

CONSUMER RESPONSE TO CIGARETTE EXCISE TAX CHANGES

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We use a rich dataset of weekly cigarette sales to examine how consumers adapt their behavior before and after excise tax increases---whether by stockpiling or substituting between quality tiers of a product. We find that stockpiling primarily occurs for low-tier cigarettes. In the short-term, consumers shift from high- to low-tier cigarettes, presumably to maintain current consumption. However, in the long-term, tax increases are associated with substitution towards high-tier cigarettes. In the long-term, average levels of tar, nicotine, and carbon monoxide consumed per pack rises, as consumer substitute across tiers and brands, suggesting a long-term negative impact on health outcomes.

Keywords: Cigarettes; Consumer Behavior; Excise Taxes; Stockpiling; Tax Avoidance; Tax Incidence

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I. INTRODUCTION

Many taxes, from cigarette taxes to proposed carbon taxes, are motivated by non-fiscal considerations. While a great number of studies estimate short- and long-term tax elasticities, fewer examine how consumers specifically adapt their behavior to tax changes. Although the tax elasticity of demand is useful for fiscal considerations, it provides an incomplete picture of whether the observed consumer response represents an actual reduction in consumption of the taxed good or whether it represents some form of consumer tax avoidance. If consumers are able to mitigate the effect of a tax increase, “sin” taxes designed to discourage consumption may be less effective. In this paper, we study how consumers adapt to cigarette tax increases in the short- and long-term. We focus on two ways consumers mitigate the effect of a tax increase. First, consumers may stockpile the good before taxes rise. Second, consumers may substitute between quality tiers of the taxed product after the tax increase.

Our paper makes several contributions to the existing literature. First, we extend the “flight-to-quality” result from Barzel (1976) and Johnson (1978) that as per-unit taxes rise, consumers will substitute towards higher-price or quality versions of a good, since the tax as a percentage of the price is lower for such goods. We extend the result by incorporating two margins specifically relevant to cigarette and other sin taxes. Our model allows for stockpiling and consumer adjustment costs, which in the cigarette context may reflect the disutility arising from reducing consumption when suffering nicotine addiction. The model illustrates how the direction of the “flight-to-quality” result may be reversed if consumers face disutility when adjusting their level of consumption. If taxes rise, consumers may choose to substitute *away* from the high-quality or high-price good in order to maintain a higher level of consumption and thus ease the transition to higher cigarette taxes. Although in the long-term, the familiar “flight-

to-quality” result still holds, the quantity of discount cigarettes may actually rise in the short-term as consumers seek to mitigate the effect of a tax increase.

We then empirically examine weekly, Universal Product Code (UPC) level data for 85 supermarkets in the Chicago area from 1989 to 1996. Our data overcome three empirical challenges commonly faced in distinguishing how consumers adapt behavior in response to tax changes. First, data on consumer purchases are rarely reported frequently enough to identify stockpiling or shifts between product tiers from idiosyncratic changes in tastes. Second, few datasets distinguish between different quality tiers of a taxed good. Aggregation across different quality tiers obscures the identification of consumer substitution from high-price to low-price brands, which may occur following a tax increase. Finally, few studies track sales at a highly disaggregated geographic level; most of the previous cigarette literature uses indirect estimates of border-crossing from high-tax to low-tax counties or states.

By comparison, we observe sales with high frequency, allowing us to examine the intertemporal pattern of sales around state and local cigarette tax changes. Furthermore, we observe prices and quantities of each particular UPC sold (e.g., Marlboro 120s soft pack) at each store. The UPC-level data distinguish sales of single packs from cartons as well as sales of different cigarette quality tiers, which allows us to estimate substitution between different products following a tax change. Finally, the supermarkets that we observe are located throughout the Chicago metropolitan area and vary demographically as well as in proximity to the Indiana border. Thus, we are able to control for consumer demographics and for proximity to the border with the relatively low-tax Indiana.

As predicted by the theoretical model, we find evidence that consumers engage in both strategies to mitigate the effect of a tax increase. In the months prior to the tax change, sales of

cigarettes rise substantially. Interestingly, stockpiling differs markedly by quality tier. Sales of high-price cigarettes do not rise, but we observe a large increase in the sales of low-tier cigarettes in the months before a tax change. Again, consistent with the theory, both effects are most pronounced at locations far from the Indiana border, where the benefits to stockpiling are likely to be greatest.

We also find evidence consistent with consumers substituting away from high-price or quality cigarettes immediately after a tax change. We find that the quantity of low-price cigarettes rises immediately following a tax change. However, in the long-term, we find suggestive evidence that tax rates reduce consumption low-price cigarettes relative to consumption of high-price cigarettes. The result here and in our earlier working paper (Chiou and Muehlegger, 2010) is broadly consistent with empirical tests of the “flight-to-quality” response (Sobel and Garrett, 1997; Espinosa and Evans, 2011).

Finally, we examine two implications of product shifting. We first examine the potential health consequences of product-shifting by acquiring information on the tar, nicotine, and carbon monoxide levels of cigarette products. We find that in the long-term, average levels of tar, nicotine, and carbon monoxide consumed per pack rises as consumer substitute across tiers and brands. Our results suggest a potential positive short-term effect on health outcomes, but a long-term negative effect on health outcomes.

Second, we examine tax incidence. Using UPC-level data to control for tax-induced substitution, we find that cigarette prices adjust quickly to the change in cigarette taxes and that the majority of cigarette taxes are borne by consumers. Our estimates of pass-through are similar to other recent estimates using disaggregated data (Hanson and Sullivan, 2009; DeCicca, Kenkel, and Liu, 2010; Harding, Leibtag, and Lovenheim, 2010). Separately estimating tax pass-

through by price-tier, we find that short-term pass-through is slightly higher for discount (low-price) cigarettes. This is consistent with the predictions of our theoretical model---all else equal, if consumers substitute towards low-price cigarettes immediately following a tax change, short-term demand for low-price cigarettes will tend to be more tax inelastic than demand for high-priced cigarettes.

In section 2, we present a stylized model of cigarette consumption, which we use to motivate our empirical predictions. In section 3, we present our data. Sections 4 and 5 discuss our empirical results. Section 6 concludes.

II. MODEL OF CONSUMER BEHAVIOR

To motivate our empirical analysis and identify the different behavioral predictions in response to a tax, we examine an extension of the standard discrete-time optimization problem of consumption smoothing. In our model, consumers smooth consumption in response to anticipated changes in per-unit taxes. We extend the standard model in three ways. First, we allow for consumers to choose between two different quality tiers of a product. Second, we allow consumers to stockpile the product in anticipation of the tax increase. Finally, we introduce adjustment costs incurred by consumers when they change their amount of consumption.

In our model of cigarette consumption, we interpret the adjustment cost as an addiction cost---consumers incur disutility if they choose to reduce smoking. Note that cigarettes are not the only good for which adjustment costs are relevant. For instance, a consumer likely incurs some adjustment cost associated with a gasoline tax; it may be difficult to reduce gasoline consumption given her car and where she lives and works, and she may choose to shift to lower-priced brands if prices of all brands increase by similar amounts.

The primary result of the model is that with adjustment costs or habit persistence, a flight *from* higher quality goods *to* lower quality goods may occur in the short-term. This prediction is in the opposite direction of previous theoretical work (Barzel, 1976; Johnson, 1978) that predicts a flight *from* low-quality (price) *to* high-quality (price) goods as per-unit prices rise. The intuition is straightforward: if consumers incur adjustment costs and per-unit taxes increase, consumers may shift towards lower quality goods to smooth their transition path to a lower level of consumption. As the strength of habit persistence increases, the short-term flight from quality will be of greater magnitude and persist for a longer period of time.

We first present the optimization problem and then examine a set of special cases that illustrate the relevant theoretical results.

A. Consumer Optimization Problem

We examine a continuum of risk-neutral individuals who smooth consumption of a high-quality and low-quality version of a good in response to a change in per-unit taxes. Consumers are differentiated by a parameter η that denotes a consumer's relative preference for the low-quality product. For expositional simplicity, we assume that consumers perfectly know their future stream of income y_t over time t and future tax-inclusive prices for the high- and low-quality product, p_t^H and p_t^L . We discuss this in more detail below.¹

Consumers choose purchases (x_t^H, x_t^L) and consumption (c_t^H, c_t^L) of two high and low quality tiers (H,L) of a particular good to maximize the value function

¹ Relaxing the assumption of perfect foresight and adding an outside good increase the complexity of the model but does not change the results. With imperfect foresight, the Euler equations equate marginal utility at time t with marginal expected utility at time $t+1$. If we include an outside good, consumers can additionally smooth the transition to higher tax rates and lower consumption by reducing consumption of the outside good. Although this mitigates the cost of adjusting consumption in response to higher taxes, it does not eliminate the short-term flight from quality.

$$[1] \quad V(A_0) = \max_{\{c_t^H, c_t^L, x_t^H, x_t^L\}} \sum_{t=0}^{\infty} \left(\frac{1}{1+\delta}\right)^t (u[c_t^H + \eta c_t^L] - \beta f[c_t^H, c_t^L, c_{t-1}^H, c_{t-1}^L])$$

$$\text{s.t.} \quad A_{t+1} = (1+r)(y_t + A_t - p_t^H x_t^H - p_t^L x_t^L)$$

$$I_{t+1}^H = (I_t^H - c_t^H + x_t^H)$$

$$I_{t+1}^L = (I_t^L - c_t^L + x_t^L)$$

with non-negativity constraints for consumption (c_t^H, c_t^L) , purchases (x_t^H, x_t^L) , and inventories of the good (I_t^H, I_t^L) .

