The data set contains weekly prices, quantity, and product characteristics for the products sold across a number of stores in the United States. NielsenIQ does not share the exact location or identity of the stores; however, a number of characteristics, including county information, zip code, and the type of retailer, are provided in the data. In Section B in the online appendix, we discuss additional technical details regarding the data definitions.

The Massachusetts menthol ban was enforced starting June 1, 2020. In response to this ban, some Massachusetts residents' cigarette purchases were diverted to neighboring states. In Section C in the online appendix, we show that this spillover effect is limited to a 30-mile ring surrounding Massachusetts. Therefore, the Massachusetts menthol ban "treats" two different groups; stores in the state of Massachusetts are negatively affected by the ban because they can no longer sell menthols, whereas non-Massachusetts stores within 30 miles of the Massachusetts border are positively affected by the ban because they are being visited by additional customers who are crossing the state border. Meanwhile, stores that are not in Massachusetts or the states bordering it (i.e., stores not in New York (NY) or New England) can serve as the control group for our analysis because these stores were unaffected by the Massachusetts menthol ban.

Table 1 provides a summary of the key variables in our sales data. There are two "flavors" in the data: menthol and nonmenthol. Menthols account for about 27% of all cigarette sales in the areas we examine. The unit of observation for our empirical analysis is a store-flavor-week combination, and we have nearly 8 million of these observations in our data.[1]

In a subset of our subsequent analyses, we calculate the total weekly cigarette sales in Massachusetts and the 30-mile ring surrounding it in order to assess the overall impact of the ban, including cross-border shopping. We refer to this agglomerated area as MA + 30. This aggregation task requires us to combine the sales across stores located in different geographies. A simple aggregation across the stores could be misleading because NielsenIQ does not collect data from every single store, and the portion of cigarettes sales recorded in the NielsenIQ data could vary across states. We correct for this issue by reweighting the store-level sales data, and the details for this procedure are provided in the online appendix.

3. Descriptive Evidence

We now examine the data to see whether any clear sales patterns arise from model-free evidence. First, we examine how cigarette sales in Massachusetts were affected by the state's menthol ban. Subsequently, we look at how sales in nearby states were affected by Massachusetts

Table 1. Summary of Store-Level Variables Used in Our Analyses

Variable	Massachusetts region (i)	30-Mile ring around Massachusetts region (ii)	Outside New York and New England region (iii)
Number of stores	558	617	36,852
Number of weeks	104	104	104
Number of flavors	2	2	2
Number of store-flavor-weeks	116,064	128,336	7,665,216
Share of menthol (%)	27.90	26.73	27.02
Avg. pretax price—menthol (2019)	9.42	8.86	6.39
Avg. pretax price—nonmenthol (2019)	9.37	8.22	6.22
Avg. post-tax price—menthol (2019)	12.93	12.37	7.76
Avg. post-tax price—nonmenthol (2019)	12.88	11.29	7.61
Avg. # of packs sold per week (2019)	395.47	577.68	417.37

Notes. The stores are located across three regions: (i) Massachusetts, (ii) a 30-mile ring around Massachusetts, and (iii) those located outside of New England and New York. Note that stores in both regions (i) and (ii) are affected by Massachusetts' menthol ban and that stores in region (iii) serve as the control group.

residents engaging in cross-border shopping after the menthol ban was instituted.

3.1. Impact on Massachusetts Sales

The Massachusetts menthol ban took effect on June 1, 2020. To study the impact of this policy, we examine calendar years 2019 and 2020. Figure 1 shows weekly cigarette sales in Massachusetts and the rest of the country (excluding New England and New York).[2] As expected, we observe that menthol cigarette sales fall to zero after the policy implementation as illustrated in Figure 1(a). Figure 1(b) demonstrates that nonmenthol cigarette sales in Massachusetts go up after the menthol ban, thereby implying that some consumers have substituted nonmenthol cigarettes. However, as depicted in Figure 1(c), this increase in nonmenthol sales does not cancel out the decline in menthol sales. Instead, overall cigarette sales in Massachusetts drop significantly after the ban.[3]

This analysis is limited because it does not account for cross-border shopping. To provide a more complete picture of the impact of the menthol ban, we need to also examine what happens just outside the Massachusetts border. This analysis is the focus of the following section.

3.2. Spillover on Neighboring Areas in New England and New York

One reason for the large drop in overall cigarette sales in Massachusetts might be that some of the Massachusetts sales have shifted to stores in neighboring states. To study this, we consider zip codes within 30 miles of the Massachusetts border. This 30-mile ring contains stores from New York, Vermont (VT), Connecticut (CT), Maine, Rhode Island (RI), and New Hampshire (NH). Figure 2 depicts Massachusetts and the 30-mile surrounding area in a darker shade. Our choice of a 30-mile ring is based on empirical analysis; in Section C in the online appendix, we show a series of regressions where we find a (declining) treatment effect up to the 30-mile mark. The effect is strongest for stores that are closest to the Massachusetts border, declines significantly for stores located in the 10- to 30-mile distance band from Massachusetts, and becomes indistinguishable from zero thereafter.

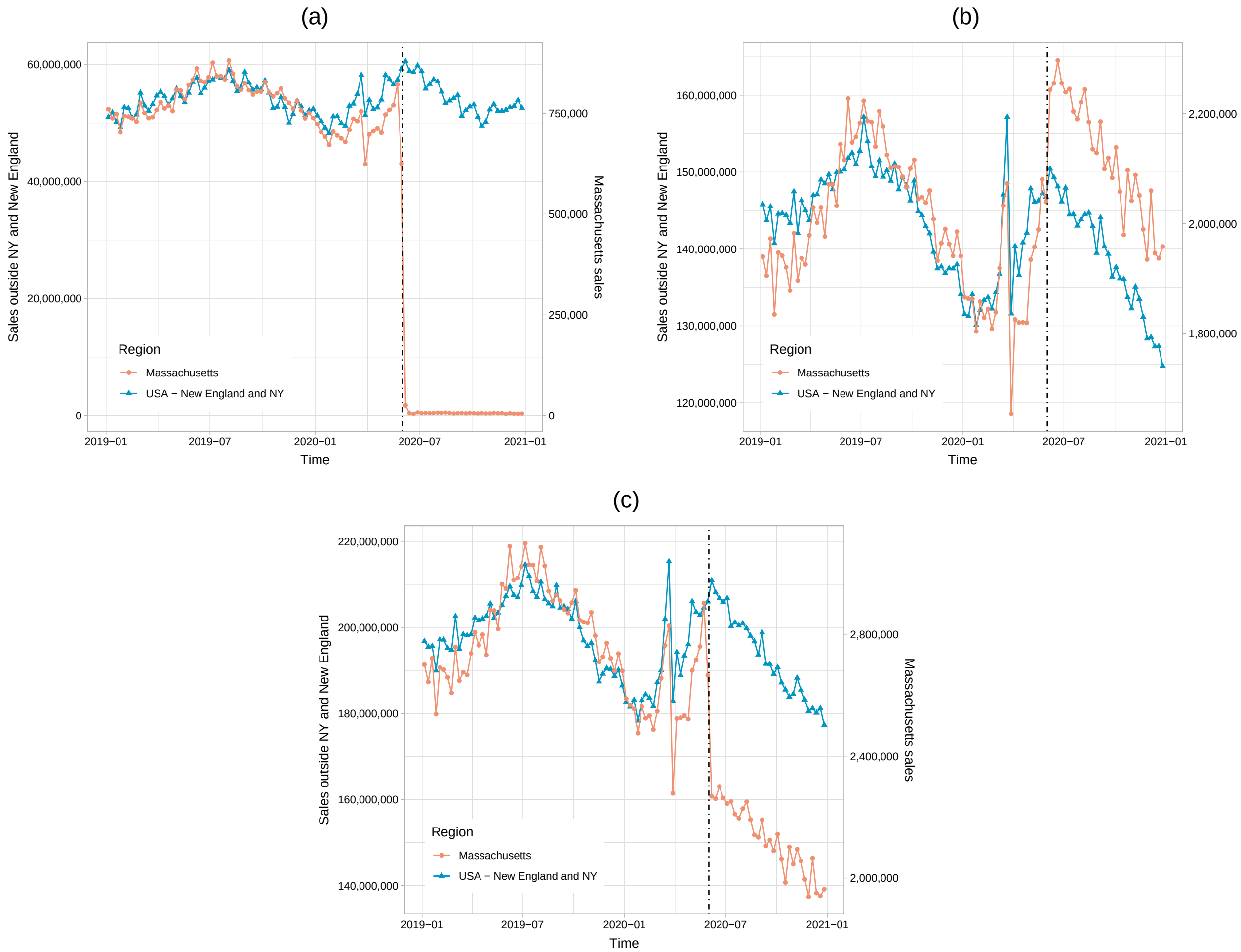
We now focus on the 30-mile area surrounding Massachusetts and plot weekly menthol and nonmenthol cigarette sales in Figure 3. Interestingly, we document an increase in both menthol (Figure 3(a)) and nonmenthol (Figure 3(b)) cigarette sales in the neighboring states. This indicates that the menthol ban intensified cross-border shopping for both menthol cigarettes and nonmenthol cigarettes, perhaps because households that smoked menthols and nonmenthols decided to buy both kinds of cigarettes when they crossed the border.[4]

More broadly, the patterns in Figure 3 highlight the importance of accounting for cross-border purchases when examining the effects of the Massachusetts menthol ban. In the next section, we take a closer look at the effects of the policy and measure the extent of substitution to nonmenthol and/or out-of-state options.

4. Empirical Analysis

Our empirical analysis builds on the descriptive evidence provided in Section 3. We now move to quantifying how the Massachusetts menthol ban affected cigarette sales in Massachusetts after accounting for cross-border shopping. We first measure the effect of the menthol ban on stores located in Massachusetts by comparing stores in Massachusetts versus stores in the control region (i.e., region (i) versus region (iii), as defined in Table 1). Next, to estimate the overall treatment effect of the ban, we include the 30-mile ring around Massachusetts and compare regions (i) + (ii) with region (iii). These regions are displayed in Figure 4. Finally, we estimate a structural model that allows us to evaluate alternative policies, like a national menthol ban and a Massachusetts menthol tax.

Figure 1. (Color online) Cigarette Sales in Massachusetts vs. Other States



Notes. (a) Menthol cigarette sales (packs). (b) Nonmenthol cigarette sales (packs). (c) Total cigarette sales (packs).

4.1. Investigating the Massachusetts Menthol Ban

To quantify the effect of the menthol ban, we first aggregate the sales data to the state level.[5] We also construct a price index for each state by calculating the sales-volume weighted average of store-specific price indexes. We consider the following difference-in-differences specification based on a standard log-log demand model:

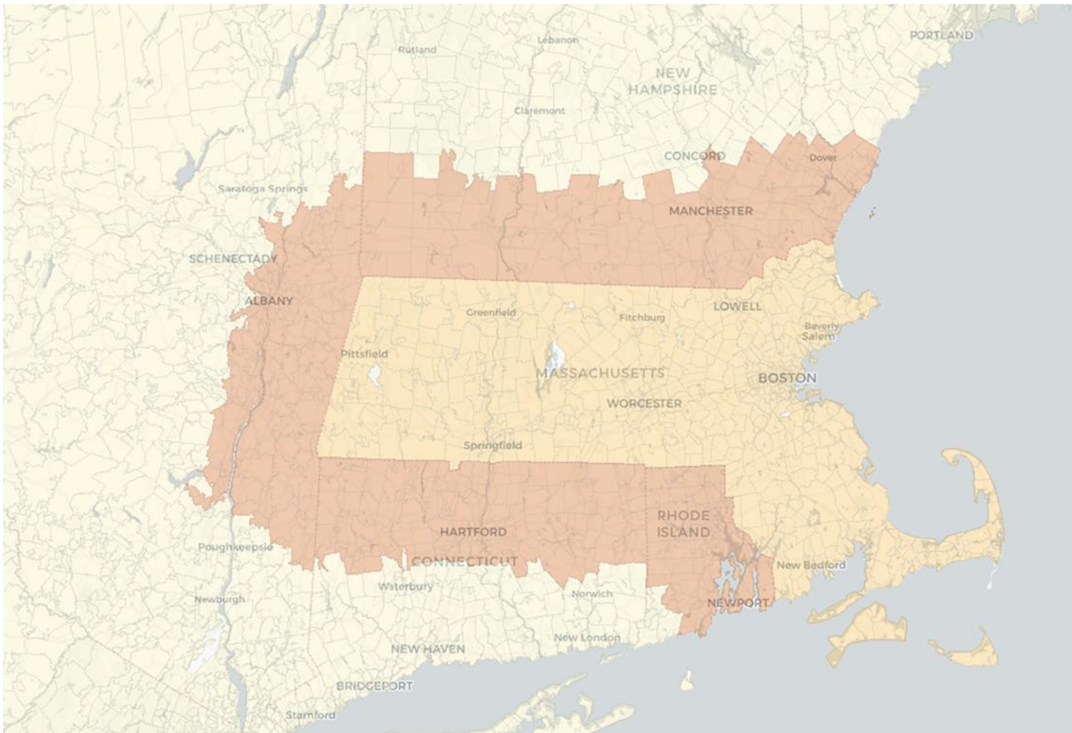
$$\begin{aligned}\log(1+Q_{st}) = {} & \alpha \cdot \mathbb{1}_{\{s=\text{MA}\}} \cdot \mathbb{1}_{\{t \geq \text{June 1, 2020}\}} + \gamma \cdot \mathbb{1}_{\{s=\text{MA}\}} \\ & + \delta \cdot \mathbb{1}_{\{t \geq \text{June 1, 2020}\}} + \beta \log(P_{st}) \\ & + \eta_s + \eta_t + \epsilon_{st}, \end{aligned} \tag{1}$$

where s and t index state and week, respectively. The outcome of interest is Q_{st}, which is the number of cigarette packs sold in state s during week t in our analysis. We also control for cigarette prices P_{st} in a given state s and week t and include η_s and η_t to control for state- and week-level fixed effects. We run this regression twice: once for nonmenthol cigarette sales and once for total cigarette sales.[6]

