# Christmas in August: Prices and Quantities During Sales Tax Holidays

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**Abstract**

This paper estimates the incidence of state sales taxes on computers by exploiting exogenous changes in tax rates due to sales tax holidays. Using scanner data that span nine tax holidays in 2007, I find that the sales tax is fully or slightly over-shifted to consumers. Demand is extremely responsive to small price changes during tax holidays. The quantity responses range from 5.76 to 16.53 more computers purchased per 10,000 people than would be predicted in the absence of the holidays. The timing response accounts for between 37 and 90 percent of the increase in purchases in the tax holiday states over the 30-week horizon.

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# 1 Introduction

Public finance economists have developed many models that predict the incidence of different taxes.[1] Estimation of these models is made difficult because of the lack of plausibly exogenous variation in tax rates. This is particularly true for sales taxes.[2] This paper exploits exogenous changes in sales tax rates due to sales tax holidays to estimate the incidence of state sales taxes on computers.

The sales tax holiday—a brief period of time during which state or local sales taxes are not levied on a set of goods—has become politically popular during the past decade (Cole (2008a)). Lawmakers' two chief policy goals in creating such holidays are to reduce the tax burden on families with children and to stimulate the economy generally or to encourage purchases of certain products in particular, e.g., computers. They implicitly, and sometimes explicitly, assume that tax-inclusive prices will decrease one-for-one with the tax rate during tax holidays.

There is some evidence supporting this hypothesis. Harper et al. (2003) sent students to collect price data on ten clothing items from retailers in the Pensacola, Florida Metropolitan Statistical Area (MSA) and the Mobile, Alabama MSA the week before, during, and after Florida's 2001 sales tax holiday.[3] They found the pre-tax price of a basket of 74 items in the Pensacola MSA increased roughly 1 percent during the holiday relative the week before and the tax-inclusive price decreased 5.6 percent when the state's 6 percent tax rate was rescinded during the holiday.

Doyle, Jr. and Samphantharak (2008) use the temporary moratoria of the sales taxes on gasoline in Illinois and Indiana in 2000 to estimate the incidence of sales tax.[4] They found "70 [percent] of the tax reduction is passed on to consumers in the form of lower prices, while prices increase by 80-100 [percent] of the tax when it is reinstated."

Using retail scanner data on computers spanning 9 tax holidays on computers during a 30-week period in 2007, I find the pre-tax price of a computer model *decreases* 0.27 percent during the tax holidays in the face of a 4.76 percentage point decrease in the sales tax rate. The point estimate is not statistically significantly different from zero. Taken at face value, though, the evidence suggests the sales tax on computers is fully or slightly over-shifted to consumers.

Separating out desktops from laptops, the data suggest (weakly) that retailers lower pre-tax prices of desktops during tax holidays, but the pre-tax prices for laptops do not change. I speculate that potential buyers of (inexpensive) desktops are more likely to be on the extensive margin of buying a computer than are purchasers of laptops. Therefore, during the tax holiday, retailers lower the pre-tax prices of desktops to induce purchases that otherwise would not have occurred in the absence of the holiday.

In addition to tax incidence, because tax holidays last for such a short period of time, lawmakers

[1] See Fullerton and Metcalf (2002) for examples.

[2] For two examples of papers that investigate the long-run incidence of the sales tax on various products, see Besley and Rosen (1999), who cannot reject full pass-through of the sales tax onto consumers for some products and over-shifting of the sales tax for other goods, and Poterba (1996), who cannot reject full pass-through.

[3] Pensacola is roughly 60 miles southeast of Mobile. Alabama did not have a sales tax holiday until 2006.

[4] Curiously, this paper was not discussed during the 2008 U.S. Presidential primaries during which Senators John McCain (R-Arizona) and Hillary Clinton (D-New York) proposed to repeal the federal gasoline excise tax during the summer months of 2008.

should be concerned that a tax holiday induces primarily a timing response from consumers—where consumers shift purchases that would have been made outside the tax holiday to occur during the the holiday to exploit the lower tax rates—instead of inducing purchases that otherwise would not have been made absent the tax holiday. This generates some tension between the two policy goals. Further, large timing responses of consumer purchases during tax holidays will generate large sales tax revenue losses on exempted goods.

Recent papers that examine the timing of purchases based on the tax benefits associated with doing so include House and Shapiro (2008), who find very large elasticities of investment supply (6-14) in response to the bonus depreciation allowance on long-lived capital goods that arose from federal laws passed in 2002 and 2003, and Sallee (2008), who finds consumers timed purchases of gasoline-electric hybrid vehicles just prior to reductions or eliminations of tax credits on those vehicles. He also finds that consumers captured nearly all of the subsidy, which is at odds with the inelastic supply of these vehicles at the time.[5] Cole (2008b) estimates the effects of having sales tax holidays on state sales tax collections; back-of-the-envelope calculations suggest up to half of the revenue reduction is due to consumers' timing purchases within the month to exploit the lower tax rate during the holiday.[6]

In response to small price changes, I find consumers purchase large numbers of computers during sales tax holidays. For the week ending August 4th, consumers purchased 9.3 percent and 7.5 percent more desktops and laptops, respectively, in the tax holiday states than they did in those same states during the week that included the Friday and Saturday after Thanksgiving, routinely regarded as one of the year's busiest shopping weeks. There were no such spikes in purchases in the non-holiday states.

The time series plots of computer purchases suggest that purchases of desktops during the tax holidays are likely to be purchases that otherwise would not have occurred in the absence of the tax holiday. In contrast, the suggest that the tax holidays induce primarily a timing response from laptop consumers. During the tax holidays, the largest increases in computer purchases were for desktops priced between \$250 and \$750 and for laptops priced between \$500 and \$1,000.

To isolate the timing response from the "extra purchases" response, I constructed a counterfactual amount of computers that would sell in each tax holiday state if purchases in that state mimicked the purchases in a non-holiday control state. For the week of the tax holiday, the quantity responses ran from 5.76 to 16.53 more computers per 10,000 people than would be predicted in the absence of the holiday. The timing response accounts for between 37 and 90 percent of the increase in purchases in the tax holiday states over the 30-week horizon.

Because the timing responses are large, the tax revenue consequences of the policy are large as well. In the extreme case where there is only a timing response, I estimate the state governments that had tax holidays on computers in 2007 lost between \$3.3 and \$5.1 million in sales tax revenue because of the tax holidays. The revenue loss was largest in Tennessee, which lost in total between

[5]The author develops a model to rationalize these two findings.

[6]He finds state sales and use tax collections decrease between 0.52 percent and 7.83 percent during tax holiday months.

$0.67 million and $1 million.

In sum, it is safe to say the tax holidays achieve policymakers' goal of reducing consumers' tax burden. More computers are purchased—particularly desktops—during the tax holidays than would be if there were no such policy. The policy, however, produces a large timing response on the part of consumers, particularly those purchasing laptops, which leads to substantial sales tax revenue losses.

The remainder of the paper is organized as follows. The next section presents relevant background information on sales tax holidays. Section 3 provides an overview of the data and estimation strategy employed in the analysis. A discussion of the empirical results is found in section 4. Finally, section 5 summarizes, offers future avenues of research, and concludes.

## 2 Background

Since 1997, Americans have routinely encountered sales tax holidays. Cole (2008a) documents a total of 118 sales tax holidays occurring from 1997 through 2007 in 20 states and the District of Columbia and provides the dates of the holidays, the goods exempt from the sales tax during the holidays, and whether the holiday is an annual occurrence codified in the state's statute. In each year from 2004 through 2007, at least 100 million people lived in a state that had a sales tax holiday. This accounts for roughly 35 percent of the US population living in states with sales taxes.

The policy began as a way to keep New Yorkers from traveling to New Jersey to purchase clothing that was tax-free year-round in the Garden State. It initially spread to Florida and Texas in the late 1990s—when the economy was reaching the peak of the business cycle and those states' budgets were in surplus—as a way to offer tax relief to the states' residents. Over time, the policy expanded geographically and in terms of the breadth of goods covered, including school supplies, energy efficient appliances, hurricane preparedness items, and computers.

South Carolina was an innovator of this policy by including school supplies and computers to the list of exempted items during its inaugural holiday in 2000. Also in 2000, Pennsylvania had the first of its four tax holidays specifically for the purchases of computers. Three years later, Vermont held the first of its three holidays on computer purchases.

Fifteen states and the District of Columbia held 20 sales tax holidays in 2007. Seven holidays explicitly exempted computers from sales tax (see Table 1). Two others (Louisiana and Massachusetts) exempted a very broad range of consumer purchases.

Part of any tax reduction is to reward those who were already going to purchase the good in question and to induce additional purchases of that good. Political justifications focused on these two aspects once school supplies were added to the list of exempted goods. "'The sales tax holiday helps Georgia parents who are preparing their children for the right start to a new school year,' said [Georgia] Gov. Sonny Perdue. 'This holiday also provides a boost to retailers catering to those families.'"[7]

[7] "Georgia sales tax holiday to begin July 29." The Associated Press State & Local Wire 30 June 2004, BC Cycle, State and Regional.

Texas state Senator Rodney Ellis (D-Houston) supported the tax holiday

> because Texas' sales tax rate of 6.25 percent is one of the nation's highest and 'has a disproportionate impact on low-income people.' ... [Adding local taxes,] the actual sales tax can be as high as 8.25 percent. 'The least we can do is help them buy shoes and socks once a year,' Ellis Said.[8]

Mogab and Pisani (2007) surveyed 710 shoppers during Texas' 2004 sales tax holiday and found the holiday was an important factor in determining whether to shop that weekend for those with household income between \$10,000 and \$40,000 and for those expecting to spend between \$100 and \$750.

The tax holidays in Pennsylvania were intended "to boost Pennsylvania's lagging computer ownership rate."[9] In describing the purpose of Vermont's holiday—to encourage families and students to purchase computers—Governor James H. Douglas said, "Personal computers help us embrace technological advances that make it possible for Vermonters to operate in a diverse, high-wage economy, even while working from the most remote corners of our state[.]"[10]

Since sales tax holidays are hyper-transitory policies, the extent to which consumers benefit from a sales tax holiday depends crucially on the behavioral responses of consumers and retailers. Consumers are better off if the equilibrium prices they pay (weakly) decrease, and only if supply and demand are not perfectly inelastic will there be additional purchases. Because the holidays last for such short periods of time and because the goods exempted from sales tax during the holidays, particularly computers, are durable goods, the behavioral response of consumers is a mixture of a timing response (reordering when purchases occur to benefit from the lower tax rate) and extra purchases that would not have been made absent the lower tax rate. In the next section, I discuss the empirical approach and data used in the analysis below to shed light on these responses.