Consumers may transfer consumption between periods in two ways. The term A_t denotes a consumer's fungible wealth (or liabilities) at the start of period t . The parameters δ and r denote a consumer's discount rate and the real interest rate on assets. Consumers can choose to save for or borrow against future consumption. Alternatively, consumers may stockpile the high-quality and low-quality tier (I_t^H and I_t^L) by purchasing more than they consume in a given period.

In each period, a consumer's utility is a function of two terms. The first term $u(\cdot)$ reflects the utility associated with smoking. The coefficient η varies by consumer and reflects a consumer's relative preference for high-quality or low-quality cigarettes. The form of the utility function $u(c_t^H + \eta c_t^L)$ ensures that in the steady-state, consumers have a strict preference for either the low-quality or high-quality version of a good. While mixing high and low qualities could be a plausible response to a price increase, anecdotal evidence shows that consumers rarely purchase more than one brand of cigarette at any given time.

The second term $f(\cdot)$ reflects the disutility associated with adjusting consumption. In the context of smoking, one interpretation of this term is that it reflects the addiction disutility a smoker experiences when decreasing how much she smokes. For illustrative purposes, we consider several alternative specifications for the adjustment cost function $f(\cdot)$. In our primary

case, we model adjustment costs as quadratic in the difference between a current period's consumption and the consumption of the prior period.

B. Case 1: No Adjustment Costs or Stockpiling

We first consider a baseline case in which consumers cannot stockpile the good and face no adjustment costs ($\beta=0$) when reducing consumption. This is an analogous case to Barzel (1976) in which consumers shift from low-quality to high-quality goods in response to a per-unit tax increase. Absent adjustment costs, we can analytically solve the optimization problem in (1).

Denoting the Kuhn-Tucker multipliers for the non-negativity constraints on c_t^H and c_t^L as μ_t^H and μ_t^L , we have the following Euler equations:²

$$[2] \quad \frac{\partial u}{\partial c_t^H} - \mu_t^H = \frac{1+r}{1+\delta} \frac{p_t^H}{p_{t+1}^H} \frac{\partial u}{\partial c_{t+1}^H} - \mu_{t+1}^H$$

$$[3] \quad \frac{\partial u}{\partial c_t^L} - \mu_t^L = \frac{1+r}{1+\delta} \frac{p_t^L}{p_{t+1}^L} \frac{\partial u}{\partial c_{t+1}^L} - \mu_{t+1}^L$$

$$[4] \quad \eta - \mu_t^H = \frac{p_t^L}{p_t^H} - \mu_t^L$$

Equations (2) and (3) equate the marginal discounted utility of consumption of the high- and low-quality goods between periods. Equation (4) equates the marginal utility of consumption of the high- and low-quality goods in a given period.

If a consumer's relative preference for the low-quality good, η , is greater than the relative marginal cost, p_t^L/p_t^H , the consumer purchases the low-quality good in a given period (i.e., the Kuhn-Tucker condition for H binds with $\mu_t^H > 0$ and $\mu_t^L = 0$). This implies the familiar “flight-to-quality” result associated with a per-unit tax increase. If the prices of the high quality and low

² The Euler equations define the optimal path of consumption. The Euler equations follow from taking the derivative of the Bellman objective function in (1) with respect to consumption of high- and low-quality goods at time t and $t+1$ and applying the Envelope Theorem to equate marginal utility across quality tiers and intertemporally.

quality goods increase by a per-unit tax τ at time $t+1$, (i.e., $p_{t+1}^H = p_t^H + \tau$ and $p_{t+1}^L = p_t^L + \tau$), consumers will purchase H and L according to their values of η :

$$[5] \quad \eta \in [0, \frac{p_t^L}{p_t^H}) \rightarrow \text{Buy } H \text{ before and after the tax change.}$$

$$\eta \in \left[\frac{p_t^L}{p_t^H}, \frac{p_t^L + r}{p_t^H + r} \right) \rightarrow \text{Buy } L \text{ before and switch to } H.$$

$$\eta \in \left[\frac{p_t^L + r}{p_t^H + r}, \infty \right) \rightarrow \text{Buy } L \text{ before and after the tax change.}$$

As an illustration, we simulate consumption under the following parameters, which we maintain for the other cases analyzed below. Consumers' values of η are uniformly distributed from $[0.7, 0.9]$. The real interest rate and discount rate are $r = \delta = 0.1$. Consumer income is constant, $y_t = 100$, and the prices of the high- and low-quality tiers are $p^H = 10$ and $p^L = 8$ before the tax change. The tax change occurs in period 10 and increases the per-unit prices of both the low- and high-quality tier by $\tau = 2$. From the Euler equations, consumers with valuations of $\eta < 0.8$ consume the high-quality good both before and after the tax change. Consumers with valuations of η in $[0.8, 0.833)$ consume the low-quality good before the tax change and the high-quality good after the tax change. Consumers with valuations of $\eta > 0.833$ consume the low-quality good both before and after the tax change.

Figure 1 graphs aggregate consumption by quality tier. In the period of the tax increase, total consumption and consumption of the low-quality tier fall. In contrast, consumption of the high-quality tier rises. Although each consumer of the high-quality good purchases less, the “flight-to-quality” by former purchasers of the low-quality tier increases the relative quantity of the high quality good.

[Insert Figure 1 here]

Allowing consumers to stockpile in response to the tax increase does not change the basic results of the model. Stockpiling provides an alternative way to transfer consumption between periods. The advantage of stockpiling is that it allows the consumer to purchase at the pre-tax price. The drawback (relative to saving using A_t) is that the stockpile does not appreciate over time at rate r .³ At the optimum, a consumer purchases cigarettes for a given period using whichever “storage technology” is less costly. Under normal circumstances, when $p_t = p_{t+1}$, the consumer will always prefer to save using A_t rather than stockpile. If the consumer knows that the tax-inclusive price will rise, $p_t < p_{t+1}$, a consumer will choose to buy cigarettes at time t to consume at time $t+j$ if and only if

$$[6] \quad p_t(1+r)^j < \frac{p_{t+r}}{p_t}$$

With stockpiling, both high-quality and low-quality sales increase immediately prior to the tax change. Consumers then deplete inventories purchased at the pre-tax price, after which they begin to purchase at the new, higher price and immediately reduce consumption.

C. Case 2: With Adjustment Costs and Stockpiling

In this section, we introduce adjustment costs. We computationally solve the model using the same set of parameters as in Figure 1.⁴

³ For expositional simplicity, we assume that individuals do not incur storage costs if they choose to accumulate a stockpile. If storage entails costs or inventories depreciate as might be the case if cigarettes deteriorate over time, storage becomes less attractive, but the intuition is similar.

⁴ Consumers’ values of η are uniformly distributed from [0.7,0.9]. The real interest rate and discount rate are $r = \delta = 0.1$. Consumer income is constant at $y_t = 100$, and the prices of the high- and low-quality tiers are $p^H = 10$ and $p^L = 8$ before the tax change. The tax change occurs in period 10 and increases the per-unit prices of both the low- and high-quality tier by $\tau = 2$. We present sensitivity analyses in an online Model Appendix (available at the authors’ websites).

As prices rise, consumers incur a cost relative to their consumption in previous periods. In the context of smoking, this may reflect the cost of reducing consumption in the presence of addiction, although adjustment costs may be relevant in other contexts. Figure 2 presents the quantity of the low quality tier over time if consumers do not anticipate the tax change or choose not to stockpile cigarettes. Model 1 corresponds to the case in which consumers do not face costs of adjustment.

[Insert Figure 2 here]

To illustrate the effect of adjustment costs, models 2, 3 and 4 increase the comparison period used to calculate the adjustment costs. In model 2, the quadratic adjustment costs are measured relative to consumption in the previous period. In models 3 and 4, the adjustment costs are measured relative to the average of the previous three and five periods respectively. As the length of the window increases, consumers incur disutility for a longer period of time. Consequently, they face stronger incentives to smooth the transition to lower cigarette prices in model 4 than in models 2 and 3.

In all three models with adjustment costs, the quantity of the low-quality tier increases after the tax change⁵, since consumers substitute to lower-priced cigarettes to maintain their level of consumption after the tax change. Over time, consumers smoothly reduce consumption and shift back towards the high-quality tier---reflecting the long-term “flight-to-quality.” This is in sharp contrast to the model without adjustment costs---in model 1, consumption and quantities adjust immediately to reflect the new relative prices of the low- and high-quality tiers.