The results of these regressions are presented in Table 2. Our preferred specifications for nonmenthols and total cigarettes are models (3) and (6), respectively; both of these include fixed effects by state and week. Our results show a $\exp(0.094) - 1 = 9.9\%$ increase in nonmenthol cigarette sales and a $\exp(-0.237) - 1 = -21.1\%$ decline in overall cigarette sales in Massachusetts relative to states outside the New England and New York region. These results remain similar if we use a synthetic control model rather than a difference-in-differences model or if we estimate a linear demand model rather than a log-log model; details and results of these procedures are presented in Sections D and E in the online appendix, respectively.[7]

Our descriptive evidence in Figure 3(c) demonstrated that stores in neighboring states but within 30 miles of the Massachusetts border received a substantial increase in cigarette sales after the Massachusetts menthol ban was introduced. To account for cross-border shopping, we now evaluate how the menthol ban affected sales in the full MA + 30 area. Our approach is to reestimate

Figure 2. (Color online) Massachusetts and the 30-Mile Surrounding Area



Equation (1), but we replace Massachusetts with the greater MA + 30 region. The full estimating equation is shown in Equation (2):

$$\log(1+Q_{st}) = \alpha \cdot \mathbb{1}_{\{s=\text{MA}+30\}} \cdot \mathbb{1}_{\{t\geq \text{June 1, 2020}\}} + \gamma \cdot \mathbb{1}_{\{s=\text{MA}+30\}} + \delta \cdot \mathbb{1}_{\{t\geq \text{June 1, 2020}\}} + \beta \log(P_{st}) + \eta_s + \eta_t + \epsilon_{st}. \quad (2)$$

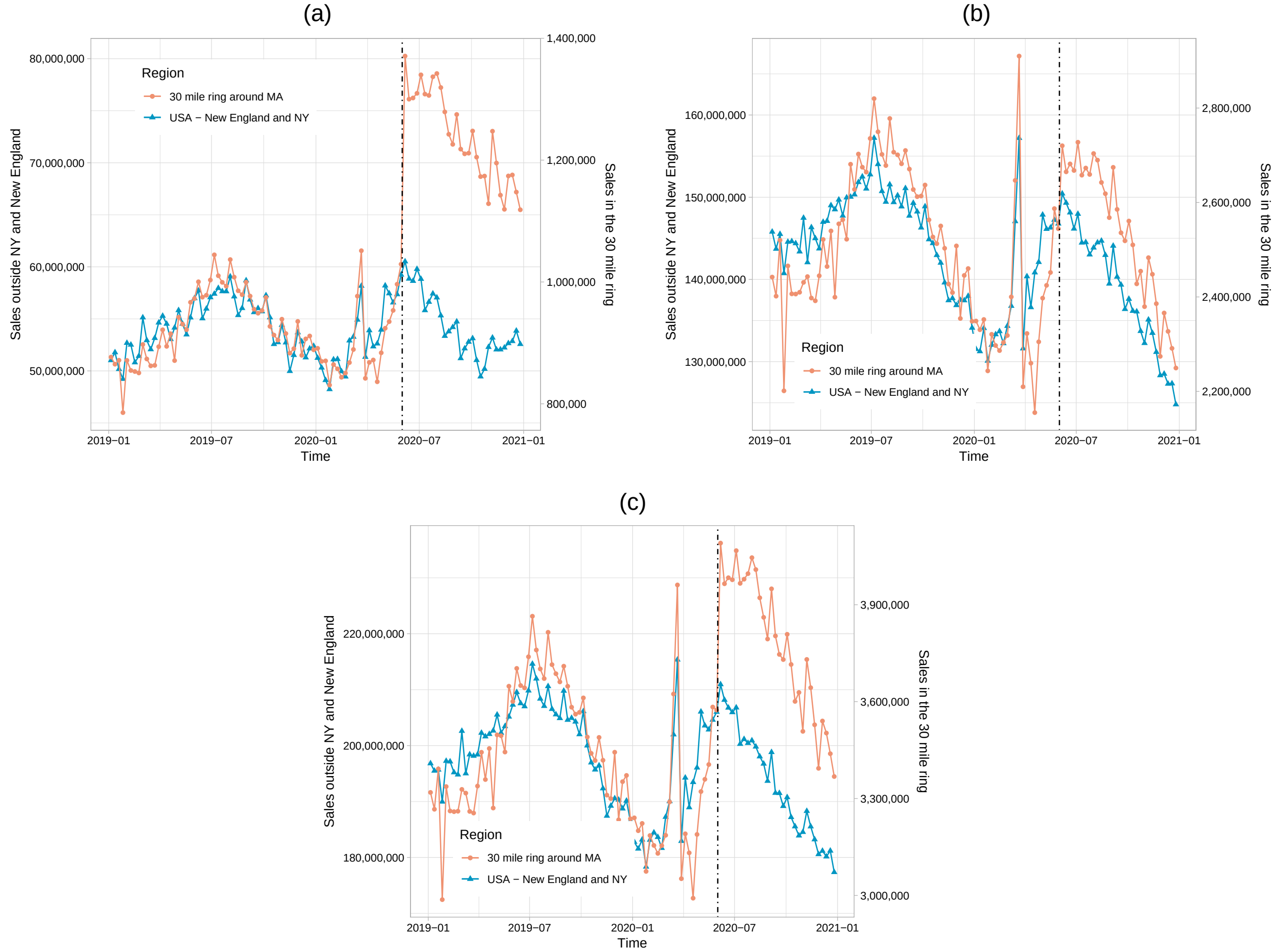
The results of this analysis are presented in Table 3. Our results indicate that nonmenthol sales in the MA + 30 area have increased by $\exp(0.073) - 1 = 7.6\%$, that menthol sales have changed by $\exp(-0.288) - 1 = -25\%$, and that the overall cigarette sales have changed by $\exp(-0.018) - 1 = -1.8\%$.

These regression results in Table 3 correspond to demand changes in the full MA + 30 area. In order to understand demand changes specifically among people who bought cigarettes in Massachusetts before the ban was enforced, we need to reweight these estimated quantities. First, we need to assume that any substantial changes in cigarette sales in the MA + 30 area are caused by Massachusetts customers responding to the menthol ban either by changing their purchasing behavior within Massachusetts or by engaging in cross-border shopping. Second, we need to calculate what percentage of menthol cigarette sales in the MA + 30 region took place in Massachusetts. Using the NielsenIQ sales data before the menthol ban was implemented, we compute the proportion of menthol sales that occurred in Massachusetts versus the larger MA + 30 region, and we find that 46% of these menthol sales took place in Massachusetts.

Our goal is to evaluate how the menthol ban affected customers who used to buy their cigarettes in Massachusetts before the menthol ban was enforced while also accounting for cross-border shopping. We can define the following quantities of interest.

- The treated population refers to people buying cigarettes in Massachusetts before the ban was enforced.
- The treated region is Massachusetts plus the 30-mile ring around it, which we refer to as MA + 30. People buying cigarettes in Massachusetts are the only ones directly treated by the menthol ban, but stores located in the 30-mile ring are indirectly treated because of cross-border shopping.
- The treatment propensity is the proportion of MA + 30 menthol sales that occur in Massachusetts. As defined, this value is 46%.
- The intent to treat treatment effect (ITT) is the change in sales in the MA + 30-treated area caused by the MA menthol ban. We can calculate this ITT for menthol sales, nonmenthol sales, or total cigarette sales.
- The average treatment effect on the treated (ATT) is the change in purchases specifically among Massachusetts customers caused by the MA menthol ban. We can calculate this ATT for menthol sales, nonmenthol sales, or total cigarette sales. The distinction between the ATT and the ITT is that the ATT measures changes among Massachusetts customers, whereas the

Figure 3. (Color online) Cigarette Sales in the 30-Mile Ring Surrounding Massachusetts vs. Other States That Do Not Share a Border with Massachusetts



Notes. (a) Menthol cigarette sales (packs). (b) Nonmenthol cigarette sales (packs). (c) Total cigarette sales (packs).

ITT measures changes in the entire MA + 30 region. The key assumption when calculating the ATT is that any postban sales changes in the MA + 30 region are attributable to changes in behavior among Massachusetts customers, not among customers in the 30-mile ring around the state. This assumption is justified by our definition of the treated population as consisting of Massachusetts customers.

The ITT for menthol cigarettes was calculated previously in Table 3, which shows that menthol sales in the MA + 30 area have changed by −25.04% after the ban. Therefore, the ATT can be calculated as the ITT divided by the treatment propensity:

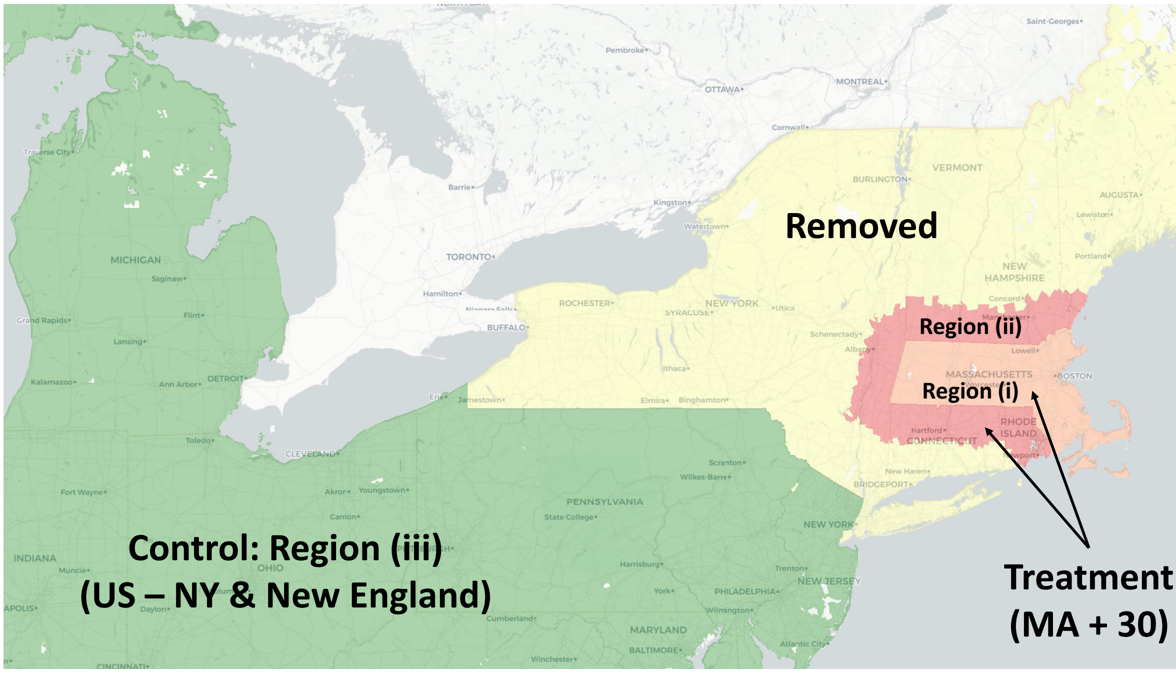
$$\begin{aligned}\text{ATT for menthols } &= \frac{\text{ITT for menthols}}{\text{treatment propensity}}\\ &= \frac{-25.04\%}{0.46}\\ &= -54.47\%.\end{aligned}$$

The estimated ATT for menthol cigarettes is −54.47%. This implies that menthol purchases among Massachusetts residents fell by roughly one half after the menthol ban was instituted, once we account for cross-border shopping. One limitation of this analysis is that it does not account for cross-border sales that were already occurring before the menthol ban was instituted. Later in this paper, we address this issue by using a structural model in Section 4.3.

We can calculate similar ITT and ATT estimates for nonmenthol sales and for total cigarette sales. Table 4 summarizes the results. We document a 9.86% increase in nonmenthol cigarette sales inside Massachusetts, whereas the MA + 30 analysis suggests an implied 17.05% increase in nonmenthol cigarette sales. Together, this means that about 17.05% − 9.86% = 7.19% of nonmenthol cigarette sales along with 100% − 54.47% = 45.53% of menthol sales have shifted to other states outside of Massachusetts.

