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

JEL Codes: D1, D4, H2, H7

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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 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 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 results 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 discusses 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 gas 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

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 (β=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] [illegible]

[3] [illegible]

[4] [illegible]

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, q, 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 μ_t^H>0 and μ_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:

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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 $\tau = 5$s9 Fomr by p-8 ™7 Qò2p À

[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] ήض 1 ὶ ش (ص ضث) / ص

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]

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[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 incu 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 Kilts 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 C 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]

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 excise 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. Fis

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 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.

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 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 plots 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 on 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 cigarette, 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 :

[7]

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

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

[9] [illegible]

Table 7 presents our incidence results. In Column (1), we estimate a common pass-

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 rates 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 ta 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-priced 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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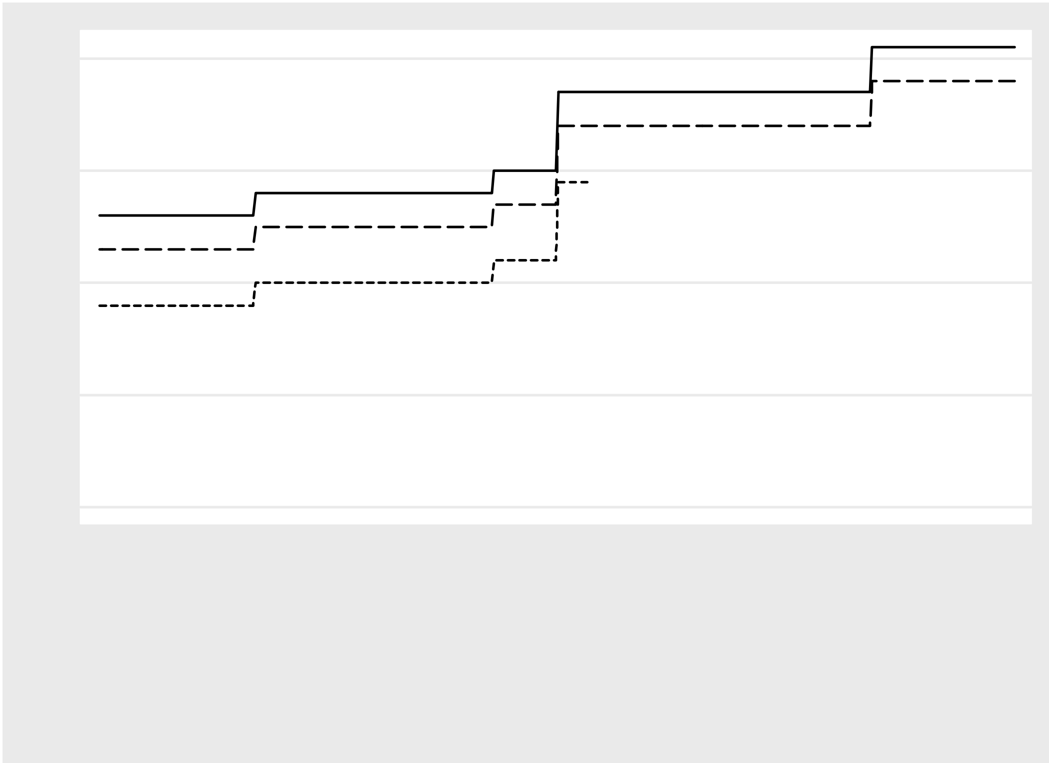
Figure 1
Consumption with no stockpiling and no adjustment costs, by quality tier

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

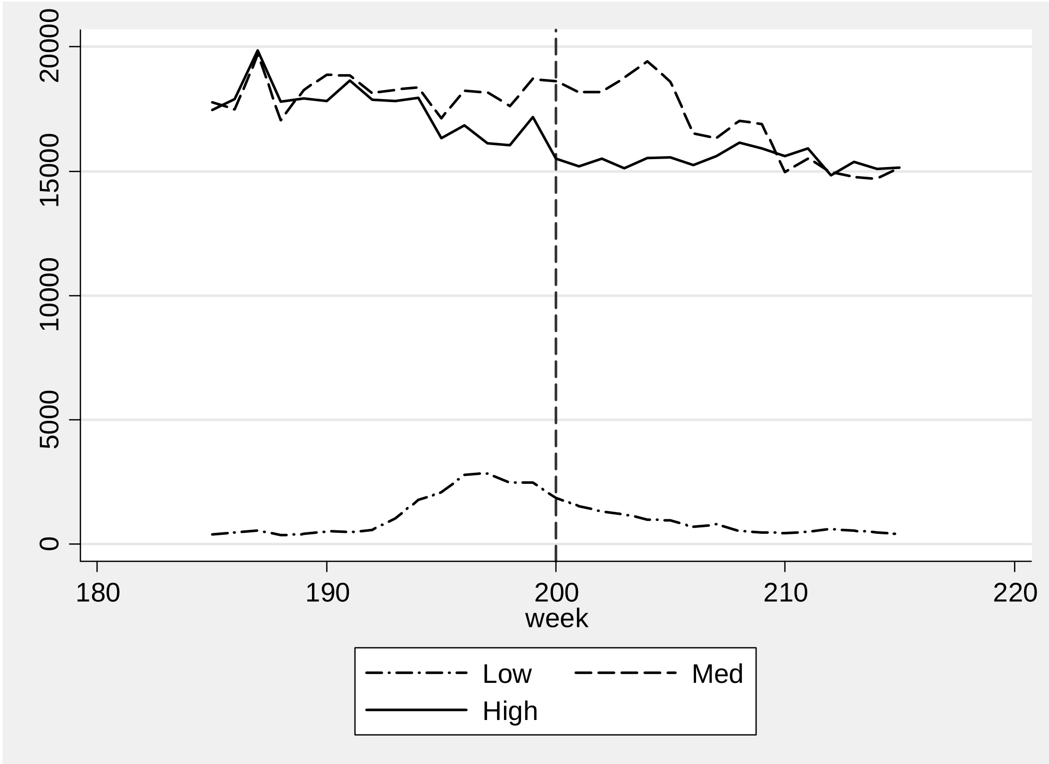
Figure 4
Cigarette Excise Tax (cents/pack)