# 3 Estimation Strategy and Data

## 3.1 Estimation Strategy

Following the framework outlined in Besley and Rosen (1999), consider a retailer selling computer model $i$ in state $s$ in week $t$. The retailer chooses a vector of variables $\mathbf{x}_{ist}$, which may include both the tax-exclusive price $p_{ist}$ and quantity $q_{ist}$, to maximize profit subject to the actions chosen by other retailers and the ad valorem sales tax rate $\tau_{ist}$. Assuming a Nash equilibrium is reached, the solution to the problem is such that the tax-exclusive price equals a markup over marginal cost, and the tax-inclusive price is $(1 + \tau_{ist})p_{ist}$. The markup is a function of the tax rate, so the tax-exclusive price can be written as a function of the tax rate and a vector of cost shifters $\theta_{ist}$ that

[8] Kaplan, David. "Tax-Free Holiday; It's a Lot Like Christmas in August." *The Houston Chronicle* [Houston, TX] 1 August 2003, 3 Star Edition, Business: 1.

[9] Rebecca Sinderbrand, "Retailers hope tax break leads to big sales," The Associated Press State & Local Wire, BC Cycle, State and Regional, Aug. 1, 2001, available in LexisNexis.

[10] "State lifts sales tax on computers for three days," The Associated Press State & Local Wire, BC Cycle, State and Regional, Aug. 4, 2003, available in LexisNexis.

vary by computer model, state, and week:

$$p_{ist} = f_{ist}\left(\tau_{ist}, \theta_{ist}\right). \tag{1}$$

Besley and Rosen estimate a semilogarithmic specification of equation (1). Because the data in the current setting span only 30 weeks, I assume the marginal cost of a computer model within a state is time-invariant, i.e., $\theta_{ist} = \theta_{is}$.[11] With this functional form and cost structure assumption, equation (1) can be written as

$$ln\left(p_{ist}\right) = \boldsymbol{\phi}_{is} + \boldsymbol{\psi}_t + \beta\tau_{ist} + \varepsilon_{ist}, \tag{2}$$

where the $\boldsymbol{\phi}_{is}$ are model-state fixed effects, the $\boldsymbol{\psi}_t$ are week fixed effects, and $\varepsilon_{ist}$ is an idiosyncratic error term. The model-state fixed effects encapsulate differences in costs and demand conditions across models and across states that are constant over time. The week fixed effects capture seasonal demand conditions that are the same across states within a week, e.g., weeks containing national holidays like Independence Day, Memorial day, and Thanksgiving.

Sales tax holidays induce variation in the sales tax rate on computers in the tax holiday states that are priced below the relevant price cap (see Table 1). Provided the variation in the sales tax rate for a computer model within a state is uncorrelated with unobservables, after netting out week-of-year effects, the parameter of interest $\beta$ is identified. Properly interpreted, $\beta$ is the percentage change in the tax-exclusive computer price, on average, given a one percentage point change in the state sales tax rate.

The value of $\beta$ relative to zero provides insight into the degree to which the sales tax is shifted to consumers. A $\beta$ that equals zero means the tax-exclusive price does not change when the sales tax rate changes. The sales tax is fully shifted to consumers; the tax-inclusive price decreases one-for-one with the tax rate during the sales tax holiday. A negative $\beta$ implies the tax-exclusive price increases when the sales tax rate decreases during a tax holiday. The sales tax burden is shared between consumers and producers; the tax-inclusive price decreases during a tax holiday but not one-for-one with the tax rate. Finally, a positive $\beta$ implies the tax-exclusive price decreases when the sales tax rate decreases during a tax holiday. The sales tax is over-shifted to consumers; the tax-inclusive price decreases more than one-for-one with the tax rate during the tax holiday.

What sign of $\beta$ should we expect? Because the attributes of computer models vary considerably across the price distribution, a model with differentiated products is an appropriate characterization of the computer market and lens through which to view the results. Below, I incorporate an ad valorem tax and an increase in the volume of shopping per household to the spatial competition model of Salop (1979).[12] Holding the volume of shopping per household and number of firms fixed in the short-run, a decrease in the sales tax rate leads to an increase in the tax-exclusive price.

[11] In contrast, their data cover 12 commodities in 155 cities from 1982 through 1990. I have no data on costs of production for any computer model. As such, and unlike Besley and Rosen, I cannot incorporate a measure of costs into the estimating equation.

[12] This draws on results in Warner and Barsky (1995) and Fullerton and Metcalf (2002).

However, holding the sales tax rate and number of firms fixed in the short-run, an increase in the volume of shopping per household (during periods of high seasonal demand) leads to a decrease in the tax-exclusive price. The model therefore yield an ambiguous prediction about the sign of $\beta$; how pre-tax prices change during sales tax holidays is an empirical question.

In the Salop (1979) model, there is a fixed number of firms $N$ located equidistantly apart on a circle, and each firm produces the good at a constant marginal cost $c$ and a fixed cost $F$. Consumers are uniformly distributed along the circle. Each consumer exogenously demands $q$ units of the good per period, and each consumer prefers to purchase the good at a location $x$ that is nearest his most preferred location $x^*$. The consumer pays a tax-inclusive price $(1+\tau)p$ per unit of the good plus a transportation cost equal to $k$ per unit of distance the farther away $x$ is from $x^*$. Utility is

$$u = v - (1+\tau)\, p \cdot q - k|x - x^*|, \tag{3}$$

where $v > 0$ is sufficiently large to ensure $u > 0$ so that a purchase is made.

Store $i$ competes with adjacent stores $i-1$ and $i+1$ for customers. Let the tax-exclusive prices at these stores be $p_{i-1}$, $p_i$, and $p_{i+1}$. A consumer located at $\widehat{x} \in [0, 1/N]$ from store $i+1$ is indifferent to traveling $\widehat{x}$ units to purchase the $q$ units at store $i$ or to travel $(1/N - \widehat{x})$ to purchase the units at store $i+1$ if

$$(1+\tau)\, p_i \cdot q + k\widehat{x} = (1+\tau)\, p_{i+1} \cdot q + k\left(\frac{1}{N} - \widehat{x}\right), \tag{4}$$

which implies

$$\widehat{x} = \frac{[(1+\tau)p_{i+1} - (1+\tau)p_i]\, q}{2k} + \frac{1}{2N}. \tag{5}$$

Similarly, a consumer located at

$$\widetilde{x} = \frac{[(1+\tau)p_{i-1} - (1+\tau)p_i]\, q}{2k} + \frac{1}{2N} \tag{6}$$

is indifferent to purchasing at store $i-1$ or at store $i$. Demand for store $i$ arises from consumers located between $\widetilde{x}$ and $\widehat{x}$:

$$Q_d(p_{i-1}, p_i, p_{i+1}) = \frac{[(1+\tau)p_{i-1} + (1+\tau)p_{i+1} - 2(1+\tau)p_i]\, q}{2k} + \frac{1}{N}. \tag{7}$$

Firm $i$ maximizes profit by choosing price $p_i$ taking the prices of the other firms and the tax rate as given:

$$\operatorname*{Max}_{p_i}\; p_i Q_d(p_{i-1}, p_i, p_{i+1}) - cQ_d(p_{i-1}, p_i, p_{i+1}) - F. \tag{8}$$

Differentiating with respect to $p_i$ and setting the resulting expression equal to zero yields firm $i$'s best-response function. In a symmetric equilibrium, $p_i^* = p_{i+1}^* = p_{i-1}^*$, and we have

$$p_i^* = \frac{k}{N(1+\tau)q} + c, \;\; \forall i = 1, \ldots, N. \tag{9}$$

In the short-run, the number of firms $N$ is fixed. This is a plausible assumption in the context of sales tax holidays since the modal holiday lasts only three days. Holding the number of units each consumer demands $q$ constant, an increase in the sales tax rate leads to a decrease in the tax-exclusive price:

$$\left.\frac{dp_i^*}{d\tau}\right|_{N,q} = -\frac{k}{Nq(1+\tau)^2} < 0. \tag{10}$$

All else equal, a tax holiday would lead to an increase in the pre-tax price of computers ($\beta < 0$ in equation (2)).

Tax holidays occur during weekends, which Warner and Barsky (1995) argue are characterized by high demand, in August just prior to the resumption of school. Higher foot-traffic through stores as consumers do bulk shopping for back-to-school items increases the perceived number of consumers in a firm's market. In the model, this increase in $q$ leads to a decrease in the firm's tax-exclusive price as firms compete more heavily with one another:

$$\left.\frac{dp_i^*}{dq}\right|_{N,\tau} = -\frac{k}{N(1+\tau)q^2} < 0. \tag{11}$$

Anecdotal evidence from media accounts suggests there is a large increase in foot-traffic in stores during tax holiday weekends. In the model, $\tau$ is decreasing simultaneously as $q$ is increasing during the tax holiday. This leads to an ambiguous prediction for how prices will change. The increased competition induced by the high seasonal demand serves to temper retailers' desire to increase their prices.

Further, consumers are primed by advertising and news stories leading up to the tax holiday to be highly cognizant of prices. This could increase the price elasticity of demand, lowering the mark-up and the tax-exclusive price. Complementary to this, retailers who sell computers as well as other items may choose to lower prices on computers (and/or other items in the store) to (1) entice consumers to purchase other goods in the store that they otherwise would not have purchased and (2) to prime consumers to think about that particular retailer the next time the consumer needs to purchase an expensive, durable good.[13] For these reasons, in the regression models, I would expect to see coefficient estimates near or greater than zero.

### 3.2 Data

The scanner data on computer purchases used in this paper come from the market research company The NPD Group, Inc. and span the 30 weeks between May 6, 2007 and December 1, 2007. During this period, nine states held tax holidays on computers (see Table 1). Eight of the holidays occurred on the first weekend in August; Massachusetts' holiday occurred one week later.

Each data cell is an item-state-week triplet. In what follows, I index items by $i$, states by $s$, and weeks by $t$. An item is a computer brand and model number. For privacy reasons, NPD generated

[13] Without scanner data on other goods sold in these stores, I cannot test hypotheses about consumer purchases of other durable goods in and around tax holidays. Future work should address this.

a unique identifier for each item that masks the computer's brand and model number. The dataset contains the NPD identifier and whether the computer is a desktop or laptop computer. No other defining characteristics of the item are contained in the dataset.