There are multiple possible explanations behind this result. One possibility might be that consumers want to purchase menthols and nonmenthols in the same purchase occasion, so they have to visit a state outside Massachusetts in order to do that. A second possibility is that

Figure 4. (Color online) Different Areas Used in the Difference-in-Differences Analyses in Section 4.1



Notes. We first compare regions (i) and (iii) to investigate the effect of the ban on Massachusetts. Next, we compare regions (i) + (ii) and (iii) to measure the overall effect of the ban (including its spillover).

consumers have changed their store choice decisions; because the product assortment has gone down among Massachusetts stores, the consumer utility derived from shopping there is now lower than comparable stores across the state border. Note that with store-level data, these two explanations are observationally equivalent, so we are unable to distinguish between them.[8] In Section 4.2.2, we develop a structural model that is able to capture this behavior through a nested logit specification, in which the inclusive value from choosing a

Table 2. The Impact of the Massachusetts Menthol Ban on Nonmenthol and Overall Cigarette Sales in Massachusetts Relative to States Outside New England and New York

	Dependent variable					
	log(*Nonmenthol packs* + 1)			log(*Total packs* + 1)		
	(1)	(2)	(3)	(4)	(5)	(6)
MA × *Post June 2020* (α)	0.090***	0.089***	0.094***	−0.242***	−0.241***	−0.237***
	(0.011)	(0.005)	(0.006)	(0.012)	(0.006)	(0.006)
MA (γ)	0.056			0.097		
	(0.308)			(0.316)		
Post June 2020 (δ)	−0.005	−0.0004		0.007	0.003	
	(0.031)	(0.005)		(0.033)	(0.006)	
Log *nonmenthol price index* (β)	−0.799	−0.897***	−0.482***	−0.832	−0.745***	−0.405***
	(0.710)	(0.100)	(0.104)	(0.737)	(0.091)	(0.107)
Constant	13.846***			14.105***		
	(0.824)			(0.851)		
State FE		X	X		X	X
Week FE			X			X
Observations	4,264	4,264	4,264	4,264	4,264	4,264
R^2	0.027	0.994	0.998	0.028	0.995	0.998
Adjusted R^2	0.026	0.994	0.998	0.027	0.995	0.998
Residual standard error	0.820	0.062	0.038	0.860	0.063	0.040
	(df = 4,259)	(df = 4,220)	(df = 4,118)	(df = 4,259)	(df = 4,220)	(df = 4,118)

Notes. All standard errors are clustered at the state level. df, degree of freedom; FE, fixed effect.
***$p < 0.01$.

Table 3. The Effect of the Massachusetts Menthol Ban on Cigarette Sales in the Agglomerated MA + 30 Region Compared with States Outside New England and New York

	Dependent variable								
	log(*Nonmenthol packs* + 1)			log(*Menthol packs* + 1)			log(*Total packs* + 1)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(MA + 30 Miles) × *Post June 2020* (α)	0.072***	0.071***	0.073***	−0.284***	−0.289***	−0.288***	−0.020**	−0.020***	−0.018***
	(0.007)	(0.006)	(0.006)	(0.012)	(0.011)	(0.010)	(0.008)	(0.006)	(0.006)
MA + 30 Miles (γ)	0.804***			0.995***			0.837***		
	(0.258)			(0.322)			(0.264)		
Post June 2020 (δ)	−0.005	−0.0004		0.040	0.018**		0.007	0.003	
	(0.031)	(0.005)		(0.051)	(0.008)		(0.033)	(0.006)	
Log *nonmenthol price index* (β)	−0.799	−0.897***	−0.488***	−0.931	−0.501***	−0.585***	−0.832	−0.744***	−0.413***
	(0.710)	(0.100)	(0.105)	(0.897)	(0.102)	(0.173)	(0.737)	(0.090)	(0.107)
Constant	13.846***			12.608***			14.105***		
	(0.824)			(0.996)			(0.851)		
State FE		X	X		X	X		X	X
Week FE			X			X			X
Observations	4,264	4,264	4,264	4,264	4,264	4,264	4,264	4,264	4,264
R^2	0.036	0.995	0.998	0.027	0.995	0.997	0.034	0.995	0.998
Adjusted R^2	0.035	0.994	0.998	0.026	0.995	0.997	0.033	0.995	0.998
Residual standard error	0.820	0.062	0.038	1.040	0.078	0.055	0.860	0.063	0.040
	(df = 4,259)	(df = 4,220)	(df = 4,118)	(df = 4259)	(df = 4,220)	(df = 4,118)	(df = 4,259)	(df = 4,220)	(df = 4,118)

Notes. All standard errors are clustered at the state/region level. df, degree of freedom; FE, fixed effect.
**$p < 0.05$; ***$p < 0.01$.

Table 4. The Summary of the Effects of the Massachusetts Menthol Ban on Cigarette Sales in Massachusetts and the Agglomerated MA + 30 Region

Variable	Menthol	Nonmenthol	All
Share (2019) in Massachusetts	27.90	72.10	100.00
Change (%) in sales post ban in MA	−99.16***	9.86***	−21.08***
Change (%) in sales post ban in MA + 30	−25.04***	7.59***	−1.82***
Portion of volume sold (2019) in MA relative to MA + 30	0.46	0.44	0.45
Implied change (%) relative to sales that took place in MA	−54.47***	17.05***	−4.05***

Note. A small number of Massachusetts stores continue to sell menthol cigarettes after the ban, but over 99% strictly abide by the ban.
***$p < 0.01$.

particular store would decline if the product assortment shrank.

4.2. Modeling the Flavor and Location Choice Using a Structural Model

So far, we have focused on demonstrating and measuring the effect of the Massachusetts menthol ban. This analysis is valuable for evaluating the policy in Massachusetts, but it does not directly allow us to measure which consumers are most affected, nor does it allow us to make predictions about the nationwide menthol ban proposed by the FDA and its impact on MA residents. Our results show that about half of Massachusetts menthol demand continued in the postban period, as many Massachusetts residents engaged in cross-border shopping for menthols. Under a nationwide menthol ban, this kind of cross-state-border shopping would no longer be possible.[9] Therefore, most menthol smokers would only have two options remaining: either switch to buying nonmenthols or stop smoking altogether. Meanwhile, other policies, like a statewide menthol tax, would also affect customers' purchasing decisions but in ways that cannot currently be predicted by our reduced form analysis.

Prior to developing a formal model, we investigate the lift in menthol cigarette sales in counties just outside Massachusetts. To carry out this analysis, we use a synthetic difference-in-differences estimator (Arkhangelsky et al. 2021) to calculate the lift at the county level. A comprehensive discussion of this analysis can be found in Section I in the online appendix. The lift in menthol cigarette sales caused by to the menthol ban is depicted in Figure 5.

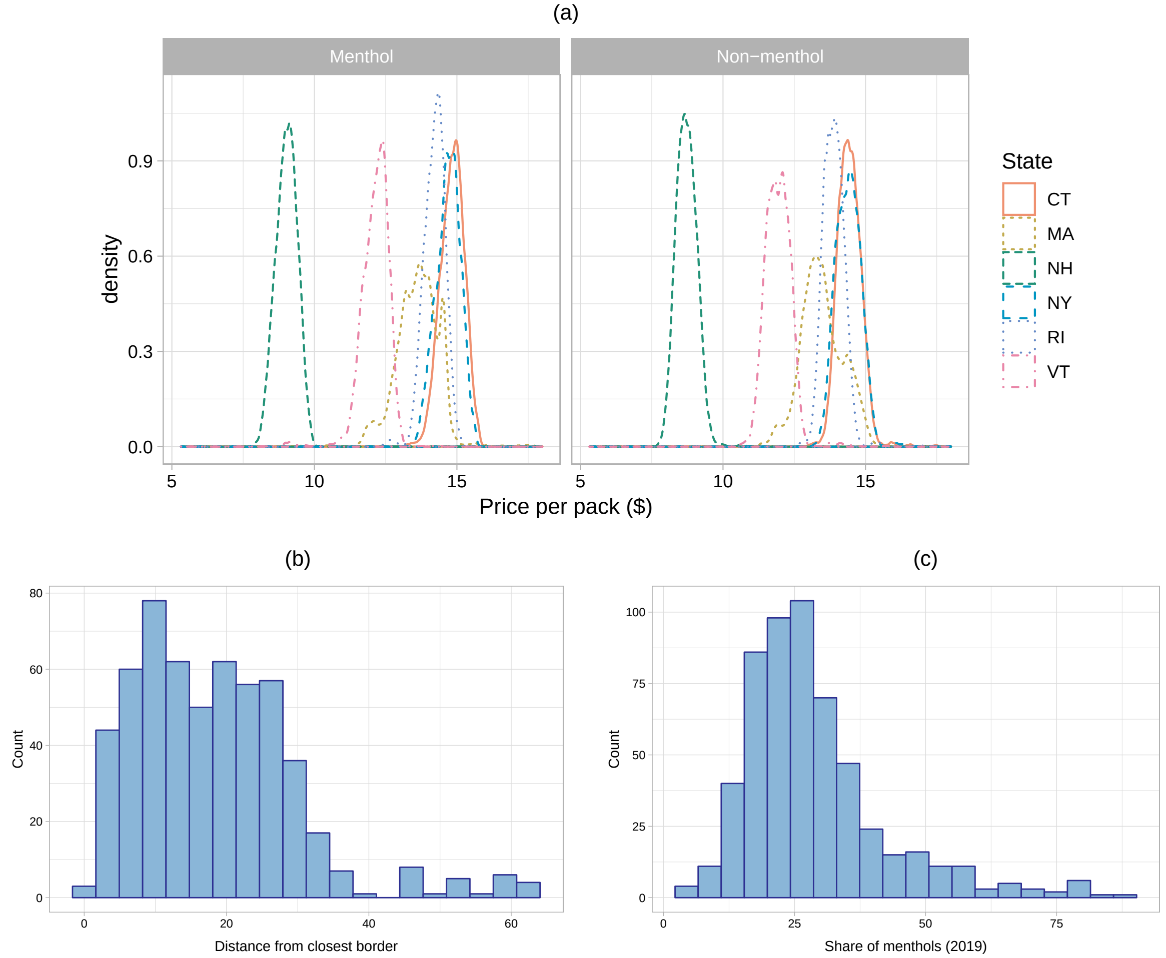
The patterns that emerge from the data in Figure 5 indicate that postban lift in cigarette sales differed significantly across counties. Counties in New Hampshire just outside the northeast border of Massachusetts experienced a much larger increase in menthol cigarette sales than counties in New York just outside the southwest border of Massachusetts (+119% versus −0.23%, respectively). These patterns appear to be a function of two factors: proximity to a major population center and cigarette prices. Areas in the southeast part of New Hampshire benefit from being close to the greater Boston area, and they also have lower prices compared with other states (see Figure 6(a)).

Although we can visually examine differences in menthol sales lifts outside the Massachusetts border, using a

Figure 5. (Color online) County-Level Increases in Menthol Cigarette Sales After the Massachusetts Menthol Ban Was Enforced

Note. Values are in percentage terms and are shown for counties neighboring Massachusetts.

Figure 6. (Color online) Heterogeneity Across Different Dimensions



Notes. (a) Price per pack (dollars). Post-tax cigarette prices across different states in the MA + 30 region during 2019. (b) Distance from closest border. Distance (miles) from the closest border across stores in Massachusetts. (c) Share of menthols (2019). Menthol share (percentage) during 2019 across stores in Massachusetts.

similar approach to analyze the impact of the ban on counties within Massachusetts is a complex task because of various factors that influence the extent of the sales decline. In Section I in the online appendix, we demonstrate that there are significant differences between counties within Massachusetts, and it is difficult to explain these patterns without a model. This is because there are numerous factors that could contribute to these differences, such as relative preferences for menthols versus nonmenthols, ease of traveling to stores in a neighboring state, proximity to stores with low tobacco prices or low tobacco taxes, etc.

Teasing apart these factors requires a more concrete model of how consumers decide which cigarettes to buy. In order to understand consumers' substitution patterns or to predict the effect of a nationwide ban or alternative policies, we need to explicitly model consumers' utility from different product and store options. This requires us to model and account for three types of heterogeneity.