Stockpiling can partially mitigate the short-term “flight-from-quality” that arises from adjustment costs. A stockpile allows consumers to partially smooth the transition path to a world

⁵ In the online Model Appendix (available at the authors’ websites), we decompose the quantity effects into high and low quality consumption for each of the three customer “classes”: (1) $\eta < 0.8$, (2) η in $[0.8, 0.833)$, and (3) ≥ 0.833 .

with higher cigarette taxes. Figure 3 presents the quantity of the low-quality tier for the four models in a world in which consumers anticipate the tax change. An increase in per-unit taxes has a larger relative effect on the price of low-quality cigarettes. Consequently, stockpiling is greatest for low-quality cigarettes, and the quantity purchased of the low-quality tier increases immediately before the tax change. Immediately after the tax change, consumers begin to deplete their stockpile of cigarettes. If the consumer depletes the stockpile before completing the adjustment to higher cigarettes taxes, consumers substitute towards low-quality cigarettes to smooth the remaining transition. When these consumers begin to purchase fresh cigarettes, their purchases may exhibit a short-term “flight-from-quality” similar to those of consumers in Figure 2 who did not anticipate the tax increase.

[Insert Figure 3 here]

III. DATA

We compare the predictions of our theoretical model to scanner data on cigarette sales from Dominick’s Finer Foods (hereafter, DFF) provided by the Kitts Center for Marketing at the University of Chicago Booth School of Business.⁶ Dominick’s Finer Foods is the second largest supermarket chain in the Chicago metropolitan area with a market share of approximately 25 percent (Chevalier, Kashyap, and Rossi, 2003). The DFF scanner dataset provides weekly, UPC-level data for twenty classes of products at 120 DFF grocery stores in Lake, Cook, Dupage, and Will Counties from 1989 to 1996. For our purposes, we focus specifically on the scanner data related to cigarettes. During our sample period, the state of Illinois, Cook County, and neighboring jurisdictions raised per pack taxes at various points.

⁶ The DFF data are publicly available at <http://research.chicagogsb.edu/marketing/databases/dominicks/index.aspx>.

Note that our data and interpretations apply to the sales of a major grocery chain in Chicago. Merriman (2008) checks the representativeness of the collection of littered samples with scanner data of vendors located in Chicago. In general, the distribution of brands is similar across the two samples. One difference is a lower quantity of “other” brands for the littered data; one possibility is either a decrease in quantity of other brands over the time period or that vendors with scanners tend to stock a greater variety of brands than average. If vendors with scanners have more product availability, then our results from the DFF scanner data suggest an upperbound on the amount of product switching that can occur after a tax increase. Our results apply to a specific region and historical tax changes. Given the larger increases in taxes recently, we note that our results may not necessarily apply to other geographic areas or magnitudes of tax changes. In particular, taxes on cigarettes have drastically increased in recent years, and consumer response may be more or less intense at higher tax amounts. As a robustness check, we also apply our analysis to different neighborhoods, and we find similar patterns across the neighborhoods.⁷

The DFF database tracks cigarette sales at approximately 83 stores.⁸ The tracked stores are located throughout the Chicago metropolitan area. Twenty five of the stores in our sample were located outside of Cook County. Thirty-eight were located within Cook County, but outside of Chicago or Evanston. Seventeen were located within the Chicago city limits, and three were located within the Evanston city limits. Using the reported latitude and longitude for each store

⁷ We also perform an additional robustness check. While we do not have data on purchases outside of Dominick’s, we use variation in pricing zones across Dominick’s stores to test whether substitution patterns differ across these neighborhoods. Presumably, the pricing zones are defined according to differences in demographics and competition across different neighborhoods. The dataset includes stores from three different pricing zones---low, medium, and high. We observe a similar patterns of DFF sales across each of the pricing zones.

⁸ The Chicago Kilts Center for Marketing worked with Dominick’s to track sales at all stores. While we do not observe a particular reason in the database description for why 83 stores are included, we observe the demographics for the stores within and outside of our sample are relatively similar.

in the DFF dataset, we calculate the straight-line distance to Indiana. On average, the stores are 27.5 miles from the Indiana border. The nearest stores are 2.0 miles from the Indiana border.

The DFF dataset also provides information about the demographics of store customers. DFF contracted with a market research firm to obtain a snapshot of regular customer demographics on a store-by-store basis. Market Metrics processed data from the 1990 Census for the Chicago metropolitan area to create a demographic profile for each of the stores. Across stores, the median household income varies from \$19,300 to \$73,100. Mean age, the fraction of minority customers, the fraction with a 4-year college degree, and the fraction living below the poverty line vary substantially as well. The 83 stores tracked in the DFF dataset are statistically indistinguishable from the untracked stores by mean incomes, age, and race.⁹

For each UPC with positive sales in a particular store and week, the scanner data report the total number of packs sold as well as the retail price.¹⁰ Because the DFF scanner data only report quantities and prices for products offered by Philip Morris for a subset of the time period, we restrict our analysis to sales of cigarettes produced by the three other major manufacturers: Lorriard, Liggett, and R J Reynolds.¹¹ For our three manufacturers, we observe positive sales for 348 distinct UPC codes. Approximately 34 percent of UPCs have positive sales in any particular

⁹ The customers of the stores tracked in the DFF dataset are slightly more educated than those of the omitted stores. Twenty-three percent of customers in the tracked stores are college-educated compared to 18 percent of the customers in the untracked stores.

¹⁰ Although the prices reported in the scanner data are sales-tax exclusive, we do not believe this substantially biases our analysis. The state sales tax rate of 6.25 percent is unchanged throughout our study period as is the sales tax in the city of Chicago (1 percent). Although Cook County does institute a sales tax during the study period, it is modest in size (0.75 percent)---equivalent to 2-3 cents per pack---and is not timed coincidentally with changes in per-pack taxes and thus unlikely to bias our analyses.

¹¹ While do not have enough weeks with Philip Morris data to estimate a regression, we were able to calculate aggregate statistics on the composition of cigarettes within each quality tier. The distribution of tiers is relatively similar across Philip Morris and other brands with high-tier cigarettes accounting for the majority of cigarettes.

week. In total, we observe sales of 13.2 million packs of cigarettes in our sample.¹² On average, stores sell approximately 400 packs of cigarettes per week.

In order to measure shifting between high and low price cigarettes, we group UPCs into high, medium and low price tiers. Table 1 summarizes the price distribution for the three price tiers. The high tier contains “premium” brands sold by the pack.¹³ Relative to the mean per pack price, packs in the high tier are sold at an eight percent premium. The 10th and 90th percentiles of prices for UPCs in this tier are 6.2 percent and 8.7 percent higher than the weighted average per pack price. For the empirical analysis below, we chose to combine premium cartons and discount packs as the “medium tier” based on the similarity of per pack prices. Fundamentally, our model doesn't provide strong predictions whether a smoker who initially purchases premium packs (“high tier”) would prefer to shift to premium cartons or discount packs in response to a tax change. “Premium” cartons and “discount” packs are sold, on average, at prices five percent and eight percent below the mean price per pack. The “low” tier consists of discount cigarettes sold by the carton. On average, these cigarettes are sold at 22 percent below the mean price per pack. The vast majority of cigarettes sold fall into the top two tiers---the highest price tier accounts for 36 percent of sales while the medium price tier account for 62 percent of sales.

[Insert Table 1 here]

Finally, we merge the scanner data with data on cigarette excise taxes levied by the federal government, Illinois, and neighboring states from the *Tax Burden on Tobacco*.¹⁴ We obtained information on county and municipal excises taxes from city ordinances online and

¹² Cigarettes sales by R. J. Reynolds, Lorillard, and Liggett total 8.4 million packs, 4.2 million packs, and 0.6 million packs.

¹³ We use two approaches to classify UPCs as “discount” and “premium” brands. First, we use industry classifications that group brands of cigarettes into premium and discount cigarettes. As an alternative, we calculate UPC-level markups (or discounts) relative to weighted average per pack price in each store and classify discount brands as brands in the bottom quartile of the price distribution. Both approaches generate very similar classifications---the use of one or the other does not substantively affect our conclusions.

¹⁴ Note that our data are historical, and the taxes are low compared to recent years.

from speaking with local government officials.¹⁵ Table 2 summarizes the various tax changes during our sample period. Federal taxes increased at two points in our sample. On January 1, 1991, the federal excise tax increased from 16 to 20 cents per pack, and on January 1, 1993, the federal excise tax increased again to 24 cents per pack. State excise taxes increased during the period as well. Illinois raised its state cigarette tax from 30 to 44 cents per pack in July 1993. The excise tax in Indiana remained constant at 15.5 cents per pack.

[Insert Table 2 here]

In addition to state and federal taxes, some of the stores are subject to county and local excise taxes. Cook County, Illinois levies a separate excise tax on cigarettes. Cook County increased the excise tax from 10 cents per pack at the beginning of the period to 18 cents in March 1996. Additionally, two cities levy municipal excise taxes on cigarettes. The city of Chicago had a 16 cent per pack excise tax, and the city of Evanston maintained a 10 cent per pack excise tax. Figure 4 displays the per-pack excise tax in four jurisdictions where DFF stores are located: within Chicago, within Evanston, within Cook county but outside of Chicago/Evanston, and outside of Cook County. In addition, Figure 4 displays the per-pack excise tax in Indiana. The mean cigarette excise tax (including federal, state and local taxes) for stores in our sample is 74 cents per pack or approximately 24 percent of the mean tax-inclusive price. Across all stores and over the entire time period, customers could save on average 35 cents per pack by traveling to Indiana.