When an item is purchased in one of NPD's retail partners' stores, its *pre-tax* price is logged into a database.[14] At the end of the week, which runs from Sunday through Saturday, the store reports to NPD the number of units purchased and the total (tax-exclusive) revenue generated from that item. NPD sums the week's totals across their retail partners' stores in the state.[15] A row in the dataset contains the total quantity of item $i$ sold in state $s$ in week $t$, $q_{ist}$, and the total revenue generated from the purchases of that item, $TR_{ist}$. The total revenue is divided by the quantity to generate the average pre-tax price of the item, $p_{ist} = TR_{ist}/q_{ist}$.[16]

A computer is exempt from sales tax during a tax holiday if it is for personal use and if its pre-tax price is below a certain level. The price caps for the tax holidays in 2007 are listed in Table 1 and vary across the states, ranging from \$750 per *purchase* in Alabama to \$3,500 per *item* in Missouri and North Carolina. According to the statutes, if the computer's pre-tax price is even \$0.01 more than the price cap, the computer is fully taxed.[17] Let $\tau_s$ be the state sales tax rate in state $s$, and $\overline{p}_s$ be the price cap in state $s$. Then, the tax rate on computer $i$ during the tax holiday period is

$$\tau_{ist} = \begin{cases} 0, & p_{ist} \leq \overline{p}_s \\ \tau_s, & p_{ist} > \overline{p}_s \end{cases} .^{18} \tag{12}$$

The sales tax rate data come from The Tax Foundation.

Local sales taxes were repealed during the tax holidays in Georgia, New Mexico, North Carolina, South Carolina, and Tennessee. Localities had a choice to repeal their taxes in Alabama, Louisiana, and Missouri. Local tax rates are not incorporated in the analysis below. As such, the state sales tax rate acts as a proxy for the combined state and local sales tax rate.

According to New Mexico's statute, retailers are *not* required to participate in the tax holiday. If a retailer does not participate, it remits taxes on sales made during the holiday as it normally would. If it chooses to participate, it remits taxes on sales made during the holiday only on computers with tax-exclusive prices exceeding \$1,000. Since it is unknown which retailers participated and which

[14] The data are for brick-and-mortar stores only. The names of NPD's retail partners are confidential. However, they include many large retailers. In 2006, according to a report from the National Retail Federation (NRF) and Shop.org, online sales of computer hardware and software totaled \$17.2 billion. This constituted 29.1 percent of the \$59.1 billion of personal consumption expenditures in 2006 on computers, peripherals, and software reported by the U.S. Bureau of Economic Analysis. See "Online sales spike 19 percent." CNNMoney.com, 14 May 2007. Accessed at http://money.cnn.com/2007/05/14/news/economy/online_retailing/ on March 12, 2009. See also "Table 2.4.5, Personal Consumption Expenditures by Type of Product," accessed at http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=69&Freq=Year&FirstYear=2006&LastYear=2007 on March 12, 2009.

[15] The 48 contiguous U.S. states and the District of Columbia are represented in the dataset.

[16] Dollar amounts are in nominal 2007 dollars.

[17] South Carolina and Louisiana are the exceptions; the former has no price caps during its holiday, and the latter exempts the *first* \$2,500 per item from tax.

[18] In Lousiana, the tax-inclusive price is $p_{ist}$ for $p_{ist} \leq \$2,500$ and $p_{ist} + \tau_s(p_{ist} - 2500)$ for $p_{ist} > \$2,500$. In coding the tax rate for computers in Louisiana, I treated the \$2,500 as a strict cutoff as in the other tax holiday states. In the data, there was only one computer during Louisiana's tax holiday that had a pre-tax price greater than \$2,500.

did not, I treated the data for New Mexico identically to that of the other states. All computers with pre-tax prices less than or equal to \$1,000 during the tax holiday had a state sales tax rate of zero.

As stated above, a reporting week in the dataset spans from Sunday through Saturday. Eight of the nine tax holidays occur on a Saturday and the succeeding Sunday. As such, the 'treatment' of the sales tax holiday technically covers two reporting weeks in the dataset. Figure 2 indicates that the majority of the purchases during the tax holiday occur during the first reporting week. In the regression analysis below, I define the tax holiday to occur the week ending August 11th for Massachusetts and the week ending August 4th for the remaining states in Table 1.[19]

Estimating equation (2) on the full sample is problematic because not every computer model is purchased in each week. If a model is not purchased in a given week, either because it was not on a store's shelf or, despite being on the shelf, no one purchased it, the model is not included in the dataset for that week. Only computers actually purchased are in the dataset. The dataset therefore is an unbalanced panel of computers available for purchase during this time period.

The unbalanced nature of the panel is important to consider when estimating a model using the fixed effects estimator since, for each computer model, the estimator first subtracts the mean price of that model over the periods it is observed. Having missing values affects this mean price. To the extent that less expensive computers have non-randomly missing observations in some of the weeks outside the tax holiday, we would expect the coefficient estimate on the sales tax rate to be biased.

The methods of addressing this issue fall under two headings: imputing prices in the missing weeks to construct a balanced panel and introducing sample selection criteria to construct a balanced panel. Bradley (2003) discusses four methods of imputing prices, the simplest of which is carrying forward the most recently observed price for the item. Instead of making what amounts to educated guesses about computer prices for missing observations, I choose to restrict the sample to include only computers that sold positive quantities each week within a window around the sales tax holiday.

A wide window around the tax holiday would better capture secular price changes during the period. The tradeoff with the wider window, however, is that fewer computers satisfy the criterion that they are observed each week. This necessarily leads to an estimate identified from an increasingly small number of computer models.

I examine computers that sold positive quantities each week in a two-week window on either side of the tax holiday (spanning the weeks ending July 21 through August 18). There are 6,177 computer models in this sample, 1,262 of which are in the tax holiday states. The number of models in these states varies from 88 in New Mexico to 177 in Georgia; the mean number of models is 140.

[19] I have produced tables where the tax holiday is defined to be the weeks ending August 11th and August 18th for Massachusetts, the week ending August 4th for Louisiana, and the weeks ending August 4th and August 11th for the remaining states in Table 1. These are found in the appendix.

# 4 Empirical Results

## 4.1 Prices

Table 2 displays summary statistics by week for the computers in the balanced panel. For the five-week period, the mean pre-tax price is \$854.37 with a standard deviation of \$391.69; the median pre-tax price is \$791.53. The mean pre-tax price for desktops is \$677.65 and \$934.99 for laptops. The mean pre-tax price in the tax holiday states is nominally lower (by at most \$30) but not statistically different from the mean pre-tax price in the non-holiday states in each week. This suggests that variation in tax-inclusive prices is due mainly to variation in sales tax rates, which in turn suggests the burden of the sales tax largely falls on consumers.

Table 3 presents results from estimating equation (2) on the sample described above. Columns I and IV pool all 6,177 computer models. 1,171 models—roughly 19 percent of the sample—qualified for the zero tax rate during the holiday. Taking the coefficient estimate in column I at face value, a one-percentage point increase in the state sales tax rate is associated with a 0.0559 percent increase in the pre-tax price, on average. In the tax holiday states, the mean state sales tax rate is 4.76 percent. So, during a tax holiday, the pre-tax price of a computer model would decrease, on average, by $4.76 \times 0.0559 = 0.266$ percent with a standard error of 0.293 percent. Nominally, the estimate indicates the sales tax is over-shifted to consumers, but statistically we cannot reject the pre-tax price of computers, on average, does not change during tax holidays. The estimate in column IV, constructed using the first difference estimator, also supports this finding.

Taken at face value, this coefficient estimate lines up with the findings in Warner and Barsky (1995). They find, controlling for type of good, month effects, and type of store, pre-tax prices decrease 0.64 percent, on average, on Friday, a day they argue that is characterized by exogenously high demand.

The regressions in columns I and IV treat computers as if they were homogeneous products. Desktops are being compared with laptops, and vice versa. \$1,500 laptops are being compared to \$750 desktops. Consumers shopping for a cheap desktop may be quite different from those shopping for a high-powered laptop. Therefore, retailers' pricing strategies before, during, and after tax holidays may differ based on the observable characteristics of the computers. Restricting the sample further to make the treatment computers (those that qualify for the tax holidays) and control computers more similar will refine the results.

I first restrict the sample to examine desktops and laptops separately. There are 1,935 desktop models in the sample, 18.5 percent of which qualified for the tax holidays; and there are 4,242 laptop models in the sample, 19.2 percent of which were tax-free during the tax holidays. When the sample is restricted to the desktops, the point estimate on the tax rate remains positive and is three times larger than it is for the pooled sample. Again, the point estimate remains statistically insignificant when the fixed effects estimator is applied to the data (column II of Table 3). When the first difference estimator is used (column V), the coefficient on the sales tax rate is marginally significant and positive, giving rise to weak evidence that retailers lower their prices on desktops during tax holidays and that therefore the sales tax on computers is overshifted to consumers. Estimating the same equation on the sample of laptops (columns III and VI), I find no evidence that pre-tax prices change during tax holidays.

Since the desktops are less expensive than laptops on average, I speculate that potential purchasers of (cheap) desktop computers are on the extensive margin of purchasing a desktop. Retailers lower their pre-tax prices during the tax holiday in an effort to get the prices below consumers' reservation prices to induce purchases that otherwise, absent the tax holiday, would not be made. Laptop customers, on the other hand, are less likely to be on the extensive margin of purchasing a computer, let alone a laptop. Therefore, retailers do not lower their pre-tax prices on laptops. If this story is true, it suggests that the purchases of laptops during a tax holiday are primarily a timing response and that purchases of desktops, particularly cheap desktops, are likely to include a greater proportion of "new" purchases.

In an effort to refine further the treatment and control computers to be more comparable to each other, I split the sample into different price groups and estimate equation (2) separately for each price group. This also allows examination of whether the pass-through implications of the sales tax vary across the price distribution. If the foregoing story is true, I would expect to see a positive coefficient on the tax rate for inexpensive desktops and coefficients near zero for laptops and more expensive desktops.

There are inherent problems with categorizing a computer based on its price, an endogenous variable. The computers that comprise a price group could change from week to week. For example, suppose only computers priced below \$750 are tax-exempt during the tax holiday, and one of the price groups has a cutoff point at \$750. It is plausible that a computer that sells for \$774.99 in the week prior to the holiday would sell for \$749.99 during the tax holiday. As the computer migrates from the higher price group to the lower price group, the mean in the lower price group could increase even though the tax rate decreases. This would attenuate the coefficient estimate on the sales tax rate.

The above example also illustrates the endogeneity a computer's tax rate, shown more formally in equation (12). The endogeneity of the tax rate appears not to be a large concern, though. Only 14 of the 994 computer models in the tax holiday states had prices above the price cap the week prior to the holiday and had prices below the price cap during the week of the holiday.