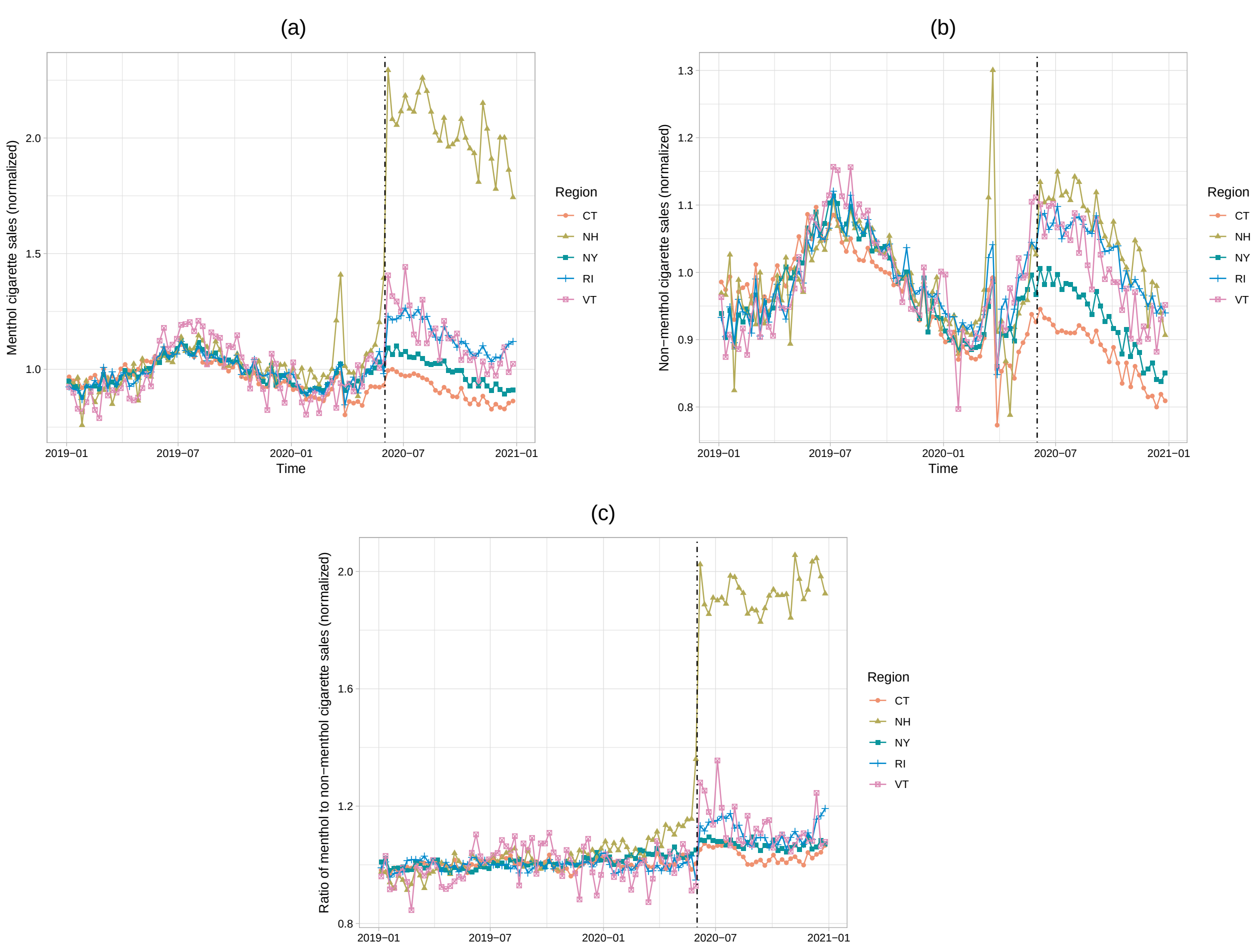
Heterogeneity in prices across states. Prices of cigarettes across the border affect consumers' purchasing patterns after additional regulations are implemented. Consumers who live near a state with cheap cigarettes will be more likely to engage in cross-border shopping versus consumers who live near a state with expensive cigarettes. For instance, one would expect diversion to out-of-state sales to be stronger for a Massachusetts market near the New Hampshire border versus a Massachusetts market near the New York border because New Hampshire has much lower tobacco prices than New York. Figure 6(a) shows the variation in tobacco prices across the states bordering Massachusetts. To generate this figure, we create a store-specific price index that measures how expensive it would be to purchase the same bundle of products from nearby stores in other states (see Section 4.2.2).

Heterogeneity in distance from borders. There is a large amount of variation in the distance of stores from state borders in Massachusetts (see Figure 6(b)). This heterogeneity affects what kinds of choices customers might make after additional regulations are imposed. Massachusetts residents who live 1 mile away from a state border can easily buy menthols even after a menthol ban is imposed in Massachusetts, whereas people who live 50 miles away from a state border would need to expend more effort and incur higher travel costs. We provide some reduced form evidence that distance from the border does indeed impact the effectiveness of the Massachusetts ban, and this affects the extent of substitution to nonmenthol cigarettes. These patterns are demonstrated in Figures 7 and 8.

Heterogeneity in menthol shares. The share of menthol cigarettes varies significantly across stores in Massachusetts because people living in different areas have different preferences for menthols versus nonmenthols (see Figure 6(c)). The impact of any menthol regulation on overall cigarette sales is a direct function of menthol cigarettes' share across different regions. Ceteris paribus, cigarette sales are expected to drop more in regions with higher menthol shares because these consumers are more affected by policies like a menthol ban or a menthol tax. In Section G in the online appendix, we show that neglecting these differences when investigating policy effects on inner areas of Massachusetts would be misleading.

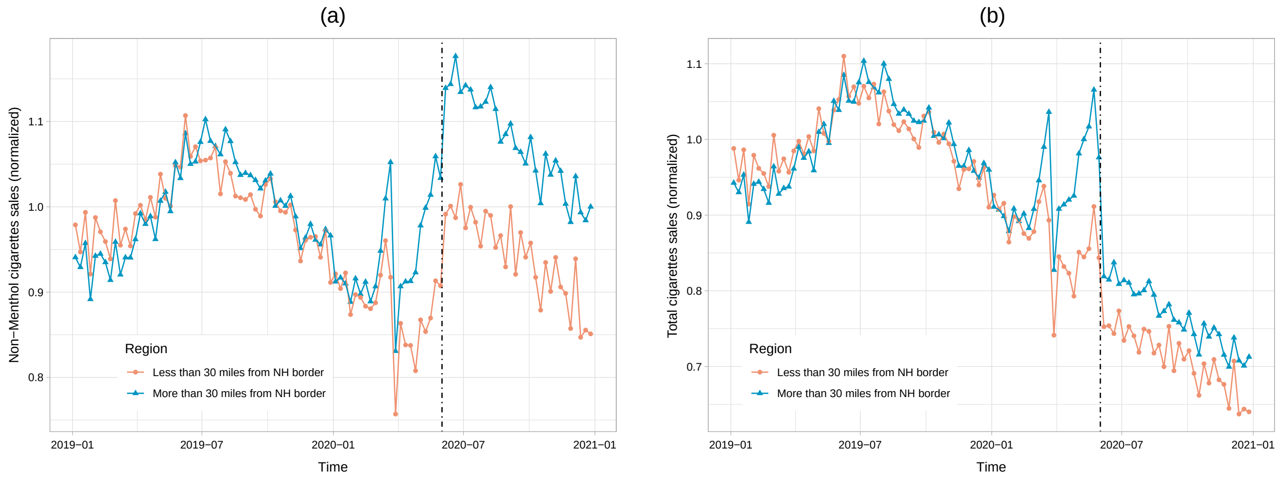
We first demonstrate the heterogeneity in each of these dimensions and then discuss how they affected the outcomes arising from the Massachusetts menthol ban. Subsequently, with our structural model in place, we examine what happens under alternative policies, such as a nationwide menthol ban or a menthol tax. To examine the variation in prices, Figure 6(a) compares the distribution of post-tax prices for menthol and nonmenthol cigarettes in the MA + 30 region during 2019. This figure illustrates that New Hampshire has by far the lowest post-tax prices for both menthol and nonmenthol cigarettes. Meanwhile, the prices in the other neighboring states (including Massachusetts) are roughly in line with each other. Figure 6(b) and (c) displays the histogram of distance (in miles) from the nearest state border and

Figure 7. (Color online) Change in Menthol Cigarette Sales in Massachusetts Neighboring States



Notes. (a) Menthol sales. (b) Nonmenthol sales. (c) Ratio of menthol to nonmenthol sales.

Figure 8. (Color online) Change in Cigarette Sales as a Function of Distance from the New Hampshire Border



Notes. (a) Nonmenthol sales. (b) Total cigarette sales.

menthol share (percentage) in 2019 for stores located in Massachusetts. This variation helps motivate the parameterization of our structural model.

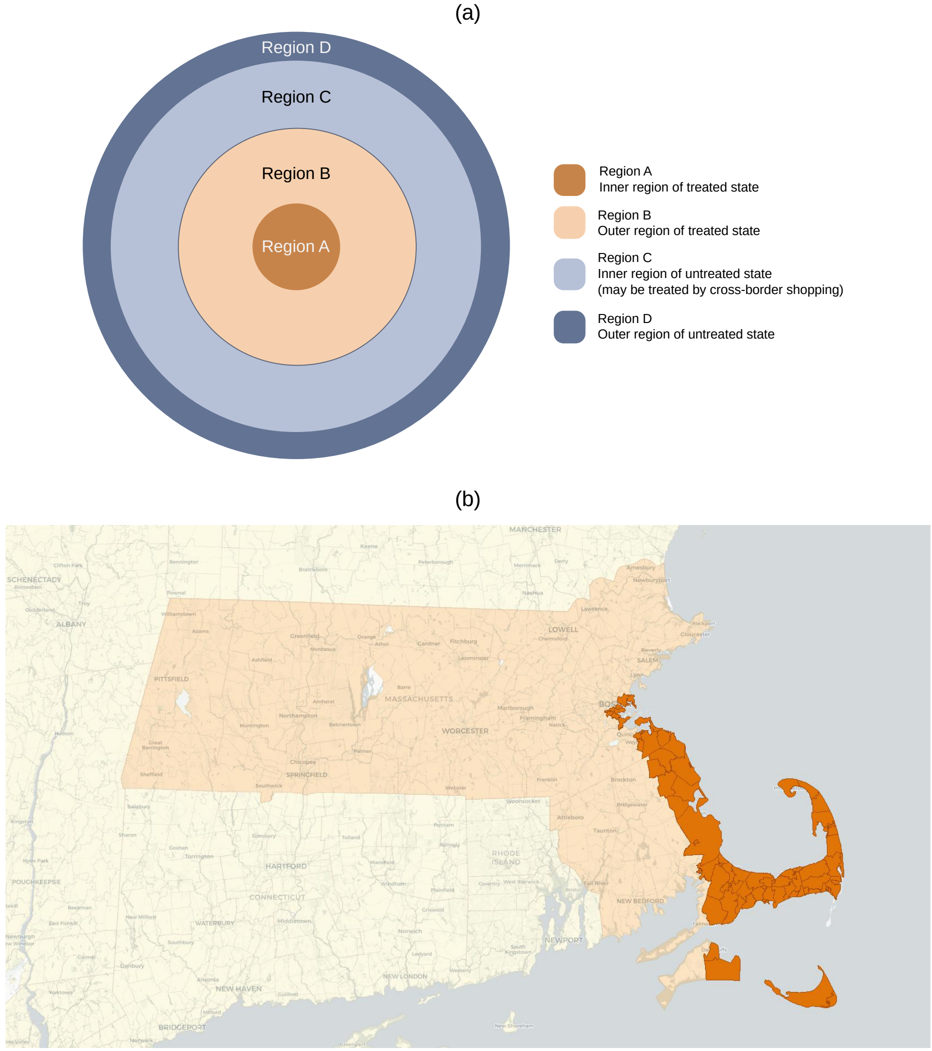
In Figure 3, we showed that stores in the 30-mile ring around Massachusetts benefited from the Massachusetts menthol ban by receiving an increase in menthol sales as well as nonmenthol sales. We now examine this phenomenon at a more granular level by splitting these stores by the state in which they are located. Results of this exercise are displayed in Figure 7(a) and (b). Similar to Figure 3, we document an increase in both menthol and nonmenthol cigarette sales in the neighboring states. These figures also show that the sales increase is noticeably stronger in New Hampshire, likely because New Hampshire shares a large border with Massachusetts and also has the lowest cigarette prices in the region. To ensure that these effects are not caused by an unrelated increase in tobacco use, Figure 7(c) compares the ratio of menthol with nonmenthol cigarette sales before and after the implementation date across different states. All of the neighboring states display an increase in this ratio after the Massachusetts menthol ban is instituted, but once again, the effect seems to be especially large for New Hampshire compared with the other states.

Our results in Figure 7 demonstrate that a large portion of sales seem to have shifted to New Hampshire, which suggests that customers located near the New Hampshire border are less affected by the ban because of the ease and convenience of buying cheap menthol cigarettes in New Hampshire; they are likely to keep smoking menthols, but they will just be buying them across the state border. In comparison, customers located far from the New Hampshire border are relatively more likely to shift their tobacco consumption from menthols to nonmenthols because it would be more costly for them to engage in cross-border shopping.

To illustrate this, we focus on the distance from New Hampshire as our results in Figure 7 suggest that a large portion of sales were diverted to New Hampshire.[10] We partition stores in Massachusetts into two groups: those that are located farther than 30 miles from the New Hampshire border versus those that are within 30 miles of the New Hampshire border. Figure 8 compares the weekly total cigarette sales and weekly nonmenthol cigarette sales across these two groups. As expected, Massachusetts stores that are located farther away from the New Hampshire border experience a larger increase in sales of nonmenthol cigarettes.[11] For customers in those markets, the option to travel across the border to obtain menthol cigarettes is less attractive, and they are, therefore, more likely to switch to buying nonmenthol cigarettes at their local store. Furthermore, the observed decline in cigarette sales in Massachusetts stores that are farther away from the New Hampshire border is smaller compared with that in Massachusetts stores that are located closer to the New Hampshire border. Once again, this suggests that purchasing tobacco across the border is more costly for customers farther from the border, and the decline in cigarette sales is, therefore, less dramatic in those markets.