[Insert Figure 4 here]

Table 3 reports the summary statistics for our panel regression. The average price per pack was \$2.24, and the average tax per pack was 73 cents. Stores were on average 28.7 miles from the Indiana border.

¹⁵ City ordinances can be found at the city websites or at <http://www.amlegal.com> and <http://www.municode.com>.

[Insert Table 3 here]

IV. EMPIRICAL RESULTS

In this section, we first motivate our empirical analysis by graphically examining a discontinuous increase in the Illinois tax in July 1993. This is the largest tax change in our sample and illustrates many of the effects we estimate in the longer panel. Then, using all of the scanner data, we formally test for evidence of stockpiling in anticipation of state and local tax changes and look for evidence that consumers substitute between quality tiers in the short- and long-term after the tax increase.

A. Event Study

We begin by graphically examining the discontinuous change in the Illinois state taxes in July 1993. The 46 percent increase in per-pack taxes represents the largest tax increase in our sample. Figure 5 graphs weekly sales for each of the three quality tiers in the weeks immediately before and after the tax change in June 1993.

[Insert Figure 5 here]

Our model suggests consumers have two strategies to help mitigate the costs associated with changing their level of consumption. First, consumers may stockpile cigarettes in advance of the tax change and use the stockpile to smooth the transition to post-tax levels of consumption. Although a consumer may incur storage costs associated with the stockpile, such as if cigarette quality depreciates with time, so long as the expected tax savings outweigh the storage costs stockpiling may be a reasonable strategy to smooth the transition to higher taxes.

Alternatively, the consumer may choose to purchase less expensive cigarettes (either by changing brands or purchasing cartons rather than packs).

Since the options available to consumer differ by quality tier, we expect sales of each tier of cigarettes to respond in a particular way. Consumers smoking the highest-tier can both stockpile and substitute towards lower quality cigarettes. Although the extent to which they do each would depend on their preferences, both effects would imply that sales of the highest tier of cigarettes would fall after the tax change. The effects on sales of the middle quality tier are ambiguous. Substitution by high-tier smokers to lower quality tiers after the tax change may offset any reduction in post-tax sales caused by pre-tax stockpiling. Finally, the sales of the lowest quality tier should be elevated in the pre-tax period (due to stockpiling) and may or may not be elevated in the post-tax period depending on whether the substitution from higher-quality tiers is greater than the post-tax reduction in sales as stockpiles are depleted.

Our empirical results line up reasonably closely with these predictions. Figure 5 illustrates the sales of three tiers of cigarettes during the 1993 Illinois tax change. We find little evidence of stockpiling of high and medium tier cigarettes, but sales of the lowest price tier rise significantly prior to the tax change. After the tax change, sales of high-tier cigarettes are lower than before.¹⁶ In contrast, sales of medium and low tier cigarettes remain elevated, consistent with substitution away from high-tier cigarettes and towards lower-tiered cigarettes immediately after the tax increase. After an adjustment period of approximately two months, the fractions of high, medium, and low tier cigarettes return to levels comparable to those several months before the tax change.¹⁷

¹⁶ A test of average sales before and after the tax change shows that we can reject the hypothesis that sales were higher after the tax increase for the low-tier cigarettes (p-value 0.053) and high-tier cigarettes (p-value 0.003).

¹⁷ While we cannot test directly for sales outside of Dominick's, we can rely on variation within demographics among the chain stores to test for possible compositional effects. As suggested by a reviewer, we have explored an

During the two months before the tax change, average weekly sales of packs of low-tier cigarettes in stores were 2.2 times higher than in the prior months. We observe the stockpiling behavior for over the course of 8 weeks. Consequently, our back-of-the-envelope calculation suggests that overall sales during the entire stockpiling period were nearly 18 times the weekly sales ($=2.2*8=17.6$). The magnitude of stockpiling represents about 2.5 months of worth of cigarette sales.¹⁸

In Figure 6a-6b, we also illustrate similar graphs for sales across stores according to their distance to the Indiana border during the Illinois 1993 tax increase. As expected, stores that are located close to the border (< 15 miles) experience less stockpiling than stores far from the border (> 30 miles). For the one month before and two months after, stores close to borders have larger stockpiling (p-values of 0.07 and 0.002). The coefficients are precisely estimated for the substitution from high to lower tier cigarettes at stores located 15-30 miles from the border, and the coefficients are not precisely estimated for stores located more than 30 miles from the border. Little evidence of stockpiling and substitution exists for stores closest to the borders (less than 15 miles away). Our result is consistent with the prior finding that cross-border shopping declines rapidly as distance to the border increases (Merriman, 2010).

[Insert Figure 6 here]

B. Panel Analysis

additional analysis using differences in demographics across neighborhoods. We run additional regressions stratified by neighborhoods that are either below or above the average level of demographics for income, poverty, education, age, and ethnicity. We find similar qualitative results of sales patterns within tiers and over time.

¹⁸ Let x be the average weekly sales without stockpiling. In the 8 weeks of stockpiling, total sales are $17.6x$, and in the absence of stockpiling, we would expect total sales to be $8x$. The amount of stockpiling is nearly 10 weeks worth of sales ($=17.6/8$).

We extend our event study analysis by constructing a longer panel that includes two federal tax changes, the 1993 tax change in Illinois, and tax changes in Cook County. We exploit the tax changes as well as heterogeneity in store location and demographics to examine both consumers' short- and long-term responses to tax changes.

In order to more cleanly and precisely analyze the substitution between product tiers, we run quantity regressions. For each tier of cigarettes, we estimate the following regression for quantity as measured by the logarithm of the total number of packs sold at store j during week t in season :

$$\begin{aligned}
 [7] \quad \log(q_{jst}) = & \gamma\tau_{jt} + \beta_1\tau_{jt} * TwoMonthsBefore_t + \beta_2\tau_{jt} * OneMonthBefore_t \\
 & + \beta_3\tau_{jt} * OneMonthAfter_t + \beta_4\tau_{jt} * TwoMonthsAfter_t \\
 & + \theta_j + \psi_s + \sum_{n=1}^4 \delta_n t^n + \epsilon_{jt}
 \end{aligned}$$

where q_{jt} is quantity of a given tier at store j in week t , and τ is the sum of the total federal, state, and local excise taxes per pack. Our unit of observation is at the store-week level, so we cluster our standard errors at the store-level to account for correlated error terms by store over time. The coefficient γ captures the long-term adjustment in quantities to the tax change (in cents per pack). The coefficients β_1 through β_4 capture the stockpiling behavior in the months preceding and the short-term adjustment immediately following the tax change. The coefficients θ and ψ capture store and quarterly fixed effects, and the coefficients ψ include linear and nonlinear time trends.

We use a full panel of tax changes from the federal, state, and county levels. First, the stockpiling coefficients are identified by exploiting differences in how sales respond to taxes levied within and outside a store's jurisdiction. For instance, consumers in Cook County will stockpile Cook County cigarettes in anticipation of a tax increase within Cook County, though consumers outside of Cook County will not stockpile cigarettes in anticipation of a tax increase

within Cook County. Second, the short- and long-term shifts in product sales are identified by differences in sales during the immediate versus longer time window after the tax increase. The short-term product shifting reflects any changes in sales immediately following the tax increase above and beyond a long-term trend. We include store fixed effects to account for any level differences in quantities of the cigarette tiers across our sample of stores. We also include quartic time trends as well as quarterly dummies to capture seasonal effects.

Our theoretical model makes several predictions about tax-induced substitution between quality tiers. Absent addiction, we should expect consumers to shift from discount to premium cigarettes following a tax increase---an increase in per-unit taxes reduces the relative price differential between premium and discount cigarettes. Although consumers will stockpile, they will stockpile whatever cigarettes they consumed in the pre-tax period. With addiction, though, consumer may shift between quality tiers to help smooth their adjustment to high cigarette taxes. If the disutility of reducing consumption is sufficiently high, the model predicts that even individuals who smoke premium cigarettes in the pre-tax period may stockpile discount cigarettes and may shift consumption to discount cigarettes for a time following a tax increase to help smooth the transition to higher taxes.¹⁹

Our results in Table 4 are consistent with these predictions. Columns (1)-(3) report quantities for the low-tier, medium-tier, and high-tier cigarettes. The coefficients on the dummy variables for the months before and after the tax change reflect the short-term changes in quantities in response to the tax increase. The quantities of low- and medium-tier cigarettes

¹⁹ Note that our theory concerns individuals. For the theory to map over with the application to stores, we need the set of consumers who purchase cigarettes from grocery stores to not change. Indeed, we find two pieces of evidence to support this. First, we do not observe a long-term shift away from or towards cigarettes across all tiers for the largest tax increase (July 1993 Illinois) in our sample. Second, Dominick's established several different pricing zones among their stores. Each zone was supposed to maintain a similar regular price for their product. We do not observe any long-term shifts among Dominick's stores across the different pricing zones.

increase substantially prior to a tax increase; quantities are lower after the tax increase compared to the stockpiling months, but still remain slightly elevated due to substitution from higher tiers. High-tier cigarettes do not experience stockpiling in the months prior to a tax change, and a sharp drop occurs after the tax increase, presumably as consumers substitute away in the short-term to lower-tier cigarettes. The relative magnitudes of the coefficients on *Tax Per Pack* reflect the long-term shifts between different quality tiers as the tax increases. Although the coefficient on *Tax Per Pack* is positive and significant, the quartic time trends imply that sales of all tiers fall. As taxes rise, the coefficients on *Tax Per Pack* implies that the share of high-tier cigarettes increases in the long-term.