I create seven price groups with price cut-offs at every \$250 from \$500 to \$2,000. In each week, I determine to which price group a computer model belongs. To address the endogenous group categorization issue, if the model remains in the same price group in each of the five weeks, it is retained in the sample. Otherwise, it is dropped from consideration.[20]

The results of estimating equation (2) for these prices groups are found in Table 4. The top panel provides estimates for when desktops and laptops are pooled together; the middle and bottom

[20]Separately, and not reported herein, I classified a computer model based on to which price group it belonged in the first week of the panel and ran the regressions shown in Table 4. The coefficient estimates differed but not in a pattern I could discern. Only laptops initially priced between \$1,250 and \$1,500 had a statistically significant coefficient on the tax rate at the five percent level (0.2078 with a standard error of 0.0980).

panels provide estimates for the sample restricted to desktops and laptops, respectively. The sample restrictions put in place to move from Table 3 to Table 4 cut the sample size approximately in half. Nearly half of all computers in the sample changed price groups at least once during this five week period.

In the pooled sample, the largest coefficient estimates are for the computers priced between \$750 to \$1,000 and the computers priced between \$1,000 and \$1,250. The estimate is marginally significant for the former price group. When desktops and laptops are pooled together, the point estimates for the other prices groups are an order of magnitude smaller, and none is statistically significant.

When the sample is restricted to desktops only, none of the coefficient estimates is statistically different from zero. However, the point estimate is nominally positive for each price group below \$1,250, and the point estimate for the \$250-\$500 desktops is the largest among these. Though not statistically significant, this relatively large coefficient—compared to the coefficients for the other desktop price groups—fits with the story that retailers would lower prices of cheap desktop computers to induce consumers on the margin to make purchases they would otherwise not have made in the absence of the holiday.

Taken at face value, during the tax holiday, the pre-tax price of computers in this group in the tax holiday states would decrease 1.33 percent, on average. The mean pre-tax price of desktops in the tax holiday states during the week ending July 28 was roughly \$416. With a 4.76 percent sales tax rate, the price consumers pay would be \$436. During the holiday, the pre-tax price would decrease to \$404; consumers would save \$29, on average, if they purchased a desktop in this price group.

The coefficient estimate for laptops in this price group, however, was negative and statistically significant at the five percent level. During the week ending July 28, the mean pre-tax price for computers in this group in the tax holiday states was \$423. Consumers would pay, on average, \$443 given the mean sales tax rate of 4.76 percent. During the holiday, the pre-tax price would increase 3.71 percent, on average, to \$436. Consumers would save only \$7 if they purchased a laptop in this price group. The evidence, though it is only suggestive, supports the notion that retailers are lowering prices of desktops to induce purchases that otherwise would not be made.

The evidence thus far points to either full pass-through or mild over-shifting of the sales tax on computers. Taking the statistical significance of the coefficient estimates seriously, however, one interpretation of the finding that the tax rate has no effect on the pre-tax price is that firms have costs of changing their prices and have determined that the expected profit from changing prices does not exceed the cost of doing so. If menu costs are driving the result, it should be the case that a large number of computers do not experience a price change from week to week.[21]

Table 5 shows the number of computer models that experienced a price decrease, a price increase, or no price change from the preceding week for the weeks ending July 28th, August 4th (the tax

[21] Since the data are aggregated up to the state level, the observed price changes cannot be strictly interpreted as an individual retailer changing its price.

holiday week), and August 11th. The computer models used to construct this table are the models used in tables 3 and 4. The top panel shows the results for all states; the middle panel shows results for the non-holiday states; and the bottom panel shows results for the tax holiday states. The table also displays the mean log price change from the preceding week for computers that had a positive or negative price change. Finally, the table displays the mean price in the preceding week for these different groups of computers.

From the week ending July 28th to the week ending August 4th, 68 of the 1,262 computer models (5.4 percent) in the tax holiday states experienced no price change, compared to 7.7 percent of the models models in the non-holiday states. The proportion of computers that decreased in price from July 28th to August 4th was 55.7 percent in the tax holiday states and 52 percent in the non-holiday states. These proportions increased, respectively, 7.5 and 1.1 percentage points from their values between the weeks ending July 21st and July 28th. The data indicate there are significant amounts of short-term price fluctuations, which is evidence against the menu cost interpretation of the finding that pre-tax prices, on average, do not change during sales tax holidays. Nominal rigidities do not appear to be operative in these data.

Finally, one particularly interesting feature of the tax holiday policy is the price cap below which a computer must fall in order to have the zero tax rate during the tax holiday. This notch may cause retailers to set prices just below the price cap and for consumers to substitute from purchasing computers that are just above the price cap to those just below the cap. Following McCrary (2008), I test whether there is a discontinuity in the density function of prices at the price cap.

Table 1 shows how the price caps vary across states. Because of this variation, I normalize a computer's pre-tax price by subtracting off the price cap in its state. I focus on the week ending August 4th since eight of the tax holidays occur that week. I restrict the sample by omitting South Carolina, which has no price cap (or, alternatively, an infinite price cap), and Massachusetts, which has its tax holiday one week later. For this exercise, I will refer this to as the "full sample." In addition, I use the 5-week balanced panel of computers for these states.

In the full sample, if a computer model is priced near the price cap, it is more likely to be below the cap than above it. This is shown in the top panel of Figure 1. The estimated log discontinuity at the price cap is large (103 percent for desktops and 79 percent for laptops) and statistically significant at the one percent level. Retailers are aware of the price caps and are pricing computers just below the cap during the holiday week; consumers are more likely to purchase a computer just below the price cap than just above it. When restricting the sample to include only those computers that sold in each of the two weeks on either side of the tax holiday (the bottom panel of Figure 1), the result holds for laptops but not desktops. The estimated log discontinuity at the price cap is 76.3 percent for laptops—again significant at the one percent level—and 58.6 percent for desktops, which is not statistically significant.

One can find a discontinuity at the price cap in these states in weeks other than the one containing the tax holiday. I conjecture that this is because the price caps occur at psychological price points, e.g., $750, $1,000, and $1,500. Retailers list prices just below these points, so we would expect a discontinuity in the density function even in the absence of a tax holiday. In the next section, I take up the quantity response of purchases in the face of price changes brought about by sales tax holidays.

### 4.2 Quantities

Figure 2 shows the aggregate time series of desktop computers (solid lines) and laptop computers (dashed lines) in states with tax holidays on computers (left axis) and in states without tax holidays on computers (right axis) for the 30-week period in 2007 covered by the dataset. Consumers in tax holiday states purchased a large number of computers during tax holidays. There is no such response in the non-tax holiday states during the same weeks, though there is a continuation of a seasonal increase in laptop purchases in the non-holiday states during the week ending August 11.

Consumers purchased 9.3 and 7.5 percent more desktops and laptops, respectively, in the tax holiday states during the week ending August 4 than sold in those states during the week ending November 24, which included the Friday and Saturday after Thanksgiving, routinely regarded as one of the busiest shopping weeks of the year. In contrast, consumers purchased 55.5 percent fewer desktops and 54.3 percent fewer laptops in the non-tax holiday states during the week ending August 4 than they purchased in those states during the week of Thanksgiving. 'Christmas in August' is not journalistic hyperbole. 8.2 percent of the desktops purchased and 8.5 percent of the laptops purchased in the holiday states during this period were purchased during the week ending August 4, compared to 3.6 percent of desktop purchases and 3.7 percent of laptop purchases in the non-tax holiday states.[22]

Consumers purchased 58,599 more computers—an increase of 161 percent—in the tax holiday states during the week ending August 4 compared to the prior week. Laptop purchases constitute 71.6 percent of this increase.[23] Increased purchases in Georgia, North Carolina, and Tennessee, respectively, accounted for 25.2 percent, 21.8 percent, and 17.8 percent of the increase in computer purchases in the holiday states over this two-week period. These states also had the largest percent increases in computers purchased over this two-week period; purchases increased 308 percent in Tennessee, 221 percent in Georgia, and 195 percent in North Carolina.

Excluding the weeks ending August 4th and 11th, the contemporaneous correlation coefficient for desktop purchases in the two groups of states was 0.989 The desktop time series plots for the two groups of states fall atop one another for the weeks up to July 21. Purchases in the non-holiday states increase slightly relative to those in the holiday states for the week ending July 28, the week prior to most of the tax holidays. Similarly, after the week ending August 18, the plot for the tax holiday states lies below the plot for non-holiday states. This is indicative of consumers timing purchases of desktops to coincide with the tax holidays. However, that the area between the two

[22] 13.4 percent of the desktops purchased and 14.5 percent of the laptops purchased in the holiday states during the period were purchased during the weeks ending August 4 and August 11. In contrast, 7.1 percent of desktop purchases and 8.1 percent of laptop purchases in the non-tax holiday states occurred during those two weeks.

[23] As a point of reference, 71.9 percent of the computers purchased in the dataset were laptops.

plots outside the holidays is small relative the area between the plots during the holidays suggests that, while there is some timing behavior in the desktop market, most of the purchases in the weeks ending August 4th and 11th are additional purchases that would not have been made absent the tax holidays.

This contrasts with the market for laptops. Excluding the weeks ending August 4th and 11th, the laptop time series for the two groups of states had a contemporaneous correlation coefficient of 0.997. The series for the holiday states lies everywhere below the series for the non-holiday states except for the tax holidays weeks. This is particularly the case in the weeks after the tax holiday and before the Labor Day holiday (the week ending September 8th). It appears the timing behavior of consumers looms much more largely in the laptop market than in the desktop market.

Taken together, the aggregate plots for desktops and laptops provide evidence supporting the notion that purchasers of desktops are more likely to be on the extensive margin of buying a computer. The lower tax rate during the tax holidays induces them to buy desktops. On the other hand, laptop buyers are less likely to be on the extensive margin, and the existence of the tax holiday appears to make them shift their purchases across time to capture the benefits of the lower tax rate.

The foregoing raises the question of what types of desktops and laptops are being purchased in the holiday states. Figures 3 and 4 decompose, respectively, the desktop and laptop purchases in the tax holiday states into five, $250 price groups.[24] Desktops priced between $500 and $750 and between $250 and $500 experienced the largest increase in the number of units purchased during the week ending August 4 compared to one week earlier, increasing by 8,064 units (242 percent) and 6,339 units (152 percent), respectively. Laptops priced between $500 and $750 and between $750 and $1,000 experienced the largest increase in the number of units purchased over this two-week period, increasing by 20,265 units (196 percent) and 11,318 units (162 percent), respectively. More computers sold in nine of the ten price groups during the week ending August 4 than during the week of Thanksgiving, with $250 to $500 laptops' being the exception. The time series of the shares of desktops or laptops within a price group are noisy.