4.2.1. Why Are Reduced Form Methods Not Appropriate in This Context? Relying on a reduced form difference-in-difference approach to predict Massachusetts residents' switching behavior under a *nationwide* menthol ban is challenging. One potential way to achieve this would be to compare two regions: parts of the state where people could not travel to purchase cigarettes versus parts of neighboring states where stores did not receive additional traffic. One example of this is illustrated in Figure 9(a), where an inner region of the treated state (region A) could be compared with outer untreated

Figure 9. (Color online) Comparing Different Regions to Potentially Approximate the Effect of a Hypothetical National Ban



Notes. (a) Ideal situation: compare region A with region D in order to approximate the effect of a national ban. (b) In Massachusetts, areas 30+ miles from any state border (darker shade) are in a small, unrepresentative coastal region of the state.

regions in other states (region D). This setup would be ideal for predicting switching behavior under a national ban only if regions A and D meet three conditions: they are both unaffected by cross-border shopping, they both have enough stores to yield enough statistical power, and they both serve as good stand-ins for each of their states at large (in terms of cigarette preferences, price sensitivities, willingness to travel, switching behavior, etc.).

In our context, it is difficult to delineate regions of Massachusetts and its neighboring states that would satisfy these requirements. The issue with defining a region that is representative of a national ban is that Massachusetts is a geographically small state, and the vast majority of the state lives a relatively short drive away from the state border. One might suggest comparing inner Massachusetts areas (for instance, regions that are farther than 30 miles from a state border) against areas outside New York and New England to achieve this.[12] This would leave us with a small portion of the state's eastern and southeastern coastal region, as displayed in Figure 9(b). Unfortunately, this area would not be a good stand-in for examining what would happen in Massachusetts more broadly under a national menthol ban because the area is not representative of the state more broadly. This, in turn, means that it is not possible to use our data in order to calculate a credible reduced form causal estimate of a national menthol ban. In Section G in the online appendix, we perform this analysis, discuss its limitations further, and show that this approach would be misleading because it does not properly account for heterogeneity across the dimensions discussed. As we show in the online appendix, one key difference between this area is that the menthol share in this area is very different from the average menthol share in Massachusetts.

Furthermore, this approach does not explicitly account for variation in distance from different borders or heterogeneity in prices across neighboring states. Not dealing with these sources of heterogeneity would lead to biased estimates and may generate incorrect conclusions regarding the effectiveness of the proposed national menthol ban.

4.2.2. Description of the Structural Model. As described in Section 4.2.1, reduced form methods do not allow us to adequately predict the effect of a nationwide menthol ban on smokers in Massachusetts. Our objective is not to understand the individual-level consumption patterns of smoking and addiction, nor do we have access to a sufficient number of panelists affected by this policy that would allow us to do so. Instead, our goal is to understand aggregate-level substitution patterns using a choice model that accounts for three sources of heterogeneity: prices, distances, and menthol preferences. To capture the effect of these variables, we now consider a structural model. In our model, consumers choose whether to buy cigarettes, which kinds of cigarettes to buy, and whether to buy them in state or out of state. Their utility from different options depends in part on how far they live from a particular store and how expensive their cigarettes are. These modeling decisions are motivated by evidence from our data, as our results show that consumers' switching behavior after the Massachusetts menthol ban was affected by their distance from the state border and the prices of cigarettes nearby. To better calibrate the structural model, we incorporate some of the insights regarding cross-border shopping that were provided by our reduced form analysis as well as some aggregate-level information from ancillary data on cigarette tax revenues and consumption. This approach is similar to Petrin (2002) and Albuquerque and Bronnenberg (2009), who also combine insights from multiple data sources to yield more reliable estimates from a structural model.

Our sales data are recorded at the store level, so we define the "market" at the store level as well.[13] Conditional on not choosing the outside option, each individual customer in a given market has a choice of flavor (menthol versus nonmenthol) and the location to purchase cigarettes. Because each market corresponds to a store, we model the choice between purchasing at the focal store versus a store located in one of the neighboring states (NY, NH, RI, VT, and CT).

The purchase utilities for cross-state transactions vary as a function of two variables: the distance from each state border and the tobacco prices in neighboring regions across other states. We observe the full zip codes for stores in our data, so we calculate the distance of the stores from each of the neighboring states by measuring the centroid-to-centroid distance between each store's zip code and the closest zip code located in each of the five neighboring states. To calculate a price index, we keep track of the average nonpromoted price of each universal product code (UPC) in a 30-mile ring bordering Massachusetts in each of the five states. If no sales are recorded for a given UPC in a given week, we fill it with the last nonpromoted price available in that region. Note that the bundles purchased at each store (market) are different from each other, and to study how customers evaluate cross-state purchasing options, we need a price index specific to the bundle purchased in a given market. For each market-flavor-state pair, we calculate a price index as follows (Stone and Rowe 1954, Deaton and Muellbauer 1980, Dubé et al. 2018):

$$\log P_{jkst} = \sum_{u \in S_k} w_{uj} \cdot \log P_{ust},$$

where k indexes flavor and S_k is the set of all UPCs of flavor k (menthol or nonmenthol) in the data. P_{ust} is the average weekly price of UPC u in the 30-mile ring neighboring the Massachusetts border in state s during week t. w_{uj} is the volume share of UPC u at store j. Because the price index uses store-specific weights, it captures differences in prices that may occur because of taste differences across different markets.

We consider the following random utility model:

$$u_{ijkst} = \eta_s + \gamma \log(d_{js} + 1) + \beta \log(P_{jkst}) + \alpha \cdot \tau_{tc_j} + \eta_{jk} + \theta_{ik} + \epsilon_{ijkst}, \quad (3)$$

where i, j, k, s, and t index individual, market (store), flavor, state, and time, respectively. c_j denotes the retail format for store j: drugstore, convenience/gas station, liquor store, mass merchandiser, or grocery store. ϵ_{ijkst} is a random variable that follows a generalized extreme value distribution.[14] η_s and η_{jk} are state and market-flavor fixed effects, respectively. τ_{tc_j} is a parameter that absorbs the effect of seasonality in tobacco sales across different formats in the 2019–2020 period.[15] θ_{ik} are random effects that aim at capturing consumer-level heterogeneity in tastes for menthol versus nonmenthol cigarettes. d_{js} is the distance (in miles) of store j from state s. If the customer chooses to shop locally at the focal store, then $d_{js} = 0$ for that choice. Finally, P_{jkst} is a price index that tracks prices of different flavors by location and week. These variables are listed in Table 5. The coefficients γ and β reflect traveling cost and price sensitivity and are identified based on two types of variation in our data. (a) As distance from state borders increases, consumers are more likely to switch to local nonmenthol cigarettes (see Figure 8), and (b) the variations in prices in the panel and across states affect consumption of cigarettes and substitution to out-of-state options (see Figures 6 and 7).

Apart from the outside option, the choice set for each user consists of 12 options. There are six options for the location (the focal local store and a store at each of the five neighboring states) and two choices for the flavor

Table 5. The List of Variables and Indexes Used in the Structural Model (Equation 3)

Index	Symbol	Parameter	Symbol
Household/customer	i	State FE	η_s
Market (store)	j	Distance of store j from state s	d_{js}
State	s	Price index for each option	P_{jkst}
Time (week)	t	Seasonality across retail formats	τ_{tc_j}
Flavor (menthol/nonmenthol)	k	Store-menthol FE	η_{jk}
Retail format for store j	c_j	Random effects at individual-flavor level	θ_{ik}

Note. FE, fixed effect.

(menthol and nonmenthol).[16] Of these 12 possibilities, we only directly observe 2 outcomes: the aggregated sales for menthol and nonmenthol products at the focal store.[17] We use a random-coefficient nested logit model because it can capture more flexible substitution patterns (see Figure 10 for a visual depiction of our demand model). For an individual i who resides in market j, the probability of purchasing flavor k from location $s =$ {local, NY, NH, RI , VT, CT} is

$$p_{ijkst} = \frac{\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)}{\sum_{s\in\mathcal{N}_s,k}\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)} \cdot \frac{\left(\sum_{s\in\mathcal{N}_s,k}\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)\right)^{\frac{\lambda_l}{\lambda_h}}}{\sum_{\mathcal{N}_s\in\mathcal{N}}\left(\sum_{s\in\mathcal{N}_s,k}\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)\right)^{\frac{\lambda_l}{\lambda_h}}} \cdot \frac{\left(\sum_{\mathcal{N}_s\in\mathcal{N}}\left(\sum_{s\in\mathcal{N}_s,k}\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)\right)^{\frac{\lambda_l}{\lambda_h}}\right)^{\lambda_h}}{\left(\sum_{\mathcal{N}_s\in\mathcal{N}}\left(\sum_{s\in\mathcal{N}_s,k}\exp\left(\frac{u_{ijkst}}{\lambda_l}\right)\right)^{\frac{\lambda_l}{\lambda_h}}\right)^{\lambda_h}+1},$$

where $\mathcal{N}$ is the set of lower-level nests that include local and out-of-state options. $\mathcal{N}_s$ is the nest that option s belongs to. Note that the higher nest level consists of two alternatives: the outside option versus all potential purchase options. λ_l and λ_h are the within-nest correlation parameters for the lower- and higher-level nests, respectively.

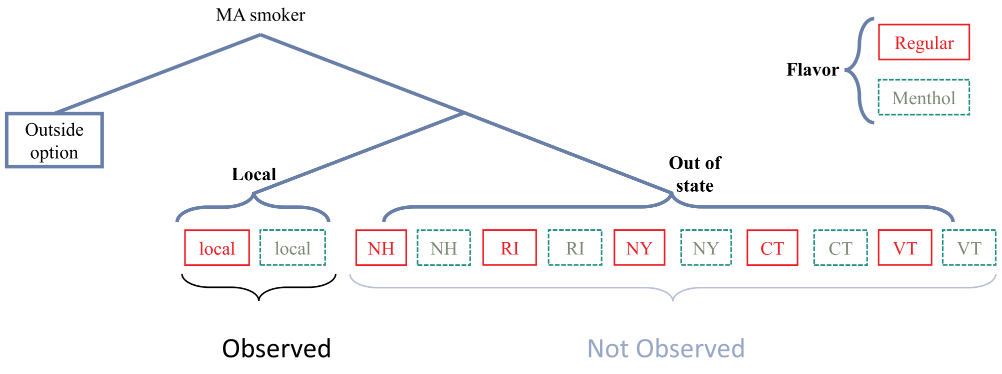
The volume of flavor k sold at location s generated by customers who reside in market j is given by

$$\hat{S}_{jkst} = M_j \cdot \int_\theta p_{ijkst}(\theta)\, d\theta, \tag{4}$$

where M_j is the total market size for market j. The term θ captures the taste heterogeneity for menthol versus nonmenthol cigarettes, and this is integrated out. Note that we only observe sales at the focal store, and we do not know which stores consumers visit when they engage in cross-border shopping. However, because post-tax cigarette prices tend to be similar across stores near each other, we are able to construct a price index for out-of-state options. In other words, although we do not observe the outcome (left-hand side) for the out-of-state options, we do observe prices and distances (right-hand side). The relative price variation between the focal store and the stores located across the state borders (see Figure 6(a)), along with the extent of substitution to purchasing nonmenthol cigarettes depending on their distance from the border (see Figure 8), helps us identify the traveling cost (γ) and state-specific baseline utilities (η_s).

In Section 4.2.1, we showed that reduced form methods are not appropriate for analyzing the effects of hypothetical policies, such as a nationwide menthol ban or a statewide menthol tax. We also pointed out that there were three key sources of heterogeneity that needed to be modeled: prices, distances, and menthol preferences. Our structural model addresses these issues; we allow different baseline preferences regarding menthols versus nonmenthols at store level (η_{jk}) through random effects at the individual level (θ_{ik}). We also estimate consumers' disutility from price increases or increased travel distances. In particular, choice utilities for each flavor-state pair not only depend on the price of that flavor in the state (P_{jkst}) but also, the distance from the state's border (d_{js}). In addition, we allow for state-specific baseline

Figure 10. (Color online) A Visual Illustration of the Nested Logit Demand Model Structure



utilities (η_s) that capture utility derived from unobserved factors beyond cigarette prices or traveling distance, such as convenience or tax/price of other goods. For instance, New Hampshire has zero sales tax on most nontobacco goods, which ceteris paribus, may make traveling to New Hampshire more attractive than other neighboring states. These aspects of the structural model allow us to better understand consumer purchasing decisions, which in turn, allow us to make predictions regarding counterfactual outcomes that may be quite different from the Massachusetts statewide menthol ban that was actually enacted.

We augment the sales data with data from the Centers for Disease Control and Prevention (CDC) and the Massachusetts Department of Revenue. The CDC data allow us to measure total cigarette consumption during 2019 in Massachusetts, whereas the Department of Revenue data allow us to measure the total cigarette tax revenue that the state received.[18] We can use this tax revenue data to calculate the total cigarette sales that occurred in the state of Massachusetts by dividing the total cigarette tax revenue by the tax per pack.