[Insert Table 4 here]

Table 5 expands the regression by incorporating a store's distance to the Indiana border. As expected, stores that are located further from the border exhibit more stockpiling for low-tier cigarettes. We expect that consumers who live in areas far from lower-price alternatives will have a stronger incentive to stockpile in anticipation of a tax increase. The results confirm the evidence from the event study in the previous section that consumers do engage in stockpiling in anticipation of tax increases. We also find that product-shifting differs in the short- vs. long-term. The difference between stockpiling among medium vs. high-tier cigarettes is statistically significant two-months before the tax change (p-value 0.013), and the difference between stockpiling among low vs. high-tier cigarettes is statistically significant at the 15 percent level one-month before the tax change (p-value 0.11).

[Insert Table 5 here]

C. Implications of Product Shifting

1. Potential Health Consequences

In the prior section, our results indicated that shifting between low- and high-tier cigarettes occurs in the short- and long-term. In this section, we consider the potential health implications of this behavior, recognizing that the health impacts of tax-induced substitution are modest relative to tax-induced cessation of smoking. To establish whether certain cigarette characteristics are potentially correlated with worse health outcomes, we obtained a historical document from the Federal Trade Commission 1998 *Tar, Nicotine, and Carbon Monoxide Report*. The report lists the tar, nicotine, and carbon monoxide yields of 1294 varieties of cigarettes. We compute the average tar, nicotine, and carbon monoxide levels for each brand of cigarettes. Then we match the brand's characteristics to the UPCs in our DFF dataset.²⁰

We run a regression similar to equation (7) with the dependent variables as the total amount of each ingredient (tar, nicotine, and carbon monoxide) from cigarettes sold at a given store as well as the average level of the ingredients per pack sold at each store. Table 6 reports the results of the regressions. As the table indicates, total tar, nicotine, and carbon monoxide levels fall immediately after the tax change. However, in the long-term as product-shifting occurs, the total levels of tar, nicotine, and carbon monoxide rise. This pattern also prevails when we examine the average amount (per pack) of nicotine, tar, and carbon monoxide sold at each store.

[Insert Table 6 here]

In fact, we find that for the subset of UPCs in our sample that we are able to match to cigarette characteristics, tar, nicotine, and CO content do not vary by price tier after conditioning

²⁰ We omit two brands, Style and UK, in our sample did not appear in the *Tar, Nicotine, and Carbon Monoxide Report*. These brands account for less than 0.004 percent of the sample.

for these characteristics.²¹ Our results suggest that as taxes rise, smokers, in addition to shifting between price tiers, also tend to shift towards higher tar, nicotine, and CO cigarettes. Our result is consistent with studies that have found that smokers may respond to taxes by inhaling “harder” and/or smoking cigarettes longer (e.g., down to the filter) (Adda and Cornaglia, 2006). As a result, potentially positive health effects may occur in the short-term as consumers switch from high- to low-tier cigarettes to maintain their current consumption. However, in the long-term, consumers are able to adapt and switch to cigarettes that contain more tar, nicotine, and carbon monoxide. This is suggestive of a potential short-term positive impact, but a long-term negative impact on health outcomes.

2. Tax Incidence

In this section, we estimate pass-through of cigarette taxes. We estimate pass-through for three reasons. First, from a policy perspective, incidence is particularly important for taxes motivated by non-fiscal considerations like “sin” taxes. If the burden of taxes falls primarily on producers, the effect of tax on smoking intensity may be lessened, and taxes may be less regressive than commonly argued.

Second, we find suggestive evidence that consumers substitute from more-expensive to less-expensive cigarettes immediately after a tax change. Consequently, short-term demand for discount cigarettes may be less tax-elastic than demand for more expensive cigarettes. We test whether this is reflected in short-term tax pass-through. Our estimates indicate whether

²¹ We are able to match the UPCs in our sample (comprising roughly fifty percent of total packs sold) to the cigarettes characteristics and tar, nicotine, and CO content. Regressions of tar, nicotine, and CO content on cigarette characteristics and price tier show that tar and nicotine levels do not vary by price tier. Carbon monoxide is higher for the lowest tier, although the effect is not significant once we condition on other characteristics aside from price tier.

differential rates of substitution across and between quality tiers lead to meaningful differences in estimated tax incidence.

Finally, the literature on cigarette tax pass-through highlights the importance the “flight-to-quality” when estimating incidence. Specifically, if consumers shift from or towards higher-price versions of a good as a result to a tax change, a regression of weighted average price on taxes provides a biased estimate of incidence. In particular, the estimate captures both the shift in quantities as well as tax pass-through. Relative to the prior literature, our results in the previous section suggest that both stockpiling and the “flight-from-quality” may bias an estimate of incidence based upon average prices. Although the direction of the effect is ambiguous (since both tend to shift the weighted average price of cigarettes downward), our work suggests that these sources of bias are likely to be important when using high frequency data.

Similar to several other recent papers (Hanson and Sullivan, 2009; Harding, Leibtag, and Lovenheim, 2010), we estimate pass-through at the UPC-level, which eliminates shifts between price tiers as a source of bias.²² To estimate cigarette tax incidence, we assume that the tax-inclusive price for UPC u in product class k and store j at time t is a function of the relevant excise tax, the excise tax interacted with our proxy for the incentive to border-cross (the tax differential to the neighboring state divided by the distance to the state), class-specific time trends, and UPC-store fixed effects:

$$[8] \quad Tax\ Inclusive\ Price_{ujt} = \alpha_{uj} + \sum_k \beta_k ExciseTax_{jt} + \delta_k * t + \epsilon_{ujt}$$

We first-difference the weekly observations (dropping the time-invariant UPC-store fixed effects) and estimate tax incidence using retail price changes contemporaneous with the tax increase. We consider four cigarette classes (branded vs. discount, pack vs. carton) denoted by k

²² Besley and Rosen (1999) find that tax incidence can also vary at the commodity-level.

and separately estimate pass-through for each class of cigarette. Consequently, the equation we estimate is

$$[9] \quad \Delta Tax \text{ Inclusive Price}_{ujt} = \sum_k \beta \Delta Excise Tax_{jt} + \delta_k + v_{ujt}$$

Table 7 presents our incidence results. In Column (1), we estimate a common pass-through coefficient and find that consumers bear approximately 80 percent of cigarette excise taxes in the Chicago area. In Column (2), we include interaction terms for carton sales and discount sales and find that pass-through for discount cigarettes is 11 percentage points higher than that for premium cigarettes. We do not find that pass-through for cigarettes sold by the carton differ from cigarettes sold by the pack. In Column (3), we separately estimate incidence for each class of cigarettes and find a similar pattern. Pass-through for discount packs and cartons are 0.90 and 0.92 while pass-through for premium packs and cartons are 0.79 and 0.80. Our results are consistent with our findings in the previous section that suggest consumers respond to tax increases by substituting towards lower-cost cigarettes in the short-term.

[Insert Table 7 here]

Although we find that taxes are primarily borne by consumers, our estimates of tax pass-through are on the low end of estimates from the previous papers. We believe that the discrepancy with the estimates from the previous literature is driven by two factors. First, in contrast to some of the earlier literature estimating cigarette tax pass-through (e.g., Keeler (1996)), our data allow us to track the prices of individual products rather than the average cigarette price in a jurisdiction. If, as suggested by the “flight-to-quality” literature, the mix of high price and low price cigarettes sold changes with tax increases, estimates of the tax pass-through based on average prices would tend to overestimate the true rate of pass-through.

Second, our estimates are local estimates for the Chicago metro area which is bordered by the low-tax jurisdiction of Indiana. As the cost of travel to low-tax jurisdictions declines, demand will become more tax elastic as it becomes easier for consumers to avoid high taxes. The most comparable estimates of pass-through to ours are Harding, Leibtag and Lovenheim (2012) who estimate average pass-through rates of 75 to 90 percent at distances of 20 to 40 miles from low-tax borders, roughly the distance from downtown Chicago to Gary, Indiana.