Plotting the time series of computer purchases by price group masks whether the computers in that group qualify for the tax holiday because of the existence of the price caps. The previous plots tell us consumers are purchasing more qualifying computers during the tax holidays. The plots do not tell us, however, whether consumers are also purchasing more non-qualifying computers at the same time.

In Figure 5, I plot the time series for desktops (solid lines) and laptops (dashed lines) that qualify for the tax holiday (left axis) and for those that do not (right axis). A computer model within a state is defined to be a "qualifying model" if its price is less than or equal to the price cap in that state. For the weeks that do not include the tax holiday, one can think of this categorization as: "If the holiday were held this week, this computer model's price is below the price cap and

[24] These groups cover 95.9 percent of desktop purchases and 98.0 percent of laptop purchases in the tax holiday states.

would therefore qualify for the zero tax rate."[25]

There is an increase in the purchases of computer models that do not qualify for the preferential tax treatment for the week ending August 4tth. Non-qualifying desktop purchases increased 43.64 percent (236 to 339), and non-qualifying laptop purchases increased 48.21 percent (1,062 to 1,574).[26] 60.2 percent of the increased desktop purchases and 84.6 percent of the increased laptop purchases come from consumers in Alabama. Recall that Alabama had the lowest price cap of any of the states at $750. This suggests there were a substantial number of consumers in Alabama who determined the attributes of the computers priced below this restrictive cap did not fit their computing needs and, while still in the store, decided to purchase a computer above the price cap, forgoing any tax savings. Because the price caps were at least $250 greater in the other holiday states, there were fewer consumers in those states for whom the cap was relevant. Thus there is not as large an increase in non-qualifying computer purchases in those states.

The data clearly show that consumers in tax holiday states purchased large numbers of relatively inexpensive computers during the tax holidays. This behavioral response to the policy is a mixture of a timing response to take advantage of a lower tax rate that lasts at most three days and extra purchases that otherwise would not have been made absent the lower tax rate. To determine the magnitudes of these responses, I construct a counterfactual number of computers that would sell in the tax holiday states if purchases in those states mimicked purchases in the non-holiday states.

I first match each tax holiday state with a control state. I use the following state-level variables in the matching process: the 2007 unemployment rate, the 2007 population, the median household income in 2006, the percentage of individuals below the poverty rate in 2006, the proportion of the population in 2006 between the ages of 18 and 64, the median age in 2006, the proportion of the population aged 25 and above with a bachelor's degree or greater for the years 2005 through 2007, and the state sales tax rate in 2007. The data come from the U.S. Census Bureau, 2005-2007 American Community Survey and the U.S. Bureau of Labor Statistics. For each state $s'$ that did not have a tax holiday, I compute the sum of squared percent deviations of these values from the corresponding values in tax holiday state $s$. I choose the state $s'$ that had the smallest sum to be the comparison state for state $s$. The top five comparison states for each tax holiday state are listed in Table 6. The comparison state's ranking among all 50 states and the District of Columbia is listed in parentheses; for example, Kentucky was the third best comparison state for Alabama.[27]

Next, I partition the price distribution into $250 bins (the same ones in Table 4). Consider price group $j$. I compute the per capita quantity of computers sold in price group $j$ in tax holiday state $s$ and control state $s'$ in week $t$. Call these $q_{jst}$ and $q_{js't}$. Using the ordinary least squares

[25] Because prices are endogenous, so is the computer's categorization. As a reminder, though, in the balanced panel I constructed, only 1.4 percent of the qualifying models had prices above the price cap in the week preceding the tax holiday.

[26] For comparison, qualifying desktop purchases increased 166.59 percent (9,915 to 26,432), and qualifying laptop purchases increased 165.09 percent (25,094 to 66,521).

[27] South Carolina and Louisiana were ranked first and second but could not be chosen as control states because they had tax holidays on computers.

estimator, I regress the former on the later using the first 10 weeks of data:

$$q_{jst} = \alpha + \beta q_{js't} + \varepsilon_{jst}, \; t = 1, \ldots, 10, \tag{13}$$

and retrieve the coefficient estimates $\widehat{\alpha}$ and $\widehat{\beta}$.[28] I use these coefficient estimates to predict the per capita number of computers in price group $j$ purchased in the holiday state $s$ for the remaining 20 weeks of the sample.[29] Call these values $\widehat{q}_{jst}$. I then convert the per capita numbers into levels $\widehat{Q}_{jst}$. The effect of the policy on the quantity of computers purchased in price group $j$ in state $s$ in week $t$ is the difference between observed purchases $Q_{jst}$ and the predicted number of purchases $\widehat{Q}_{jst}$ and for the $(n-m)$-week period is

$$\sum_{t=m}^{n} \left( Q_{jst} - \widehat{Q}_{jst} \right). \tag{14}$$

I do this separately for each price group between \$250 and \$1,500 and separately for desktops and laptops.

In words, I am engaging in the following thought experiment. Suppose purchases of \$250-\$500 desktops in Alabama mimic those in Kentucky, which did not have a tax holiday on computers. Then how many \$250-\$500 desktops would we expect to be purchased in Alabama in the absence of a tax holiday? I regress the per capita number of desktop purchases in this price group in Alabama on those in Kentucky using the data from the weeks ending May 12th through July 14th. I then use the coefficient estimates to predict the per capita quantity of \$250-\$500 desktops purchased in Alabama for the weeks ending July 21st through December 1st. I convert these back to level quantities by multiplying by Alabama's population. These quantities are the purchases of \$250-\$500 desktops we would expect to see in Alabama in the absence of a tax holiday. The difference between the actual purchases in the week of the tax holiday and the purchases predicted by the models yields an upper bound on the timing response for purchases in that price group. The difference between the actual purchases over the 30-week period and the purchases predicted by the models provides an estimate of the number of additional computer purchases that would not have otherwise been made in the absence of the holiday.

Table 7 presents results of these counterfactual exercise. The first column contains the total number of computers—desktops and laptops combined—priced between \$250 and \$1,500 that consumers purchased. The second column contains the predicted number of computers in this price range consumers would have purchased in the absence of the tax holiday. The third column is the difference between the observed and predicted number of computer purchases. It provides an estimate of the extra number of computers sold due to the tax holiday. Columns four through six replicate the first three columns but are scaled to be the number of computers purchased per 10,000 people. The top panel presents estimates for the first week of the the tax holiday; this means the

[28]This corresponds to the weeks ending May 12th through July 14th.

[29]The week ending August 4th corresponds to week 13 in the dataset.

week ending August 11th for Massachusetts and the week ending August 4th for the other states. The middle panel gives estimates for tax holidays that span two reporting weeks; for Massachusetts, this means the weeks ending August 11th and 18th, and for the remaining states (save Louisiana), this means the weeks ending August 4th and 11th. The bottom panel presents estimates for the entire 30-week period.

As an example, consumers in Alabama purchased 7,216 computers priced between $250 and $1,500 during the week ending August 4th. Using Kentucky as the control state, if purchases in Alabama mimicked those in Kentucky, we would expect consumers in Alabama to have purchased 2,689 computers during that week. Therefore, the timing effect is at most 4,527 computers; consumers purchased at most 168 percent more computers that week than would be predicted in the absence of Alabama's tax holiday.

Over the 30-week horizon, consumers in Alabama purchased 81,319 computers priced between $250 and $1,500. The models predict in the absence of the holiday, those consumers would have purchased 72,362 computers in this price range during this period. An upper bound for the additional computer purchases induced by the tax holiday over this horizon is therefore 8,957 computers; consumers purchased at most 12.4 percent more computers than they would have in the absence of Alabama's tax holiday. The timing effect accounts for up to 50.5 percent (4,527/8,957) of the increase in computer purchases in Alabama over this period.

This pattern largely holds with the other tax holiday states. Shifting purchases that were already going to be made across time to coincide with the lower tax rate is an important response to this policy. Timing explains 90 percent of the increase purchases over the 30-week horizon in South Carolina—which, recall, has no price cap—and 82 percent in Georgia and North Carolina.[30] On the low end of the spectrum, timing explains only 37.3 percent and 41.9 percent of the increased purchases in New Mexico and Massachusetts, respectively.

The results are sensitive to the choice of control state but in ways that are not easily discernable or predictable. Taking the next best match based on the procedure outlined above, timing explains 44.5 percent on the increase in purchases over the horizon in South Carolina. The results for Georgia and North Carolina are roughly comparable, at 81 percent and 76 percent, respectively. Using West Virginia as a control state for New Mexico, timing accounts for up to 50 percent of the increased purchases for the 30-week period.

On a per capita basis, the policy induced the largest response in Tennessee, where consumers purchased 16.53 more computers per 10,000 people during the week ending August 4th than they would absent the holiday. Georgia followed closely with 15.56 extra computers per 10,000 people. Interestingly, both states did not have the largest price caps. North Carolina, South Carolina, and Missouri had the largest price caps; consumers in those states bought 14.03, 10.92, and 10.82 more computers per 10,000 people than if those states didn't have tax holidays during that week.

Unsurprisingly, states with lower price caps had smaller quantity responses. Alabama and New

[30]Missouri is anomalous in that timing explains more than 100 percent of the increased purchases over the 30-week period.

Mexico had the first and second most restrictive price caps and the fourth and second lowest per capita quantity response, respectively. However, Louisiana, which had a relatively generous cap on the first $2,500 of each computer purchase, had the lowest quantity response at 5.76 extra computers per 10,000 people during the week ending August 4th. Louisiana and Massachusetts, which had the third lowest quantity response, had holidays that covered all consumer purchases of non-titled personal property priced $2,500 or less. With the wider array of tax-free goods from which to choose, I speculate that consumers in these states may have opted to increase purchases of other goods at greater rates than they did for computers.

### 4.3 Revenue Loss Estimation

Finally, in order to judge the costs and benefits of tax holidays, policymakers need a measure of the revenue lost as a consequence of this temporary tax moratorium. During the week of the tax holiday, computer purchases dramatically increase. I have argued above that part of the increase is a shifting of purchases across time to coincide with the lower tax rate, and the balance is purchases that otherwise would not have been made in the absence of the tax holiday. As a bounding exercise, we can think of the two extremes: one where there is only a timing response and another where there is no timing response. In the case where there is no timing response, there is obviously no tax revenue loss because the computers sold during the tax holiday would not have been purchased in the counterfactual world. Estimating the revenue loss when there is only a timing effect will provide policymakers with an upper bound for the truth.