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

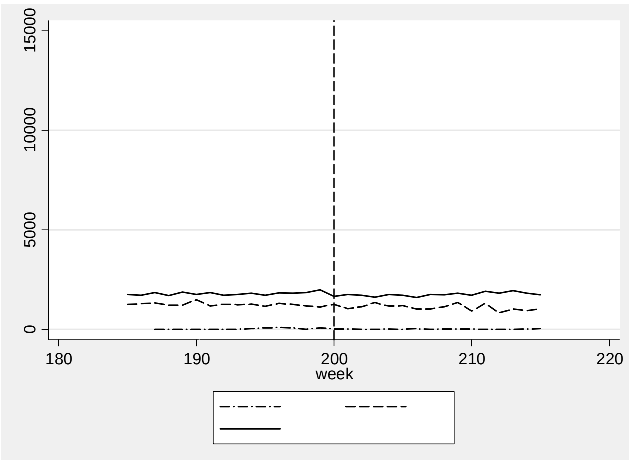
Figure 5

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
ice				

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) Low	(2) Medium	(3) High
Tax Per Pack (τ)	-0.215	0.343	2.382***
	(0.559)	(0.435)	(0.677)
2 Months Before Tax Change x τ	3.902***	0.608***	-0.272
	(0.466)	(0.192)	(0.232)
1 Month Before Tax Change x τ	4.848***	0.428*	0.145
	(0.484)	(0.246)	(0.289)
1 Month After Tax Change x τ	2.145***	0.223	-1.818***
	(0.478)	(0.273)	(0.437)
2 Months After Tax Change x τ	0.472	0.0664	-1.793***
	(0.443)	(0.262)	(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	0.148	2.192***
	(0.547)	(0.407)	(0.563)
<15 miles x 2 Months Before x τ	2.873*	0.643	-0.695
	(1.597)	(0.510)	(0.658)
<15 miles x 1 Month Before x τ	3.301***	0.0235	0.326
	(0.533)	(0.728)	(0.585)
<15 miles x 1 Month After x τ	0.996	-0.278	-2.175***
	(1.185)	(0.661)	(0.977)
<15 miles x 2 Months After x τ	1.819***	0.270	-1.961**
	(0.704)	(0.462)	(0.838)
15-30 miles x 2 Months Before x τ	2.700***	0.776***	-0.658
	(0.556)	(0.279)	(0.396)
15-30 miles x 1 Month Before x τ	4.426***	0.483	0.0725
	(0.804)	(0.381)	(0.443)
15-30 miles x 1 Month After x τ	1.538**	0.323	-1.462***
	(0.626)	(0.318)	(0.443)
15-30 miles x 2 Months After x τ	1.146*	0.0960	-1.660***
	(0.642)	(0.296)	(0.431)
>30 miles x 2 Months Before x τ	4.576***	0.135	0.650**
	(0.667)	(0.193)	(0.271)
>30 miles x 1 Month Before x τ	5.161***	0.283	0.406
	(0.606)	(0.186)	(0.271)
>30 miles x 1 Month After x τ	.685***	0.425	-1.427***
	(0.578)	(0.305)	(0.304)
>30 miles x 2 Months After x τ	0.210	0.0753	-1.158***
	(0.568)	(0.307)	(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

	Total			Average		
	(1)	(2)	(3)	(4)	(5)	(6)
	Tar	Nicotine	CO	Tar	Nicotine	CO
Tax Per Pack (τ)	0.0173***	0.0189***	0.0171***	0.0187***	0.0170***	0.0186***
	(0.00413)	(0.00412)	(0.00411)	(0.00411)	(0.00413)	(0.00413)
2 Months Before Tax	-0.0449	-0.123	-0.0500	-0.128	-0.0430	-0.121
Change $\times \tau$	(0.155)	(0.153)	(0.157)	(0.155)	(0.156)	(0.154)
1 Month Before Tax	0.221	0.0310	0.224	0.0342	0.218	0.0283
Change $\times \tau$	(0.137)	(0.135)	(0.135)	(0.134)	(0.136)	(0.135)
1 Month After Tax	-1.000***	-1.321***	-0.979***	-1.299***	-0.977***	-1.297***
Change $\times \tau$	(0.316)	(0.316)	(0.313)	(0.313)	(0.315)	(0.315)
2 Months After Tax	-1.093***	-1.140***	1.081***	-1.128***	-1.076***	-1.122***
Change $\times \tau$	(0.282)	(0.282)	(0.281)	(0.281)	(0.282)	(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***		

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.