In Table 8, we estimate the speed of pass-through. We regress first-differenced tax-inclusive price on contemporaneous and lagged values of the first-differenced tax rate. Since not all UPCs are sold in each week, for this analysis, we restrict the sample to UPC-store combinations for which we observe prices and sales for five weeks before each price change. For comparison, column (1) replicates the specification in Table 7 using this subset. Column (2) presents the results estimating the speed of pass-through. Consistent with Harding, Leibtag, and Lovenheim (2012), we find that cigarette taxes are passed onto consumers immediately. In the week of the tax change, 80 percent of taxes are passed onto consumers. In subsequent weeks, we do not find that the tax-inclusive price changes significantly.

[Insert Table 8 here]

Finally, our detailed data allow us to consider one additional analysis. Discussions of tax incidence often make an implicit assumption that pass-through is relatively uniform for all brands of a particular good (such as cigarettes). In our particular context, we can estimate pass-through rates specific to each UPC-store. We examine how much of the variation in UPC-store level pass-through rates is explained by class- or UPC- dummy variables and find that much of

the variation in pass-through rates occurs at the class-level.²³ Between-class variation accounts for approximately 44 percent of the variation in pass-through rates. Within-class but between-UPC variation accounts for an additional 8 percent of the variation in pass-through rates. The remaining variation in pass-through rates at different stores occurs within UPCs. This suggests that much of the variation in pass-through rates can be captured by relatively parsimonious product characteristics.

VI. CONCLUSION

Consumers can adapt and respond to tax changes in various ways over the short- and long-term that may undermine the intent of the tax. In this paper, we investigate how consumers may respond by stockpiling prior to a tax change and by substituting between high-tier and low-tier products in the short- and long-term after a tax change.

We construct a dynamic model of consumer behavior that includes stockpiling and adjustment costs to account for addiction. Our micro-level data allow us to test these predictions by controlling for border-crossing to lower-tax jurisdictions as well as customer demographics. We use a rich panel of cigarette sales at 85 locations of Dominick's Finer Foods in the Chicago area, and we apply two distinct empirical approaches to examine consumers' responses to changes in cigarette excise taxes. First, we explore an event study of a major tax change in Illinois during July 1993. Then we extend our analysis to exploit a long panel of state and local tax changes as well as heterogeneity in store location and demographics.

Our empirical results are consistent with the model's predictions. We find that stockpiling differs markedly by quality-tier. For discount cigarettes, we find evidence of

²³ For the analysis, we exclude UPCs appearing infrequently in the data. We limit our sample to UPCs appearing in at least one-quarter of the stores and with positive sales for at least twenty-six weeks. As in the analyses above, we include UPC-store fixed effects. We also include UPC-specific time trends.

substantial stockpiling. We find some evidence that consumers substitute between quality-tiers in the short-term in response to tax changes. In the month after a tax increase, we find that the quantity of low-tier cigarettes rises, consistent with consumers substituting to lower-cost cigarettes to help smooth their reduction in consumption. While most smokers absorb the additional taxes, customers at these stores appear to shift from premium cigarettes to less expensive discount cigarettes to offset the increase in taxes. Over the longer term, we find suggestive evidence of substitution in the opposite direction, from low-tier to high-tier cigarettes consistent with the “flight to quality,” literature. Taxes decrease sales of low-tier cigarettes more than sales of high-tier cigarettes. Our results have two important implications for policy. First, in the long-term, average levels of tar, nicotine, and carbon monoxide consumed per pack rises, as consumer substitute across tiers and brands, suggesting a long-term negative impact on health outcomes. Second, we find meaningful differences in excise tax incidence. On average, taxes are heavily borne by consumers and immediately incorporated into the price of cigarettes. We estimate that pass-through is slightly higher for discount brands, possibly reflecting the limited ability of smokers of discount brands to substitute towards lower tier cigarettes in response to tax changes.

Our results have public policy implications for tax increases, especially for “sin” taxes with non-fiscal motives. For goods subject to “sin” taxes, the short-run response to a tax increase may differ from the long-run response if cessation occurs gradually. Our results provide evidence of an alternative reason why the short-run response to a tax increase is likely to misrepresent long-term changes in behavior. In the short-term, stockpiling and substitution to low-price cigarettes allow consumers to partially mitigate the effects of a tax increase. Thus, policy

evaluation based on short-run changes in sales may further misrepresent the true degree to which taxes affect smoking.

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Figure 1
Consumption with no stockpiling and no adjustment costs, by quality tier

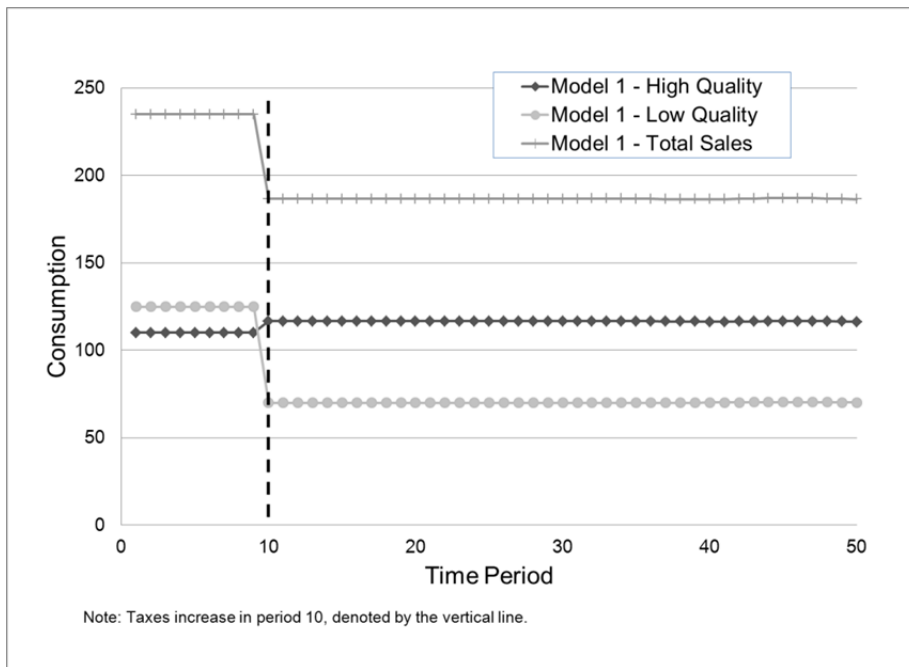


Figure 2
 Market share of low-quality tier with increasing adjustment costs: unanticipated tax changes

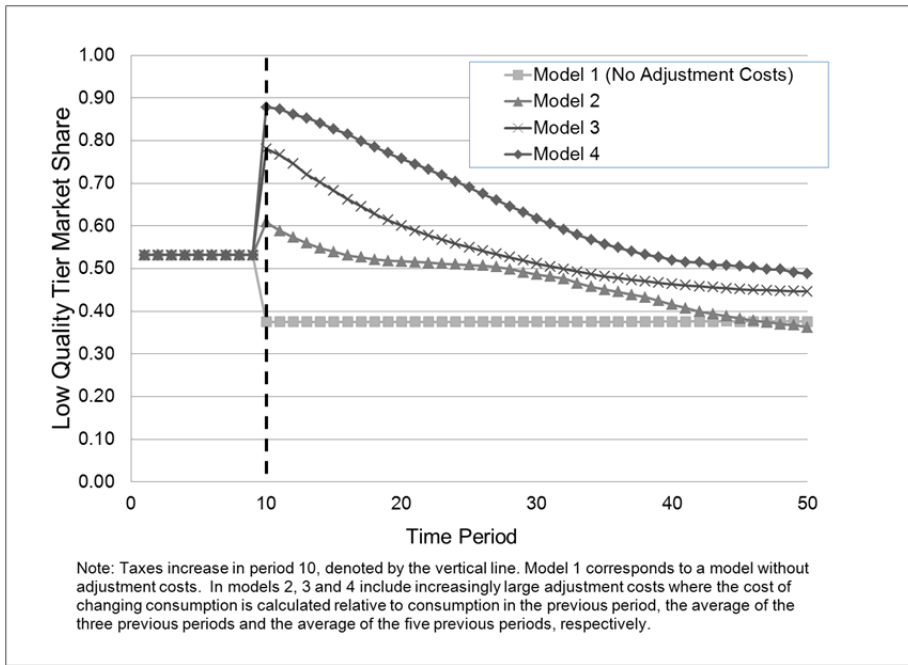


Figure 3
 Market share of low-quality tier with increasing adjustment costs: anticipated tax changes