As done above, index computer models by $i$, states by $s$, and weeks by $t$. The tax revenue raised in state $s$ in week $t$ is

$$R_{st} = \sum_i \tau_{ist} \cdot p_{ist} \cdot q_{ist}. \tag{15}$$

Suppose there is only a timing response of consumer purchases, and further suppose there is no price response by retailers. Under these assumptions, the counterfactual prices and quantities $\widehat{p}_{ist}$ and $\widehat{q}_{ist}$ equal their observed values *in some period*. If price data existed for each computer model in each week, the quantities sold during the tax holiday could be allocated across the other weeks and matched up the prices in those weeks. A range for the counterfactual tax revenue could then be produced and compared to the actual tax revenue raised.

However, I cannot do this with this dataset. I therefore assume that the price paid during the week of the tax holiday is what the price would have been had the consumer purchased the model outside the holiday. In effect, I am answering the question: "If consumers made the same purchases during the week of the tax holiday and the sales tax rate had been in effect, for the observed prices consumers paid that week, what would the tax revenue have been?" Since the tax rate is the same for all computer models $i$, the counterfactual tax revenue raised, given the assumptions, is

$$\widehat{R}_{st} = \sum_i \tau_{st} \cdot \widehat{p}_{ist} \cdot \widehat{q}_{ist} = \sum_i \tau_{st} \cdot p_{ist} \cdot q_{ist}. \tag{16}$$

The revenue loss associated with the tax holiday is

$$\widehat{R}_{st} - R_{st} = \sum_{i} (\tau_{st} - \tau_{ist}) \cdot p_{ist} \cdot q_{ist}. \tag{17}$$

Given the assumption that the response of consumers is purely a timing response, $\widehat{R}_{st} = R_{st}$ for all non-holiday weekends. Therefore, the revenue loss in percentage terms decreases as the window around the tax holiday increases.

Table 8 provides estimates of the revenue loss on computers due to the tax holidays in 2007. In the top panel, the tax holiday week is the week ending August 11th in Massachusetts and the week ending August 4th in the remaining states. In the bottom panel, the tax holiday weeks are the week ending August 4th in Louisiana, the weeks ending August 11th and 18th in Massachusetts, and the weeks ending August 4th and 11th in the remaining states.

The revenue loss from the tax holidays is substantial. In raw dollar terms, Tennessee experienced the largest decrease in tax revenue, between \$676,692 and \$1,014,018. It also has the largest sales tax rate among the tax holiday states at seven percent. The state governments that had tax holidays on computers in 2007 collectively lost between \$3,285,508 and \$5,127,858 in sales tax revenue because of these policies.

Not surprisingly, the states with the largest price caps—South Carolina, North Carolina, and Missoui—generated no sales tax revenue from computer sales during the week ending August 4th. Louisiana and Massachusetts, which also had generous price caps, raised between \$55 and \$615, respectively, during their tax holidays. Alabama, which had the most restrictive price cap, raised the most tax revenue during its tax holiday but lost between \$134,578 and \$203,037 by having the policy.

Tax revenue statements are published at the monthly frequency, so I examine how much revenue loss would occur in August 2007. By construction, the dollar amount of the revenue loss is the same as it was during the week of the tax holiday. However, the percentage loss in tax revenue takes on a slightly different interpretation. It assumes that all the timing behavior of purchases induced by the tax holiday occurs during August, i.e., all the purchases were going to be made in August, but consumers moved those purchases into the week of the tax holiday. Under this assumption, sales tax revenue generated from computer sales declined between 27 and 40 percent in Alabama and 44 to 97 percent in Georgia. Similarly, if we assume the timing behavior occurs over the entire 30-week period, the sales tax revenue loss from having a tax holiday on computers ranges from 5.8 to 8.8 percent in Alabama to 12.4 to 18.5 percent in Tennessee. South Carolina is the median state and lost between 9 and 14.6 percent of its sales tax revenue from computers over this period because of the tax holiday.

## 5 Conclusion

Estimating the incidence of the sales tax has been a difficult task because of the lack of plausibly exogenous variation in tax rates. The sales tax holiday, a temporary moratorium of the sales tax on certain goods, is a source of such variation. In this paper, I exploited the transitory reduction in the tax base to estimate the incidence of the sales tax on computers using weekly, retail scanner data covering nine tax holidays in 2007.

Modifying slightly the spatial competition model of Salop (1979), I showed that when the sales tax rate is reduced during a period of high demand, the model produces an ambiguous prediction about the direction pre-tax prices will change. The increased competition retailers face due to greater foot-traffic in their stores during sales tax holidays serves to temper their desire to increase pre-tax prices. The incidence of the sales tax, as identified from changes in tax rates during tax holidays, is ultimately an empirical question.

When desktops and laptops are pooled together, I find the pre-tax price of a computer model would decrease 0.266 percent during the tax holidays, on average, in the face of a 4.76 percentage point decrease in the sales tax rate. Though the estimate is not statistically different from zero, taken at face value, it suggests that the sales tax on computers is either fully or slightly over-shifted to consumers. Because there are significant amounts of short-term price fluctuations in the data, menu costs do not drive the results.

This pattern remains when one examines desktops separately from laptops. There is weak evidence that retailers lower their prices on desktops during tax holidays. In contrast, I find pre-tax prices for laptops do not change during tax holidays.

Because desktops are less expensive than laptops, I speculate that retailers lower prices on desktops to induce purchases by consumers who are on the extensive margin of buying a computer. Laptop customers are less likely to be on the extensive margin, so retailers do not lower the pre-tax prices of these computers during tax holidays. When desktops and laptops are grouped into $250 price bins, the constellation of coefficient estimates for the desktops—though not statistically significant—supports the conclusion that either pre-tax prices are not changing or are decreasing slightly during tax holidays, particularly in the $250 to $500 price bin. Retailers selling laptops in the $250 to $500 price group, on the other hand, increased the pre-tax prices of these computers by a statistically significant 3.7 percent, on average, during the tax holiday.

A key feature of tax holidays is the existence of a price cap. In order for a computer to qualify for the zero tax rate during the holiday, its price had to be below a certain level, ranging from $750 in Alabama to $3,500 in Missouri and North Carolina. This notch creates an incentive for retailers to price computers just below the price cap and for consumers to purchase those computers during the tax holidays. There is evidence supporting the conclusion that retailers and consumers do just this. However, this phenomenon exists not only during tax holiday weeks. I speculate this is because the price caps occur at psychological price points, e.g., $750, $1,000, and $1,500.

In the presence of minimal price changes, consumers purchase large amounts of computers during tax holidays. Consumers purchased 9.3 percent and 7.5 percent more desktops and laptops, respectively, during the week ending August 4th in the tax holiday states than they did in those states during the week including the Friday and Saturday after Thanksgiving, routinely regarded as one of the busiest shopping weeks of the year. There was no such spike in purchases in the non-holiday states.

The time series plots provide evidence that the purchases of desktops during the tax holidays are more likely to be purchases that would otherwise not have been made in the absence of the tax holidays and that the tax holidays induce primarily a timing response by purchasers of laptops. The largest increases in desktop purchases come from those priced between $250 and $750, while the largest increases in laptop purchases come from computers priced between $500 and $1,000. During the tax holidays, there is clearly an increase in purchases of computers that receive the preferential tax treatment, but there is also an increase in purchases of computers that remained taxable. This phenomenon was mainly isolated in Alabama, which had the strictest price cap at $750.

I isolated the timing effects and the "extra purchases" effects of the tax holidays by constructing a counterfactual amount of computers that would sell in each of the tax holiday states if purchases in those states mimicked purchases in non-holiday control states. Though the results are sensitive to the choice of control state, I found that the timing response accounts for between 37 and 90 percent of the increase in purchases in the tax holiday states over the 30-week horizon. Tennessee had the largest per capita response during the week of the holiday, 16.53 more computers per 10,000 people than would be predicted in the absence of the holiday. Louisiana, which had a generous price cap applied to all non-titled goods, had the smallest response at 5.76 computers per 10,000 people greater than would be predicted for the week ending August 4th in the absence of the tax holiday.

The sales tax revenue lost as a consequence of the policy is substantial. The state governments that had tax holidays on computers in 2007 lost between $3.3 and $5.1 million in sales tax revenue because of the tax holidays. The largest dollar loss was in Tennessee; the suspension of its 7 percent sales tax on computers priced below $1,500 reduced sales tax collections between $0.67 million and $1 million. If the timing behavior were solely isolated to purchases in August, South Carolina was the median state and lost between 9 and 15 percent of its sales tax revenue arising from computer sales during this month.

Lawmakers' policy aims in creating tax holidays are to reduce the tax burden on families with children and to stimulate purchases of certain products such as computers. The evidence presented in this paper suggests that the sales tax on computers is fully or marginally overshifted to consumers. The tax holidays do appear to be achieving the goal of reducing consumers' tax burden.

The results herein also suggest that the reduction of the sales tax rate does induce purchases of computers that otherwise would not have been purchased in the absence of the holiday. This is particularly true for inexpensive desktops. However, the policy also generates large-scale retiming of purchases to coincide with the lower tax rates. This appears to be the case more for laptops than desktops, as laptops are more expensive, on average, and potential purchasers of laptops are less likely to be on the extensive margin of purchasing a computer.

Though the policy may be achieving the goals of policymakers, it comes at a substantial revenue cost. I question whether this is the most efficient way of achieving these goals. If it is desirable to eliminate the sales tax on computers for three days during the year, why not reduce it for the entire year (and raise the sales tax rate on other goods to make the policy revenue neutral)?

Future work on tax holidays should address the prevalence of cross-border shopping effects. The tax incidence results may differ depending on whether a jurisdiction is close to a state boundary or in the interior of a state or if the jurisdiction is in a large metropolitan area or in a rural part of a state. Data on other products exempt from tax during sales tax holidays should also be analyzed to see if the results of this paper are relevant only to computers or if they can speak more broadly to consumer and retailer behavior in and around tax holidays.