Taken jointly, the CDC data and the Department of Revenue data allow us to distinguish between cigarette sales in Massachusetts and cigarette consumption in Massachusetts. We can also use these quantities to measure how much of the tobacco consumed in Massachusetts was purchased out of the state; we estimate that this is 16.61% during 2019 (see Section B in the online appendix for full details). Therefore, we constrain the share of in-state purchases in the 2019 period to be equal to $100 - 16.61 = 83.39\%$. We consider the following constrained minimum distance optimization problem:

$$\begin{aligned}
\underset{\eta_s,\eta_j,\eta_{w_t},\theta_{ik},\gamma,\beta,\lambda}{\text{minimize}} \quad & \sum_{j,k,t,s=\text{MA}} \|S_{jkst} - \hat{S}_{jkst}\|^2 \\
\text{subject to} \quad & \frac{\sum_{jkst}(\hat{S}_{jkst}\cdot \mathbb{1}_{\{t=2019\}}\cdot \mathbb{1}_{\{s\in MA\}})}{\sum_{jkst}(\hat{S}_{jkst}\cdot \mathbb{1}_{\{t=2019\}})} = 0.8339, \\
& \qquad k \in \{\text{Menthol}, \text{Regular}\}, \\
& \frac{\sum_{jst}(\hat{S}_{jk'st}\cdot \mathbb{1}_{\{t>t^*\}}\cdot \mathbb{1}_{\{s\notin MA\}})}{\sum_{jkst}(\hat{S}_{jkst}\cdot \mathbb{1}_{\{t>t^*\}})} = \psi_1 = 0.157, \\
& \qquad k' = \text{Menthol}, \\
& \frac{\sum_{jst}(\hat{S}_{jk'st}\cdot \mathbb{1}_{\{t>t^*\}}\cdot \mathbb{1}_{\{s\in MA\}})}{\sum_{jst}(\hat{S}_{jk'st}\cdot \mathbb{1}_{\{t>t^*\}})} = \psi_2 = 0.802, \\
& \qquad k' = \text{nonmenthol},
\end{aligned} \tag{5}$$

where t^* is the menthol ban date of June 1st, 2020 and $\mathbb{1}_{\{t>t^*\}}$ is an indicator that filters postban observations. We minimize the distance between observed and predicted sales of menthol and nonmenthol cigarettes in Massachusetts while imposing two sets of constraints.

Pre-ban cross-border purchases. Given the high tobacco prices in Massachusetts, some residents were likely buying cigarettes from neighboring states even before the menthol ban was instituted. We combine tobacco consumption data from the CDC with tobacco tax revenues collected by the state of Massachusetts to calculate the share of in-state tobacco purchases, which is 0.8339. The first constraint ensures that the total volume of in-state cigarette purchases made by Massachusetts residents during 2019 matches the estimates calculated using CDC and tax revenue data.[19]

Postban out-of-state purchases. The analysis in Section 4.1 informs us about the change in composition of in-state versus out-of-state menthol purchases after the Massachusetts' menthol ban. In particular, our analysis shows that about half of the menthol consumption in Massachusetts continues after the menthol ban through cross-state purchases. We also show that a portion of nonmenthol cigarette sales is transferred to other states as well. We impose two aggregate-level constraints using this information. (a) We constrain the overall share of menthol purchases to match our analysis in Section 4.1, and (b) because some of the nonmenthol cigarette sales are also diverted to other states, we constrain the share of in-state nonmenthol purchases to match the results from Section 4.1. These constraints help to ensure that the structural model's predictions for consumers' postban purchase decisions match the aggregate results from the difference-in-differences analysis. The calculations for deriving the right-hand-side values (ψ_1 and ψ_2) are presented in Section B in the online appendix.

Our structural model allows us to understand how consumers make decisions regarding which type of cigarettes to buy and where to buy them. However, this requires some assumptions and simplifications. One limitation is that we are using store-level retail scanner data, and therefore, we do not observe individual household shopping trips.[20] This means that we do not observe what individual households do when they stop buying cigarettes from a specific store (i.e., we do not directly observe whether they go to another store (and if so, which one) or whether they stop buying cigarettes altogether). Instead, we observe sales changes in different stores, and we also incorporate information about cross-border shopping through the constraints, which are derived from CDC data and our reduced form analysis. These constraints are key for deriving correct substitution patterns to out-of-state options, as we show in Section K in the online appendix. Our approach is similar to Petrin (2002) and Albuquerque and Bronnenberg (2009) in that we are using ancillary data to generate additional moment conditions and constraints that improve the fit and counterfactual validity of our structural model.

The structural model also assumes that people have the same travel cost γ and the same price coefficient β because it is hard to identify heterogeneous γ and β separately from the fixed effects. In Section J in the online appendix, we discuss this issue further and show that allowing these parameters to be heterogeneous does not have a major effect on the main results. Our model also assumes that consumers are not engaging in stockpiling or copurchasing of products. The fact that we are using store-level retail data means that we cannot identify these behaviors from the observed data. In Section H in the online appendix, we use household panel data to examine both of these phenomena, and we find that they are both relatively rare.

The structural parameter estimates and bootstrapped standard errors are reported in Table 6. As expected, the distance and price coefficients are negative and statistically significant; consumers prefer traveling less and paying less for their cigarettes. The coefficient for the parameter that captures seasonality and time trends (α) is also positive and statistically significant. The upper-level nest correlation is $1 - \lambda_h = 1 - 0.228 = 0.772$, and the lower-level nest correlation is $1 - \lambda_l = 1 - 0.533 = 0.447$. New Hampshire has the largest state fixed effect of 0.420, which is statistically different from the New York, Rhode Island, and Vermont fixed effects. This indicates that even after accounting for distances and cigarette prices of different choices, customers still have a preference for shopping in New Hampshire.[21]

This structural model enables us to evaluate the impact of two types of counterfactual policies on smokers in Massachusetts compared with the effect of a statewide menthol ban: a *national menthol ban* and a *Massachusetts menthol tax*. To simulate and compare the effect of counterfactual policies, such as a menthol tax or a nationwide ban, we need to know the price of both menthol and nonmenthol cigarettes in Massachusetts in each counterfactual scenario. However, we do not observe the price of menthol cigarettes in Massachusetts after the ban goes into effect on June 2020. To resolve this issue, we use data from the second half of 2019 (when prices for both menthols and nonmenthols were available) to simulate the effect of counterfactual policies, such as a menthol tax or a national ban. These analyses rely on two key assumptions; (a) the treatment effect of these policies in 2019 would be similar to 2020, and (b) stores would not shift cigarette prices in response to a ban or a menthol tax. In Section F in the online appendix, we validate assumption (b) by showing that the Massachusetts ban did not have a significant impact on cigarette prices. This is in line with previous findings in the literature, which have found that retailers do not strategically change their pricing in response to tobacco excise increases that affect nearby stores (Brock et al. 2016). In the marketing literature, Tuchman (2019) and Seiler et al. (2021) do not find evidence supporting a strategic price response to regulation in the case of e-cigarette advertising and soda excise taxes.

Table 6. The Structural Parameter Estimates from Model (5)

Parameter	Mean	Standard error
Travel cost (γ)	−0.441	0.088
Price coefficient (β)	−1.322	0.257
Trend/seasonality (α)	1.444	0.163
Upper-level nest correlation parameter (λ_h)	0.228	0.058
Lower-level nest correlation parameter (λ_l)	0.533	0.091
Connecticut fixed effect	−0.566	0.630
New Hampshire fixed effect	0.420	0.264
New York fixed effect	−1.291	0.645
Rhode Island fixed effect	−1.682	0.771
Vermont fixed effect	−1.211	0.596

Note. Standard errors are calculated via bootstrap by sampling stores with replacement.

4.3. Understanding the Impact of State and National Menthol Bans

We use the structural model to compare the effects of a hypothetical national menthol ban versus the Massachusetts menthol ban that was actually implemented. To estimate the effect of a national ban, we use the structural model parameter estimates (Table 6) and then simulate consumers' purchase decisions if all of the menthol options that were originally present in the demand model (see Figure 10) were no longer available. Results from this exercise are shown in Table 7.

To check whether our structural model yields reasonable predictions, we can compare a subset of the structural model's counterfactual predictions with the estimates from our reduced form analysis. In the case of a Massachusetts menthol ban in the second half of 2019, the structural model predicts a 6.77% increase in sales of nonmenthol cigarettes in Massachusetts and a −23.51% decline in overall cigarette sales. Meanwhile, the results from our reduced form analysis in Table 4 show that the realized estimates from the 2020 menthol ban were 9.86% and −21.08% for nonmenthol sales and overall cigarette sales, respectively. This comparison demonstrates that the structural model is well calibrated and provides reasonable estimates for counterfactual outcomes. Note that we only use pre-ban data to estimate the model, so the fact that we are able to predict postban outcomes to a high degree of accuracy is a good sign for the applicability of our structural model.[22]

Furthermore, consistent with our previous findings in Section 4.1, the structural model predicts a large increase in out-of-state menthol purchases and a spillover to nonmenthol out-of-state purchases under a state-specific menthol ban. In particular, the share of out-of-state menthol purchases is predicted to increase by 227.16% when Massachusetts enacts a ban. Note that in 2019, in-state purchases accounted for 83.39% of cigarette consumption in Massachusetts. Therefore, a 227.16% increase in out-of-state purchases means that the postban menthol consumption in Massachusetts is (1 +

$2.271) \times 0.166 = 54.3\%$ of what it would have been without a state-specific menthol ban.

Table 7 shows that a nationwide menthol ban would reduce overall cigarette consumption in Massachusetts by 7% rather than the 4.8% that a statewide ban would yield. Under a nationwide menthol ban, the shares of in-state and out-of-state purchases of nonmenthol cigarettes are both predicted to grow by about 30%. This implies that the share of in-state versus out-of-state purchases among Massachusetts residents would not change dramatically under a nationwide ban, which is a major difference compared with the Massachusetts ban. Nevertheless, we would like to highlight that the sales of out-of-state nonmenthol purchases grow slightly more than in-state nonmenthol purchases (33.93% versus 28.73%) in this scenario as well. This is because of the fact that under a nationwide menthol ban, a portion of menthol smokers who have low traveling cost (i.e., those who live near the border) would prefer to substitute out-of-state nonmenthol cigarettes rather than in-state nonmenthol cigarettes because lower out-of-state prices could partially offset their disutility from consuming nonmenthols instead of menthols.

Our summary of the effects of a statewide ban and a nationwide ban in Table 7 represents the effects specifically among Massachusetts smokers because the model has been calibrated specifically on data from their purchase behavior. We expect the estimates to be different for other states or other sales contexts. In states where much of the population lives near the state border, we expect the overall patterns to be similar to what we see here, where a statewide ban is relatively ineffective at limiting people's menthol consumption. However, there are other contexts where a statewide ban would be expected to be more effective: (a) if most of the population lives very far away from a border, (b) if neighboring states have much higher cigarette prices or cigarette taxes, or (c) if menthol smokers only have weak relative preferences for menthols versus nonmenthols. In all of these scenarios, consumers are disincentivized from engaging in cross-border shopping, so a statewide menthol ban would be more successful compared with the Massachusetts context.

Table 7. Comparing the Effects of a State-Specific Massachusetts Menthol Ban vs. a Hypothetical National Menthol Ban

		Percentage change in sales		
Scenario	Product	In state	Out of state	All
Massachusetts ban	Menthol	−100	227.16	−46.23
	Nonmenthol	6.77	35.20	11.54
	All	−23.51	88.72	−4.80
National ban	Menthol	−100	−100	−100
	Nonmenthol	28.73	33.93	29.60
	All	−7.78	−3.41	−7.05

Note. Values correspond to the percentage change in sales (packs sold) under two different policy scenarios relative to the pre-ban status quo.

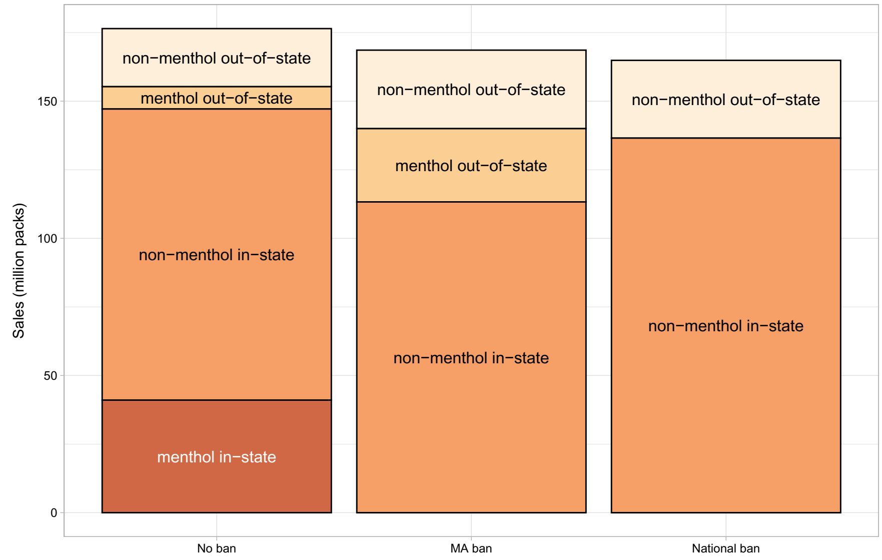
To summarize Massachusetts consumers' cigarette purchases by flavor and store location, Figure 11 categorizes sales into four groups: menthol in state, menthol out of state, nonmenthol in state, and nonmenthol out of state. We show how these four sales quantities vary across three different scenarios: the 2019 status quo in which there was no menthol ban, a statewide menthol ban, and a hypothetical nationwide menthol ban. Under a statewide menthol ban, menthol in state is zero, the three remaining sales options all increase in quantity, and overall cigarette consumption in Massachusetts decreases slightly by 4.80%. Under a national ban, both menthol options are zero, the two remaining nonmenthol sales options both increase in quantity, and overall cigarette consumption decreases by 7.05%.