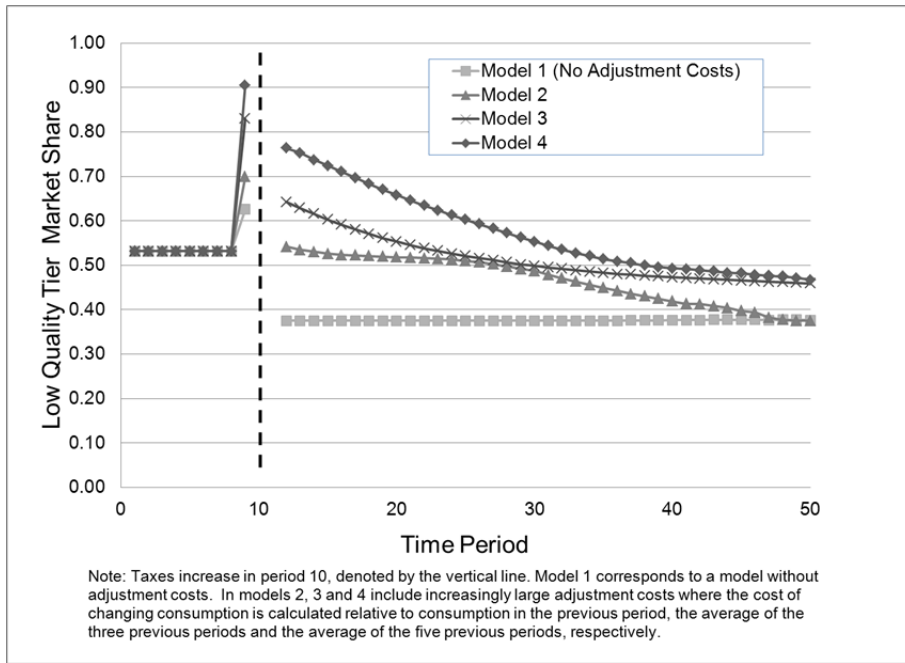
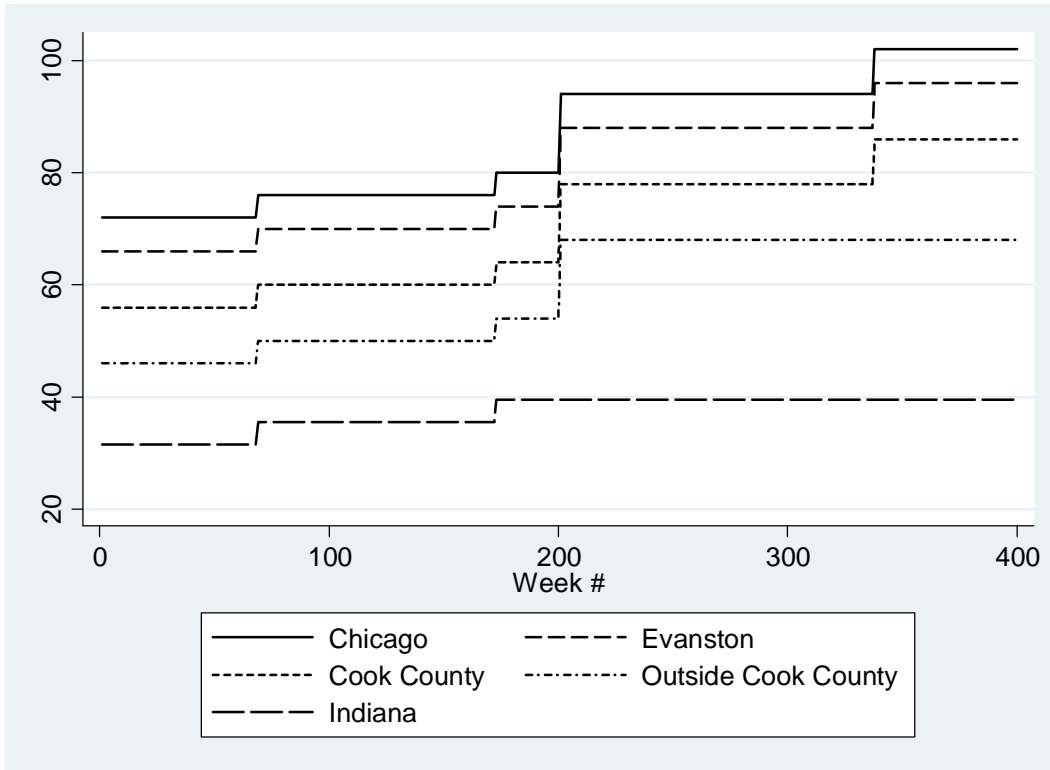
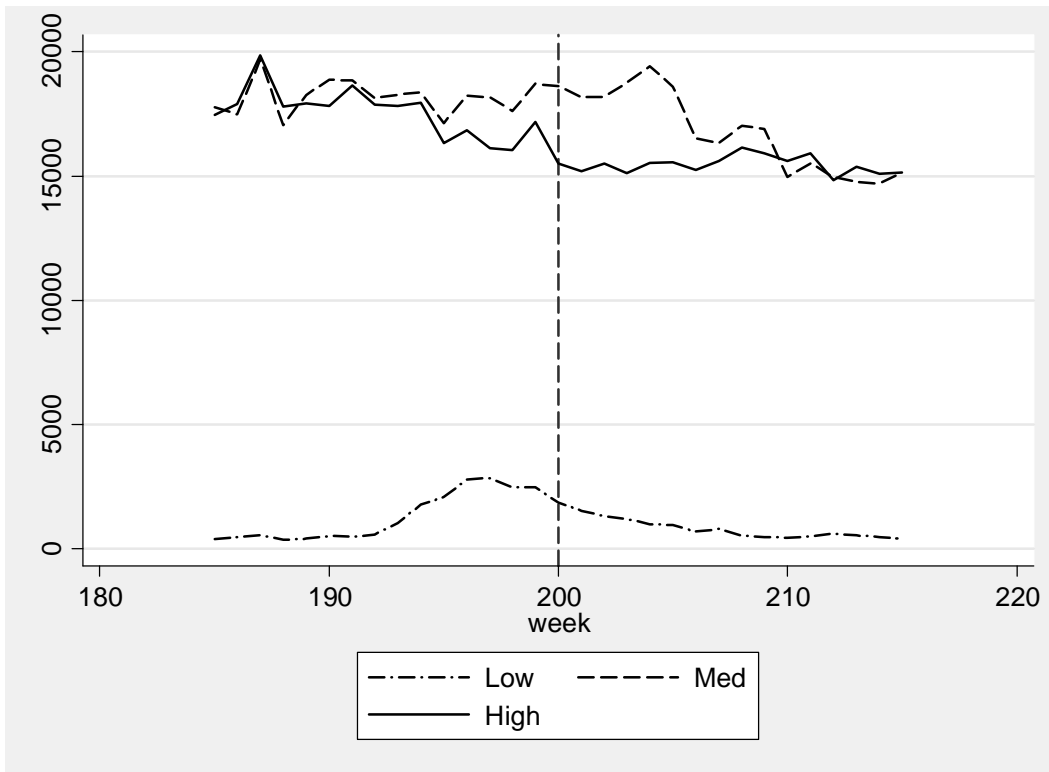


Figure 4
Cigarette Excise Tax (cents/pack)



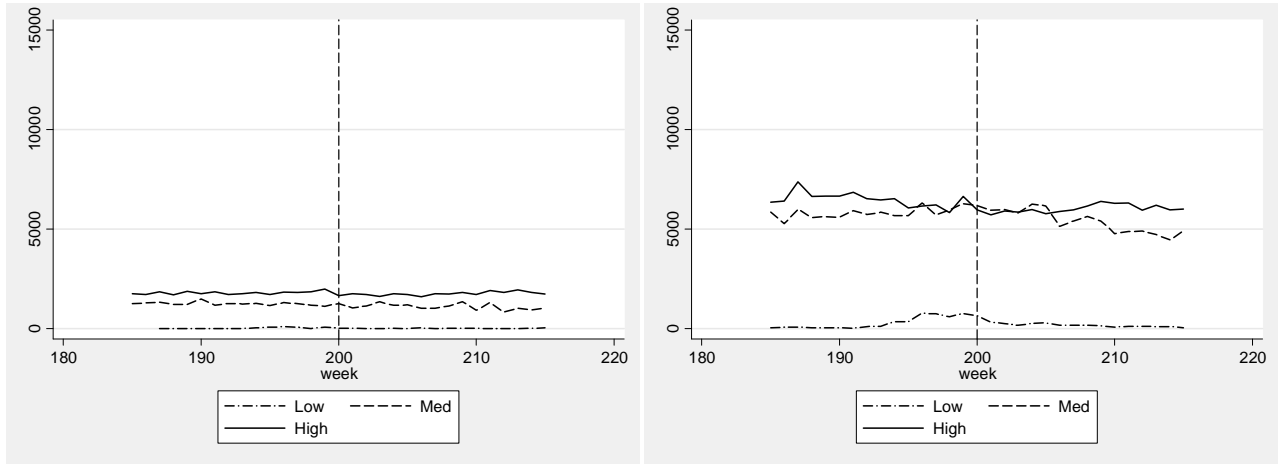
Notes: The figure depicts cigarette excise taxes around the time of the July 1993 Illinois tax increase, which occurred in week 200.