**Table 1: Tax Holidays on Computers, 2007**

| State | Dates | Price Cap | Annual | Tax Rate (%) | Notes |
|---|---|---|---|---|---|
| Alabama | Fri., 8.3 - Sun., 8.5 | $750/purchase | Yes | 4 | Counties and municipalities can choose to exempt these items from their sales tax during the state's holiday. |
| Georgia | Thurs., 8.2 - Sun., 8.5 | $1,500/item | No | 4 | Local sales taxes repealed for the state's tax holiday. |
| Louisiana | Fri., 8.3 - Sat., 8.4 | *First* $2,500/item | Yes | 4 | Local sales taxes are *not* automatically repealed for the state's holiday, but it appears parishes can vote to do so. |
| Massachusetts | Sat., 8.11 - Sun., 8.12 | $2,500/item | No | 5 | None. |
| Missouri | Fri., 8.3 - Sun., 8.5 | $3,500/item | Yes | 4.225 | Fifty-one counties and 169 cities chose to collect local taxes during the holiday. |
| New Mexico | Fri., 8.3 - Sun., 8.5 | $1,000/item | Yes | 5 | Retailers are *not* required to participate in the holiday. If they do not participate, they pay tax on otherwise eligible sales and may recover their tax costs from the customer. |
| North Carolina | Fri., 8.3 - Sun., 8.5 | $3,500/item | Yes | 4 | Local sales taxes repealed for the state's tax holiday. |
| South Carolina | Fri., 8.3 - Sun., 8.5 | No price cap | Yes | 6 | Local sales taxes repealed for the state's tax holiday. |
| Tennessee | Fri., 8.3 - Sun., 8.5 | $1,500/item | Yes | 7 | The state reimbursed localities for local sales tax losses. |

**Note:** The tax rate is the state sales tax rate. See Cole (2008a) for more detail. Full citations available from the author upon request.

**Table 2: Summary Statistics**

| | | Week Ending | | | | |
|---|---|---|---|---|---|---|
| | | 7/21 | 7/28 | 8/4 | 8/11 | 8/18 |
| All States | Mean Pre-tax Price ($s) | 875.67 | 863.52 | 851.13 | 844.53 | 837.03 |
| | (Standard Deviation) | (393.02) | (392.12) | (396.82) | (391.64) | (383.65) |
| | Computers Sold | 192,073 | 191,510 | 255,382 | 242,675 | 253,689 |
| Non-holiday States | Mean Pre-tax Price ($s) | 879.98 | 867.70 | 856.27 | 850.35 | 842.03 |
| | (Standard Deviation) | (399.01) | (398.56) | (403.88) | (397.89) | (389.62) |
| | Computers Sold | 162,016 | 163,671 | 176,399 | 190,658 | 214,083 |
| Holiday States | Mean Pre-tax Price ($s) | 858.87 | 847.23 | 831.09 | 821.88 | 817.53 |
| | (Standard Deviation) | (368.47) | (365.65) | (367.52) | (365.55) | (358.90) |
| | Computers Sold | 30,057 | 27,839 | 78,983 | 52,017 | 39,606 |
| Alabama | Mean Pre-tax Price ($s) | 850.83 | 842.18 | 821.18 | 816.15 | 807.20 |
| | (Standard Deviation) | (350.85) | (347.59) | (356.45) | (355.32) | (341.78) |
| | Computers Sold | 2,090 | 1,831 | 5,621 | 3,121 | 2,844 |
| Georgia | Mean Pre-tax Price ($s) | 850.74 | 836.61 | 823.72 | 816.32 | 812.53 |
| | (Standard Deviation) | (364.31) | (357.61) | (362.20) | (361.08) | (357.05) |
| | Computers Sold | 5,904 | 5,270 | 18,556 | 10,058 | 6,895 |
| Louisiana | Mean Pre-tax Price ($s) | 882.41 | 865.90 | 850.19 | 838.30 | 838.91 |
| | (Standard Deviation) | (396.67) | (403.94) | (399.84) | (406.69) | (399.62) |
| | Computers Sold | 2,830 | 2,593 | 5,122 | 3,100 | 3,188 |
| Massachusetts | Mean Pre-tax Price ($s) | 862.02 | 847.52 | 836.92 | 820.80 | 821.22 |
| | (Standard Deviation) | (378.00) | (382.10) | (383.17) | (373.92) | (370.72) |
| | Computers Sold | 4,197 | 4,363 | 4,176 | 9,802 | 8,087 |
| Missouri | Mean Pre-tax Price ($s) | 830.24 | 829.97 | 807.41 | 803.37 | 791.19 |
| | (Standard Deviation) | (359.39) | (346.78) | (350.79) | (353.55) | (347.16) |
| | Computers Sold | 3,343 | 2,863 | 9,062 | 5,466 | 3,965 |
| New Mexico | Mean Pre-tax Price ($s) | 800.05 | 808.27 | 785.92 | 780.77 | 774.38 |
| | (Standard Deviation) | (293.47) | (290.63) | (302.13) | (299.16) | (284.84) |
| | Computers Sold | 844 | 854 | 2,128 | 1,334 | 1,140 |
| North Carolina | Mean Pre-tax Price ($s) | 872.85 | 855.50 | 834.61 | 827.88 | 825.66 |
| | (Standard Deviation) | (372.20) | (372.20) | (371.87) | (368.34) | (363.99) |
| | Computers Sold | 5,570 | 5,159 | 16,318 | 9,648 | 6,464 |
| South Carolina | Mean Pre-tax Price ($s) | 877.52 | 867.18 | 851.21 | 844.14 | 839.11 |
| | (Standard Deviation) | (352.00) | (343.96) | (347.51) | (342.01) | (336.69) |
| | Computers Sold | 2,552 | 2,322 | 6,772 | 3,865 | 3,524 |
| Tennessee | Mean Pre-tax Price ($s) | 876.53 | 857.14 | 849.50 | 833.03 | 827.88 |
| | (Standard Deviation) | (408.11) | (403.83) | (398.83) | (396.13) | (386.85) |
| | Computers Sold | 2,727 | 2,584 | 11,228 | 5,623 | 3,499 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007.

**Table 3: Effect of Sales Tax Holidays on Pre-tax Prices**

| Dependent variable: $ln$(pre-tax price) | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Sales Tax Rate | 0.0559 | 0.1844 | 0.0066 | 0.0436 | 0.2271* | -0.0317 |
| | (0.0614) | (0.1276) | (0.0680) | (0.0685) | (0.1371) | (0.0779) |
| $r^2$ | 0.034 | 0.0357 | 0.0364 | | | |
| $F$ | 144.18 | 57.04 | 118.45 | | | |
| Wald $\chi^2$ | | | | 719.06 | 283.39 | 591.69 |
| Computers | All | Desktops | Laptops | All | Desktops | Laptops |
| Computer Models | 6,177 | 1,935 | 4,242 | 6,177 | 1,935 | 4,242 |
| Models in Holiday States | 1,262 | 377 | 885 | 1,262 | 377 | 885 |
| Qualifying Models | 1,171 | 358 | 813 | 1,171 | 358 | 813 |
| Observations | 30,885 | 9,675 | 21,210 | 24,708 | 7,740 | 16,968 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007. Columns I through III have computer model-state fixed effects and are estimated using the within estimator. Columns IV through VI are estimated using first differences for weeks endings July 28th, 2007 through August 18th, 2007. All specifications have week fixed effects. Robust standard errors, in parentheses, are clustered at the computer model-state level. A *, **, and *** represents statistical significance at the 10-, 5-, and 1-percent level, respectively.

Table 4: **By Price Group, Effect of Sales Tax Holidays on Pre-tax Prices**

| Dependent variable: *ln*(pre-tax price) | \$250.01-\$500 | \$500.01-\$750 | \$750.01-\$1,000 | \$1,000.01-\$1,250 | \$1,250.01-\$1,500 | \$1,500.01-\$1,750 | \$1,750.01-\$2,000 |
|---|---|---|---|---|---|---|---|
| | | | | **All Computers** | | | |
| Sales Tax Rate | -0.0053 | 0.0211 | 0.1537* | 0.1219 | -0.0075 | -0.0295 | 0.0190 |
| | (0.2128) | (0.0819) | (0.0913) | (0.1190) | (0.0757) | (0.1240) | (0.1598) |
| Computer Models | 605 | 1,087 | 945 | 252 | 242 | 41 | 56 |
| Qualifying Models | 112 | 239 | 175 | 51 | 37 | 5 | 7 |
| Observations | 3,025 | 5,435 | 4,725 | 1,260 | 1,210 | 205 | 280 |
| | | | | **Desktop Computers** | | | |
| Sales Tax Rate | 0.2791 | 0.0762 | 0.1484 | 0.1052 | -0.3393 | | |
| | (0.2415) | (0.1025) | (0.1355) | (0.1529) | (0.4603) | | |
| Computer Models | 449 | 456 | 257 | 48 | 18 | 14 | |
| Qualifying Models | 81 | 98 | 42 | 7 | 3 | 1 | |
| Observations | 2,245 | 2,280 | 1,285 | 240 | 90 | 70 | |
| | | | | **Laptop Computers** | | | |
| Sales Tax Rate | -0.7787** | -0.0067 | 0.1653 | 0.0796 | 0.0019 | -0.0707 | 0.0190 |
| | (0.3923) | (0.1132) | (0.1118) | (0.1323) | (0.0784) | (0.1523) | (0.1598) |
| Computer Models | 156 | 631 | 688 | 204 | 224 | 27 | 56 |
| Qualifying Models | 31 | 141 | 133 | 44 | 34 | 4 | 7 |
| Observations | 780 | 3,155 | 3,440 | 1,020 | 1,120 | 135 | 280 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007. Each regression is estimated using the fixed effects within estimator. All specifications have computer model-state fixed effects and week fixed effects. Robust standard errors, in parentheses, are clustered at the computer model-state level. A *, **, and *** represents statistical significance at the 10-, 5-, and 1-percent level, respectively.

**Table 5: Mean Tax-Exclusive Prices for Models Decreasing, Increasing, or Not Changing Price**

| | | Price Decreases Week Ending | | | Price Increases Week Ending | | | No Price Change Week Ending | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 7/28 | 8/4 | 8/11 | 7/28 | 8/4 | 8/11 | 7/28 | 8/4 | 8/11 |
| All States | Mean log Price Change | -0.105 | -0.105 | -0.087 | 0.092 | 0.093 | 0.082 | - | - | - |
| | (s.d.) | (0.1367) | (0.134) | (0.109) | (0.137) | (0.133) | (0.108) | | | |
| | Mean Price$_{t-1}$ ($s) | 898.62 | 867.64 | 891.45 | 822.84 | 839.28 | 787.07 | 982.01 | 965.39 | 961.83 |
| | (s.d.) | (398.32) | (391.74) | (416.89) | (374.30) | (385.29) | (357.88) | (410.79) | (414.74) | (418.55) |
| | Computer Models | 3,119 | 3,296 | 3,066 | 2,493 | 2,435 | 2,678 | 565 | 446 | 433 |
| Non-holiday States | Mean log Price Change | -0.103 | -0.106 | -0.089 | 0.090 | 0.092 | 0.086 | - | - | - |
| | (s.d) | (0.140) | (0.142) | (0.111) | (0.138) | (0.135) | (0.111) | | | |
| | Mean Price$_{t-1}$ ($s) | 902.00 | 870.99 | 903.10 | 828.70 | 844.08 | 783.80 | 985.07 | 969.10 | 970.84 |
| | (s.d.) | (405.78) | (397.39) | (426.81) | (381.02) | (392.88) | (359.12) | (407.81) | (419.89) | (424.22) |
| | Computer Models | 2,502 | 2,558 | 2,401 | 1,974 | 1,979 | 2,141 | 439 | 378 | 373 |
| Tax holiday States | Mean log Price Change | -0.112 | -0.101 | -0.080 | 0.098 | 0.097 | 0.070 | - | - | - |
| | (s.d.) | (0.124) | (0.101) | (0.098) | (0.133) | (0.122) | (0.094) | | | |
| | Mean Price$_{t-1}$ ($s) | 884.95 | 856.03 | 849.36 | 971.34 | 944.73 | 905.79 | 800.57 | 818.44 | 800.12 |
| | | (366.49) | (371.50) | (376.22) | (422.49) | (387.10) | (379.84) | (347.01) | (350.07) | (352.91) |
| | Computer Models | 617 | 738 | 665 | 519 | 456 | 537 | 126 | 68 | 60 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007. Each column entry is for the set of computers whose tax-exclusive price decreased, increased, or did not change from the preceding week. For example, the first column refers to computer models whose tax-exclusive price decreased from the week ending July 21st, 2007 to the week ending July 28th, 2007. Standard deviations are in parentheses.