4.3.1. Effect on Black Consumers. Apart from understanding the effects on overall smoking behavior, regulators may also be interested in examining how the menthol ban affected different demographic groups. In the context of menthol cigarettes, this concern is particularly salient because menthols are disproportionately popular among Black consumers.

Our structural model accounts for cross-sectional variations across different markets (stores) through the use of nonparametric market-flavor (η_{jk}) fixed effects in Equation (3). To investigate the extent to which the fixed effects from the structural model capture taste differences for menthol cigarettes that are systematically correlated with the proportion of the Black population in each area, we first obtain the proportion of the Black population in each zip code from U.S. Census data and merge it with our data. Next, we calculate the difference between the store-menthol and store-nonmenthol fixed effects, which reflects the extent to which consumers in a particular market (store) have a relative preference for menthols versus nonmenthols. This variable is then plotted against the log percentage of the Black population, and the results are presented in Figure 12. As anticipated, we find that markets with a higher percentage of Black people exhibit a greater preference for menthol cigarettes over nonmenthol cigarettes.

Having established that the fixed effects effectively capture meaningful patterns across customer segments, we can now use our model to examine the impact of the Massachusetts menthol ban on different customer segments. In particular, we measure the extent to which menthol and nonmenthol cigarette sales are shifted to other states after the Massachusetts ban across different markets in Massachusetts. Figure 13 presents the results from this analysis. The figure shows that markets with a larger Black population (in percentage terms) are more likely to purchase menthol cigarettes from out-of-state

Figure 11. (Color online) Massachusetts Cigarette Sales by Flavor and Store Location Under Three Policy Scenarios

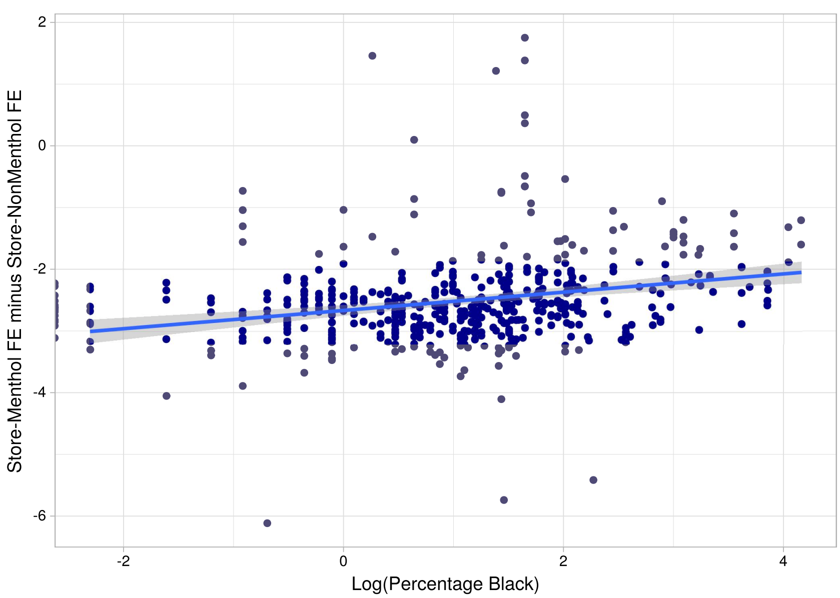


Note. These yearly sales quantity estimates are based on our structural model.

sources, with a small increase in out-of-state purchases for nonmenthol products as well. These markets also show a lower tendency toward in-state nonmenthol purchases, likely because of their higher overall preference for menthols. These results imply that the Massachusetts ban disproportionately affects the Black population in the sense that Black smokers are expending more effort to travel out of state to purchase their preferred cigarettes versus non-Black smokers.

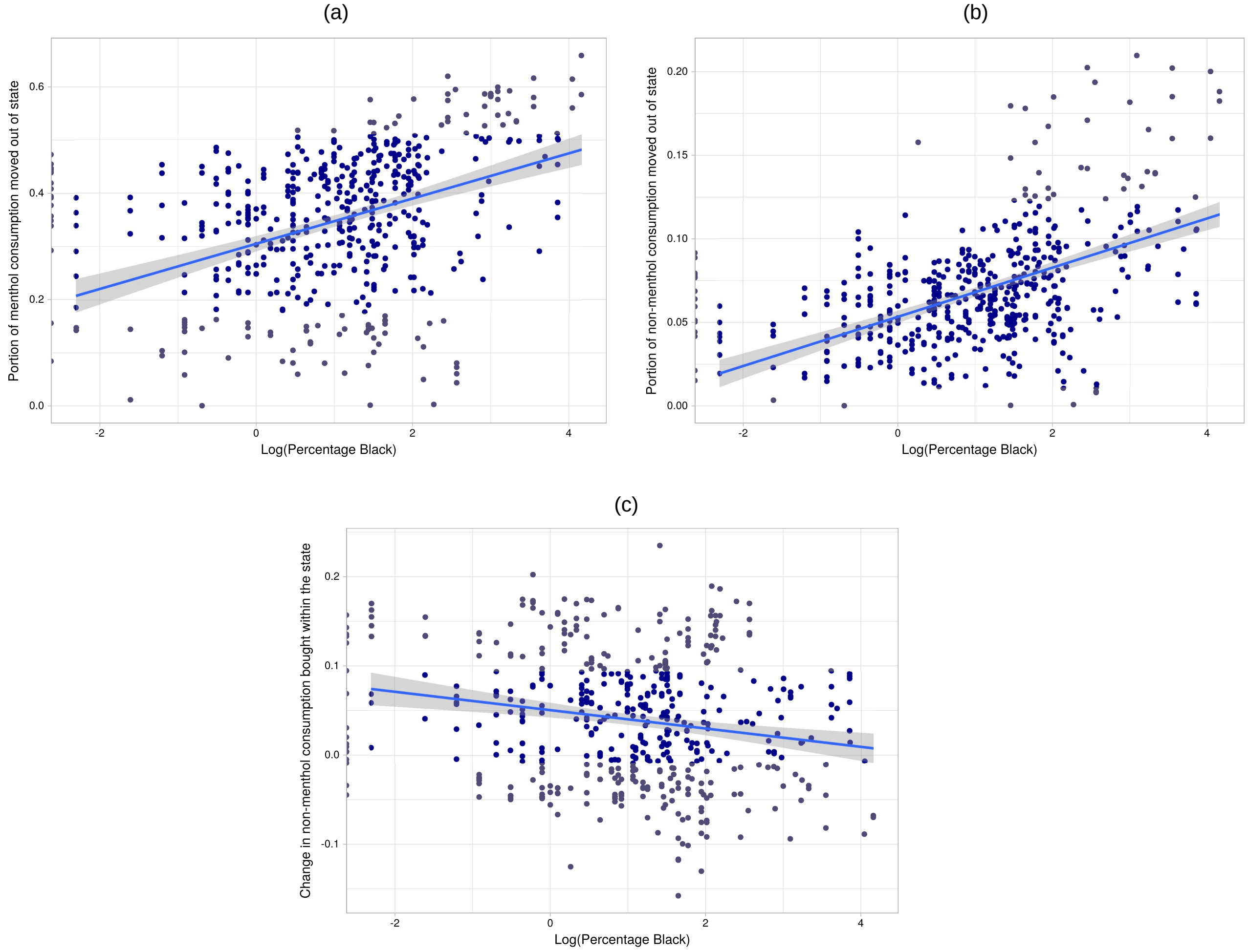
Apart from the travel costs, there are other dimensions in which menthol bans might yield disproportionate effects for Black consumers versus the rest of the population. First, removing menthols from the choice set (or making them harder to purchase) would have a disproportionately large negative effect on the utility of Black smokers versus non-Black smokers. Second, policy makers and social leaders have pointed out that criminalizing menthol sales might lead to increased smuggling or black

Figure 12. (Color online) Scatterplot of Relative Preference for Menthol Cigarettes in Each Store vs. the Percentage of Black People in That Zip Code



Notes. Each dot represents a unique store in Massachusetts. Relative preference for menthol cigarettes is calculated based on the fixed effects (FEs) from the structural demand model.

Figure 13. (Color online) Scatterplots That Examine How Shopping Habits Change After the Menthol Ban and How Those Changes Relate to the Black Population in Each Area



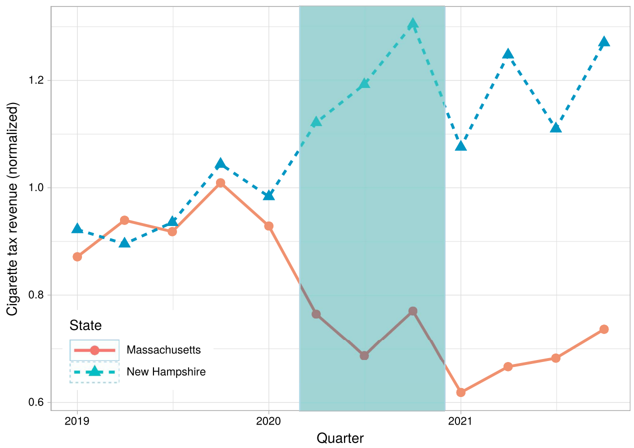
Notes. Each dot within each panel represents a unique store in Massachusetts. Predicted changes in sales are based on the structural demand model. Our findings indicate that markets with a higher concentration of Black people are more likely to shift their purchases out of state for both menthol cigarettes (panel (a)) and nonmenthol cigarettes (panel (b)). Panel (c) shows that Black consumers are comparatively less likely to substitute in-state nonmenthol cigarettes. These findings suggest that the Massachusetts ban imposes a disproportionate burden on the Black population because they have a stronger preference for menthol cigarettes and therefore, are much more likely to travel to out-of-state stores to acquire menthol cigarettes. (a) Change in out-of-state menthol sales. (b) Change in out-of-state nonmenthol sales. (c) Change in nonmenthol in-state sales.

market sales of menthols, which in turn, might lead to more police encounters and arrests (Ferré-Sadurni 2023). Third, if menthols are in fact more damaging to people's health than nonmenthols, then the positive health effects of this ban would be disproportionately received by Black consumers. Our data and model cannot quantify these different effects, so we are unable to discuss larger welfare effects and how they might differ between demographic groups.

4.3.2. Effect on Tax Revenues. Our structural model allows us to estimate how sales from Massachusetts smokers were redirected after the statewide menthol ban. As shown in Table 7, we find that out-of-state cigarette sales went up by 88.72%. Using our model, we can further decompose this by examining how much additional sales went to each of the neighboring states. Of the sales that were redirected to other states, we estimate that 94.25% of sales went to New Hampshire, 4% went to Connecticut, 1% went to Vermont, and less than 1% went to New York and Rhode Island.

Because nearly all of the sales diversion went to New Hampshire, we can examine whether this increase in sales was large enough to yield a noticeable increase in New Hampshire's cigarette tax revenue intake. In Figure 14, we show quarterly cigarette tax revenues for Massachusetts and New Hampshire, normalized by their respective 2018 revenues. Note that these data come from each

Figure 14. (Color online) Cigarette Tax Revenue (Normalized by 2018 Values) for Massachusetts and New Hampshire



Notes. The highlighted area corresponds to the postban time period we analyze with our retail scanner data. The postban shopping behavior changes we observe in the retail data seem to persist through the end of 2021.

state's tax authority rather than our retail data; therefore, it serves as a full account of all cigarettes sold through legal channels in each state.

Figure 14 highlights the postban period that we observe in our retail data, which runs from June to December 2020. During that period, there is a big shift in cigarette revenue; New Hampshire cigarette revenue increases dramatically, whereas Massachusetts cigarette revenue decreases by roughly the same proportion. This pattern of data aligns very closely with the predictions from our structural model, which indicated that there would be a big shift in consumers' shopping patterns after the menthol ban because of people choosing to travel across the New Hampshire border.

One benefit of the tax data shown in Figure 14 is that it can speak to long-run effects (i.e., after the end of our retail scanner data). We find that the decrease in Massachusetts cigarette tax revenues appears to be sustained through 2021, as is the increase in New Hampshire cigarette tax revenues. These patterns indicate that significant portions of menthol sales were not substituted by an increase in in-state nonmenthol consumption in the long term, as this would have been reflected in the tax revenues. More broadly, they also suggest that cross-border shopping trips were likely still taking place 18 months after the ban was enacted.