Figure 5
Total sales for all cigarettes during July 1993 Illinois Tax Increase



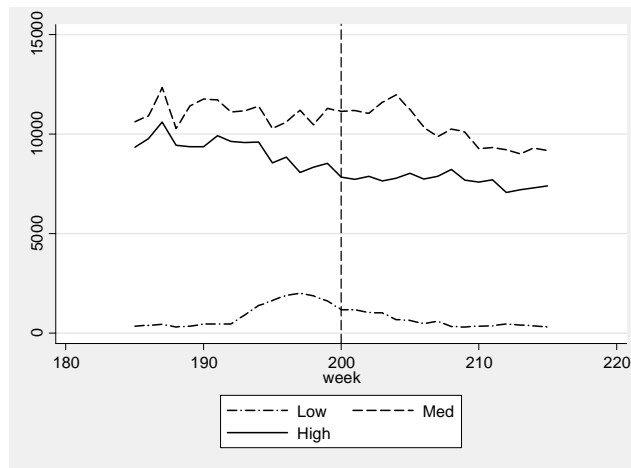
Notes: This figure shows the total number of packs sold in each quality tier (low, medium, and high). The figure spans the period surrounding the July 1993 Illinois tax increase, which occurred in week 200.

Figure 6
 Total sales by distance to Indiana during 1993 Illinois tax increase



(a) < 15 miles

(b) 15-30 miles



(c) > 30 miles

Notes: This figure shows the total number of packs sold in each quality tier (low, medium, and high) by a store's distance to the Indiana border. The figure spans the period surrounding the July 1993 Illinois tax increase, which occurred in week 200.

Table 1
Characteristics of Cigarette Tiers

	High Price Tier	Medium Price Tier		Low Price Tier
	Premium Packs	Premium Cartons	Discount Packs	Discount Cartons
Number of UPCs	144	141	49	47
Pack Sales Recorded (million)	4.7	8.0	0.2	0.3
Quantity (%)	35.5	60.6	1.5	2.4
Markup or Discount Relative to Mean Per Pack Price (%)				
Mean	+8.1	-5.0	-9.0	-23.7
90 th Percentile	+8.6	-1.0	-5.2	-18.0
Median	+7.7	-4.2	-7.5	-22.7
10 th Percentile	+6.2	-11.5	-16.7	-30.2

Table 2
Timeline of tax changes

Date	Location	Tax Change (cents)
Jan 1993	Federal	20 to 24
July 1993	Illinois	30 to 44
March 1996	Cook County	10 to 18

Table 3
Summary Statistics for Panel

	Mean	Std Dev	Min	Max	Observations
Packs of cigarettes	180.5	158.4	1	1372	52797
Price per pack (in dollars)	2.24	0.32	1.30	4.72	52797
Low Tier	0.12	0.32	0	1	52797
Medium Tier	0.43	0.50	0	1	52797
High Tier	0.45	0.50	0	1	52797
Tax per pack (in dollars)	0.73	0.13	0.50	1.02	52797
Distance to Indiana border	28.7	11.1	2.02	56.6	52797
Observations	52797				

Table 4
Quantity regressions for panel

	(1)	(2)	(3)
	Low	Medium	High
Tax Per Pack (τ)	-0.215 (0.559)	0.343 (0.435)	2.382*** (0.677)
2 Months Before Tax Change $\times \tau$	3.902*** (0.466)	0.608*** (0.192)	-0.272 (0.232)
1 Month Before Tax Change $\times \tau$	4.848*** (0.484)	0.428* (0.246)	0.145 (0.289)
1 Month After Tax Change $\times \tau$	2.145*** (0.478)	0.223 (0.273)	-1.818*** (0.437)
2 Months After Tax Change $\times \tau$	0.472 (0.443)	0.0664 (0.262)	-1.793*** (0.423)
Store fixed effects	Yes	Yes	Yes
Quarterly fixed effects	Yes	Yes	Yes
Observations	6230	22888	23679
R-Squared	0.402	0.805	0.653

Notes: The dependent variable is the logarithm of weekly sales at a store. *, **, and *** denote significance at the 10%, 5% and 1% levels. Monthly dummies before and after the tax change are interacted with the size of the tax.

Table 5
Quantity Regressions for Panel

	(1) Low	(2) Medium	(3) High
Tax Per Pack (τ)	-0.394 (0.547)	0.148 (0.407)	2.192*** (0.563)
<15 miles x 2 Months Before x τ	2.873* (1.597)	0.643 (0.510)	-0.695 (0.658)
<15 miles x 1 Month Before x τ	3.301*** (0.533)	0.0235 (0.728)	0.326 (0.585)
<15 miles x 1 Month After x τ	0.996 (1.185)	-0.278 (0.661)	-2.175*** (0.977)
<15 miles x 2 Months After x τ	1.819*** (0.704)	0.270 (0.462)	-1.961** (0.838)
15-30 miles x 2 Months Before x τ	2.700*** (0.556)	0.776*** (0.279)	-0.658 (0.396)
15-30 miles x 1 Month Before x τ	4.426*** (0.804)	0.483 (0.381)	0.0725 (0.443)
15-30 miles x 1 Month After x τ	1.538** (0.626)	0.323 (0.318)	-1.462*** (0.443)
15-30 miles x 2 Months After x τ	1.146* (0.642)	0.0960 (0.296)	-1.660*** (0.431)
>30 miles x 2 Months Before x τ	4.576*** (0.667)	0.135 (0.193)	0.650** (0.271)
>30 miles x 1 Month Before x τ	5.161*** (0.606)	0.283 (0.186)	0.406 (0.271)
>30 miles x 1 Month After x τ	.685*** (0.578)	0.425 (0.305)	-1.427*** (0.304)
>30 miles x 2 Months After x τ	0.210 (0.568)	0.0753 (0.307)	-1.158*** (0.325)
Store fixed effects	Yes	Yes	Yes
Quarterly fixed effects	Yes	Yes	Yes
Observations	6230	22888	23679
R-Squared	0.413	0.810	0.671

Notes: The dependent variable is the logarithm of weekly sales at a store. *, **, and *** denote significance at the 10%, 5% and 1% levels. Monthly dummies before and after the tax change are interacted with the size of the tax.

Table 6
Tar, Nicotine, and Carbon Monoxide By Cigarettes Characteristics

	(1)	Total (2)	(3)	(4)	Average (5)	(6)
	Tar	Nicotine	CO	Tar	Nicotine	CO
Tax Per Pack (τ)	0.0173*** (0.00413)	0.0189*** (0.00412)	0.0171*** (0.00411)	0.0187*** (0.00411)	0.0170*** (0.00413)	0.0186*** (0.00413)
2 Months Before Tax Change x τ	-0.0449 (0.155)	-0.123 (0.153)	-0.0500 (0.157)	-0.128 (0.155)	-0.0430 (0.156)	-0.121 (0.154)
1 Month Before Tax Change x τ	0.221 (0.137)	0.0310 (0.135)	0.224 (0.135)	0.0342 (0.134)	0.218 (0.136)	0.0283 (0.135)
1 Month After Tax Change x τ	-1.000*** (0.316)	-1.321*** (0.316)	-0.979*** (0.313)	-1.299*** (0.313)	-0.977*** (0.315)	-1.297*** (0.315)
2 Months After Tax Change x τ	-1.093*** (0.282)	-1.140*** (0.282)	1.081*** (0.281)	-1.128*** (0.281)	-1.076*** (0.282)	-1.122*** (0.282)
Store fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarterly fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24213	24213	24213	24213	24213	24213
R-Squared	0.806	0.802	0.810	0.806	0.809	0.805

Notes: The dependent variable is the total amount of tar, nicotine, and carbon monoxide from sales of packs of cigarettes. *, **, and *** denote significance at the 10%, 5% and 1% levels. Monthly dummies before and after the tax change are interacted with the size of the tax.

Table 7
Cigarette Excise Tax Incidence

	(1)	(2)	(3)
Δ Tax Rate	0.801*** (0.00491)	0.789*** (0.00411)	
Δ Tax Rate * Carton		0.00944 (0.0122)	
Δ Tax Rate * Discount		0.108*** (0.0235)	
Δ Tax Rate * Premium Pack			0.790*** (0.00412)
Δ Tax Rate * Premium Carton			0.798*** (0.0121)
Δ Tax Rate * Discount Pack			0.897*** (0.0260)
Δ Tax Rate * Discount Carton			0.916*** (0.0308)
Observations	807827	807827	807827
R-Squared	0.0886	0.0888	0.0888

Notes: The dependent variable is the first-difference of the tax-inclusive price. All independent variables are first-differenced. All specifications include class-specific fixed effects. The unit of observation is the UPC-week level. A pack of cigarettes contain 20 cigarettes, and each carton of cigarettes contains 10 packs. Robust Standard Errors clustered at the UPC level. *, **, and *** denote significance at the 10%, 5% and 1% levels.

Table 8
Cigarette Excise Tax Incidence

	(1)	(2)
Δ Tax Rate	0.795*** (0.0114)	0.795*** (0.0114)
$\Delta TaxRate_{t-1}$		0.00221* (0.00114)
$\Delta TaxRate_{t-2}$		0.00584*** (0.00156)
$\Delta TaxRate_{t-3}$		-0.00066 (0.00106)
$\Delta TaxRate_{t-4}$		-.000795 (0.00107)
Observations	457009	457009
R-Squared	0.0926	0.0926

Notes: The dependent variable is the first-difference of the tax-inclusive price. All independent variables are first-differenced. All specifications include class-specific fixed effects. The unit of observation is the UPC-week level. Robust Standard Errors clustered at the UPC level. *, **, and *** denote significance at the 10%, 5% and 1% levels.