4.4. Understanding the Impact of a Massachusetts Menthol Tax

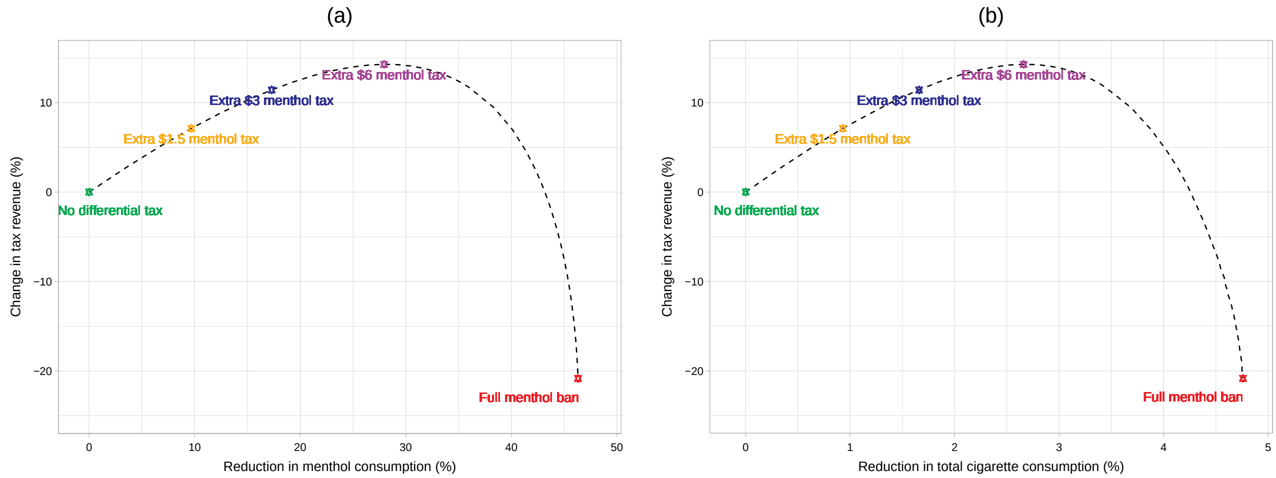
The results in Table 7 reveal that considerable portions of menthol and nonmenthol tobacco sales were shifted to other states after the Massachusetts menthol ban was instituted. The large volume of substitution to out-of-state stores under a state-specific menthol ban implies that this policy could drastically affect state tobacco tax revenues. An alternative policy would have been to institute a statewide menthol tax, which could potentially reduce cigarette consumption while also increasing tax revenues at the same time. We now use our structural model to evaluate how an additional excise tax on menthol cigarettes (rather than a retail sales ban) would affect consumption and tax revenues in Massachusetts. We implement this counterfactual by artificially increasing the post-tax prices of menthol products and then using our structural model to reestimate what the new demand levels would be.[23]

Figure 15 provides a Pareto frontier curve to illustrate the trade-off between cigarette consumption and tax revenue. Each point on this curve corresponds to a different excise tax level. When taxes are zero (i.e., the leftmost point on the curve), there is no reduction in menthol consumption, nor is there a change in tax revenue. As the tax rate rises, this yields two benefits; people start to substitute away from menthols, and the people who continue buying menthols are now providing added tax revenue to the state. This pattern continues until about a six dollars per pack menthol tax. After that, the tax revenue starts to fall because most consumers are sufficiently incentivized to buy cigarettes across the state border if they can.

If the state's only goal is to limit menthol consumption or overall cigarette consumption as much as possible, a menthol ban is still the right approach. As shown in Figure 15, a state-specific menthol ban would shrink tobacco tax revenues by about 21%, but it is the most effective policy for mitigating cigarette consumption; menthol consumption would decrease by 46%, and overall cigarette consumption would decrease by 4.8%. However, if the state is willing to jointly optimize some combination of tax revenue and cigarette reduction, then a menthol tax becomes a more appealing option. A six dollar per pack menthol tax would increase the state's tax revenues by about 14% while reducing menthol and overall cigarette consumption by 28% and 2.7%, respectively.

To provide an estimate of the financial benefits of a menthol tax, we can use the revenue numbers in Massachusetts before the menthol ban was instituted. The gross cigarette tax revenue in Massachusetts during the 2019 fiscal year was about \$516 million. A menthol ban would reduce the tax revenue by 21% (i.e., a change of −\$108 million compared with the status quo). Meanwhile, a six dollar per pack menthol tax would increase the tax number by 14% or +\$72 million. The difference between these two options is about \$180 million; this represents the relative financial loss that Massachusetts incurred by implementing a menthol ban rather than a menthol tax.

Figure 15. (Color online) Pareto Frontier Curve for Tax Revenue vs. Cigarette Consumption



Notes. Each point on this curve represents a different value for a menthol excise tax. The menthol tax (per pack) increases from left to right. The leftmost point on the curve represents no additional menthol tax, whereas the bottom right point represents the effect of a full ban. (a) Menthol consumption vs. tax revenue. (b) Total cigarette consumption vs. tax revenue.

5. Discussion and Conclusion

The results from our structural model demonstrate that a state-specific menthol ban yields slightly larger reductions in menthol consumption and overall cigarette consumption compared with a $6 per pack menthol tax, but it does so with the downside of forgoing about $180 million in tax revenue. This tax revenue represents a lost opportunity to decrease smoking rates in other ways because it could be used to substantially bolster tobacco control programs that run antismoking messages, engage in outreach and education efforts, fund local organizations that help with enforcing tobacco regulations, etc. In Massachusetts, the state government funds a tobacco control program known as the Massachusetts Tobacco Cessation and Prevention Program (MTCP), and this organization received only $4.2 million in state funds in 2019. Doubling or tripling the MTCP's budget would require only a small percentage of the tax revenue that would be generated by a menthol tax, and it would likely yield substantial public health benefits and reductions in smoking as a result.

Overall, our analysis of retail data shows that consumers respond to the state-specific Massachusetts menthol ban in a few different ways. About half of the menthol users in Massachusetts switch from menthol cigarettes to nonmenthol cigarettes, whereas the other half continue to buy menthols by shopping in a neighboring state. Consumers who live far away from New Hampshire are more likely to keep buying cigarettes from their local store and to switch to nonmenthols, whereas consumers who live closer to New Hampshire are more likely to travel across the border because it is convenient for them to buy cheap menthol cigarettes in New Hampshire. Given that cross-border shopping is a clear concern, we estimate a structural model that allows us to estimate how consumers' shopping behavior would change under different kinds of hypothetical policy changes. We find that a nationwide menthol ban would be more effective than a Massachusetts-specific menthol ban because it leads to a 47% larger reduction in overall tobacco consumption among Massachusetts residents. We also show that a menthol tax can yield substantial tax revenue increases for Massachusetts while also reducing the consumption of menthol cigarettes and total cigarettes among Massachusetts smokers, thereby making it an attractive option for lawmakers.

These results have important implications for policy makers and regulators, as they provide insights into the relative effects of a statewide menthol ban, a nationwide menthol ban, and a statewide menthol tax. Given our results, we expect that states that are interested in reducing menthol consumption would find a statewide menthol ban to be relatively ineffective if stores in nearby states sell menthols at relatively cheap prices. New Hampshire, Indiana, Virginia, Idaho, Wyoming, North Dakota, Montana, Delaware, and Nevada all have relatively low cigarette prices, so these states would serve as convenient options for cross-border shopping if any nearby states were to pursue a statewide menthol ban.

The second state to implement a menthol ban was California, whose menthol ban went into effect starting on December 21, 2022 (California Department of Public Health California Tobacco Control Branch 2023). Our modeling approach could be used to analyze California data after the ban was implemented, but we expect that the actual estimated quantities regarding cross-border shopping and product substitution would be quite different than in Massachusetts. One of our key results is that consumers have travel costs, so consumers who live far away from the state border are less likely to engage in cross-border shopping. These travel costs are likely to be magnified for Californians because the majority of them are a 4+-hour drive away from the nearest state borders. On the other hand, if consumers have strong preferences for menthol cigarettes versus nonmenthol cigarettes, then the California menthol ban might lead to increased black market sales and smuggling of cigarettes because consumers have no convenient legal ways to buy their preferred products.

At the federal level, the FDA has proposed a nationwide ban on menthol cigarettes, and we find that this would be helpful for states like Massachusetts, in which residents can easily engage in cross-border shopping. In the absence of a nationwide ban, we find that a statewide menthol tax would be an attractive option for many states because this would allow them to directly reduce menthol consumption while also generating a large amount of additional tax revenue that could be used to fund other antismoking and public health outreach efforts.

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Endnotes

[1] We only examine sales of traditional combustible cigarettes, which make up the majority of sales during the time period we examine. Some menthol smokers may have switched to other products, like e-cigarettes, vaping products, or cigars, after the menthol ban was introduced, but we do not capture this behavior.

[2] See Section 2 for an explanation of why New England and New York need to be removed from the control comparison group.

[3] There is also a sales spike during March 2020, likely because of consumers changing their shopping behavior during the coronavirus disease 2019 shutdowns. In Section D in the online appendix, we show that this temporary sales spike happened in most of the country and can, therefore, be controlled for with synthetic control methods.

[4] Although we describe this result as cross-border shopping, part of this increase in sales may also be because of smuggling or black-market sales (e.g., if residents of neighboring states purchase cigarettes in bulk locally and then informally resell them in Massachusetts). We cannot empirically distinguish between these different sales channels.

[5] An alternative possibility would be to use disaggregate store-level observations in a linear demand model. This yields similar results, and the full results are shown in Section E in the online appendix.

[6] Note that after the Massachusetts menthol ban, we no longer observe prices for menthols in Massachusetts. In the regressions where the outcome variable is total cigarette sales, we control for the price of nonmenthol cigarettes.

[7] In Section F in the online appendix, we also verify that cigarette prices in Massachusetts or neighboring areas did not change significantly relative to areas outside New York and New England.

[8] In Section H in the online appendix, we examine copurchasing of menthols and nonmenthols using household panel data on shopping trips. Our results suggest that copurchasing is not the main driver of this result.

[9] People could potentially buy menthols after a nationwide menthol ban by traveling across the international border to Canada or Mexico (or by flying overseas), but these options would cause additional legal challenges.

[10] This analysis of and focus on New Hampshire are only for illustrative purposes. In the structural model, we consider distances from all borders, not just New Hampshire.

[11] This difference starts to appear a few months before the menthol ban was actually implemented. In Section L in the online appendix, we show that this could be caused by differences in when stores stopped selling menthols. We also investigate whether Massachusetts stores altered prices based on proximity to the New Hampshire border, but we do not find any evidence supporting that.

[12] Although the analysis in Section C in the online appendix shows that the spillover effect of this policy is limited to a 30-mile radius around Massachusetts, this does not imply that smokers are willing to travel at most 30 miles to get menthol cigarettes when they are banned. Instead, it suggests that conditional on crossing the state borders, smokers are not likely to travel more than 30 miles to purchase cigarettes.

[13] For each store, the market size is set as five times the maximum weekly sales in that store during the 2019–2020 time period.

[14] We consider a bilevel nested logit model, where all tobacco options are under a large nest with two subnests (in state versus out of state) and the outside option is in its own isolated nest (Bresnahan et al. 1997).

[15] We construct this parameter by taking the average demeaned log sales of cigarettes across different retail formats in states outside the New England and New York region.

[16] Our model assumes that households are not purchasing both menthols and nonmenthols in the same shopping trip. In Section H in the online appendix, we provide empirical evidence for this assumption. We also remove menthols from the choice set at each specific store once we stop observing menthols being sold there.

[17] Our model assumes that Massachusetts consumers do not choose a different (nonfocal) store in Massachusetts. This limitation is justified by the fact that nonfocal Massachusetts stores cause higher travel costs without providing access to menthol cigarettes (or any other new benefits).

[18] We cannot use our retail sales data for these tasks because the NielsenIQ data contain a sample of stores rather than a full census.

[19] This calculation assumes that non-Massachusetts residents do not buy a substantial percentage of the cigarettes that are sold in Massachusetts sales. We do not directly observe this behavior, and therefore, we cannot evaluate it empirically. However, the assumption is plausible given that Massachusetts is a net importer of cigarettes (see Section B in the online appendix) and that it has high tobacco prices and taxes relative to its neighbors.

[20] Although household panel data are available, the data are limited and lack sufficient statistical power. We discuss these issues in Section H in the online appendix.

[21] This could reflect the effect of unobservables, such as shopping environment, convenience, or price and taxes on other goods. As we noted, New Hampshire has zero sales tax on most nontobacco goods.

[22] We also estimate a version of the structural model that allows for heterogeneity in travel cost γ and price sensitivity β, and we find that the counterfactual predictions remain very similar. Details of this procedure are in Section J in the online appendix.

[23] Our structural model uses post-tax prices, and we do not estimate different coefficients for prices versus taxes. Instead, we assume that consumers' purchasing decisions are identically affected by a one-dollar increase in retail prices versus a one-dollar increase in excise taxes.

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