**Table 6: Control States for Counterfactual Exercise**

| Tax Holiday State | Control State Possibilities |
|---|---|
| Alabama | Kentucky (3), Oklahoma (4), Oregon (5), Wisconsin(8), and Coloardo (9) |
| Georgia | Michigan (1), Ohio (3), Virginia (4), Pennsylvania (5), and Arizona(6) |
| Louisiana | Kentucky (1), Oklahoma (4), Oregon (5), Mississippi (6), and Iowa (7) |
| Massachusetts | Washington (1), Maryland (2), Virginia (3), Minnesota (4), and Wisconsin (5) |
| Missouri | Indiana (2), Wisconsin (3), Arizona (4), Washington (7), and Minnesota (9) |
| New Mexico | Nebraska (1), West Virginia (2), Idaho (3), Maine (4), and Kansas (5) |
| North Carolina | Michigan (2), Ohio (3), Indiana (4), Arizona (5), and Virginia (8) |
| South Carolina | Kentucky (1), Oklahoma (4), Oregon (5), Colorado (6), and Wisconsin (7) |
| Tennessee | Indiana (2), Arizona (3), Wisconsin (4), Kentucky (8), and Washington (9) |

**Notes:** Control states are chosen based on the minimum sum of the squared percent deviations from the tax holiday state based on the following variables: the 2007 unemployment rate, the 2007 population, the median household income in 2006, the percentage of individuals below the poverty rate in 2006, the proportion of the population in 2006 between the ages of 18 and 64, the median age in 2006, the proportion of the population aged 25 and above with a bachelor's degree or greater for the years 2005 through 2007, and the state sales tax rate in 2007. The data come from the U.S. Census Bureau, 2005-2007 American Community Survey and the U.S. Bureau of Labor Statistics. The values in parentheses indicate the state's ranking among all other states and the District of Columbia. A (3) indicates the state had the third lowest sum among the remaining states.

**Table 7: The Effect of Tax Holidays on Computer Purchases**

| | | | | Per 10,000 People | | |
|---|---|---|---|---|---|---|
| State | Quantity Sold | Predicted Quantity | Effect | Quantity Sold | Predicted Quantity | Effect |
| | | | 1-week Impact | | | |
| Alabama | 7,216 | 2,689 | 4,527 | 15.59 | 5.81 | 9.78 |
| Georgia | 21,244 | 6,391 | 14,853 | 22.26 | 6.70 | 15.56 |
| Louisiana | 5,948 | 3,479 | 2,469 | 13.85 | 8.10 | 5.75 |
| Massachusetts | 11,692 | 5,525 | 6,167 | 18.13 | 8.57 | 9.56 |
| Missouri | 10,356 | 3,995 | 6,361 | 17.62 | 6.80 | 10.82 |
| New Mexico | 2,735 | 1,065 | 1,670 | 13.88 | 5.41 | 8.48 |
| North Carolina | 19,039 | 6,329 | 12,710 | 21.01 | 6.98 | 14.03 |
| South Carolina | 8,435 | 3,620 | 4,815 | 19.14 | 8.21 | 10.92 |
| Tennessee | 13,713 | 3,534 | 10,179 | 22.27 | 5.74 | 16.53 |
| | | | 2-week Impact | | | |
| Alabama | 11,621 | 5,429 | 6,192 | 25.11 | 11.73 | 13.38 |
| Georgia | 33,248 | 13,825 | 19,423 | 34.83 | 14.48 | 20.35 |
| Louisiana | | | | | | |
| Massachusetts | 20,881 | 10,946 | 9,935 | 32.37 | 16.97 | 15.40 |
| Missouri | 17,254 | 8,317 | 8,937 | 29.35 | 14.15 | 15.20 |
| New Mexico | 4,625 | 2,117 | 2,508 | 23.48 | 10.75 | 12.73 |
| North Carolina | 30,608 | 13,542 | 17,066 | 33.78 | 14.94 | 18.84 |
| South Carolina | 13,771 | 7,313 | 6,458 | 31.24 | 16.59 | 14.65 |
| Tennessee | 20,910 | 7,324 | 13,586 | 33.96 | 11.90 | 22.07 |
| | | | 30-week Impact | | | |
| Alabama | 81,319 | 72,362 | 8,957 | 175.72 | 156.36 | 19.35 |
| Georgia | 206,242 | 188,035 | 18,207 | 216.08 | 197.00 | 19.08 |
| Louisiana | 97,964 | 93,291 | 4,673 | 228.18 | 217.30 | 10.88 |
| Massachusetts | 160,904 | 146,186 | 14,718 | 249.47 | 226.65 | 22.82 |
| Missouri | 115,249 | 109,387 | 5,862 | 196.05 | 186.08 | 9.97 |
| New Mexico | 35,322 | 30,846 | 4,476 | 179.31 | 156.58 | 22.72 |
| North Carolina | 198,059 | 182,482 | 15,577 | 218.58 | 201.39 | 17.19 |
| South Carolina | 98,302 | 92,974 | 5,328 | 223.02 | 210.94 | 12.09 |
| Tennessee | 110,146 | 95,459 | 14,687 | 178.90 | 155.05 | 23.85 |

**Notes:** The one-week impact columns are for the week ending August 11th in Massachusetts and August 4th in all other states. The two-week impact columns are for the weeks ending August 11th and August 18th in Massachusetts and August 4th and August 11th in all other states. The results are aggregated for desktops and laptops priced between $250 and $1,500. Kentucky serves as the control state for Alabama, Louisiana, and South Carolina; Michigan for Georgia and North Carolina; Indiana for Missouri and Tennessee; Washington for Massachusetts; and Nebraska for New Mexico.

**Table 8**: **Estimates of State Sales Tax Revenue Loss Due to Tax Holidays**

| | Week of Tax Holiday | | | August 2007 | | | 30-week Period | | |
|---|---|---|---|---|---|---|---|---|---|
| State | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. |
| Alabama | 58,745 | 193,323 | -69.61 | 367,269 | 501,848 | -26.82 | 2,170,410 | 2,304,988 | -5.84 |
| Georgia | 11,277 | 598,643 | -98.12 | 738,594 | 1,325,959 | -44.30 | 5,250,404 | 5,837,770 | -10.06 |
| Louisiana | 55 | 179,414 | -99.97 | 329,953 | 511,212 | -35.46 | 2,752,924 | 2,944,683 | -6.51 |
| Massachusetts | 150 | 407,334 | -99.96 | 717,040 | 1,124,224 | -36.22 | 5,311,961 | 5,719,144 | -7.12 |
| Missouri | - | 310,011 | -100 | 465,773 | 775,784 | -39.96 | 3,106,149 | 3,416,160 | -9.07 |
| New Mexico | 13,205 | 96,017 | -86.25 | 188,264 | 271,076 | -30.55 | 1,225,290 | 1,308,102 | -6.33 |
| North Carolina | - | 545,493 | -100 | 743,830 | 1,289,323 | -42.31 | 5,137,388 | 5,682,882 | -9.60 |
| South Carolina | - | 362,013 | -100 | 547,796 | 909,809 | -39.79 | 3,655,804 | 4,017,817 | -9.01 |
| Tennessee | 10,046 | 686,738 | -98.54 | 737,204 | 1,413,896 | -47.86 | 4,794,667 | 5,471,359 | -12.37 |

| | Week(s) of Tax Holiday | | | August 2007 | | | 30-week Period | | |
|---|---|---|---|---|---|---|---|---|---|
| State | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. | Tax Rev. ($s) | Counterfactual Tax Rev. ($s) | % Dif. |
| Alabama | 110,636 | 313,673 | -64.73 | 298,811 | 501,848 | -40.46 | 2,101,951 | 2,304,988 | -8.81 |
| Georgia | 19,872 | 920,390 | -97.84 | 425,441 | 1,325,959 | -96.81 | 4,937,251 | 5,837,770 | -15.43 |
| Louisiana | 55 | 179,414 | -99.97 | 329,953 | 511,212 | -35.46 | 2,752,924 | 2,944,683 | -6.51 |
| Massachusetts | 615 | 735,845 | -99.92 | 388,994 | 1,124,224 | -65.40 | 4,983,915 | 5,719,144 | -12.86 |
| Missouri | - | 510,981 | -100 | 264,803 | 775,784 | -65.87 | 2,905,179 | 3,416,160 | -14.96 |
| New Mexico | 25,071 | 161,626 | -84.49 | 134,521 | 271,076 | -50.38 | 1,171,547 | 1,308,102 | -10.44 |
| North Carolina | - | 863,139 | -100 | 426,184 | 1,289,323 | -66.95 | 4,819,743 | 5,682,882 | -15.19 |
| South Carolina | - | 585,021 | -100 | 324,787 | 909,809 | -64.30 | 3,432,796 | 4,017,817 | -14.56 |
| Tennessee | 19,400 | 1,033,418 | -98.12 | 399,879 | 1,413,896 | -71.72 | 4,457,341 | 5,471,359 | -18.53 |

**Notes:** The counterfactual tax revenue is computed by multiplying the state sales tax rate by the price and quantity of computers sold in the state during the period in question. In the top panel, the tax holiday week is the week ending August 11th in Massachusetts and the week ending August 4th in all other states. In the bottom panel, the tax holiday weeks are the week ending August 4th in Louisiana, the weeks ending August 11th and August 18th in Massachusetts, and the weeks ending August 4th and August 11th in all other states.

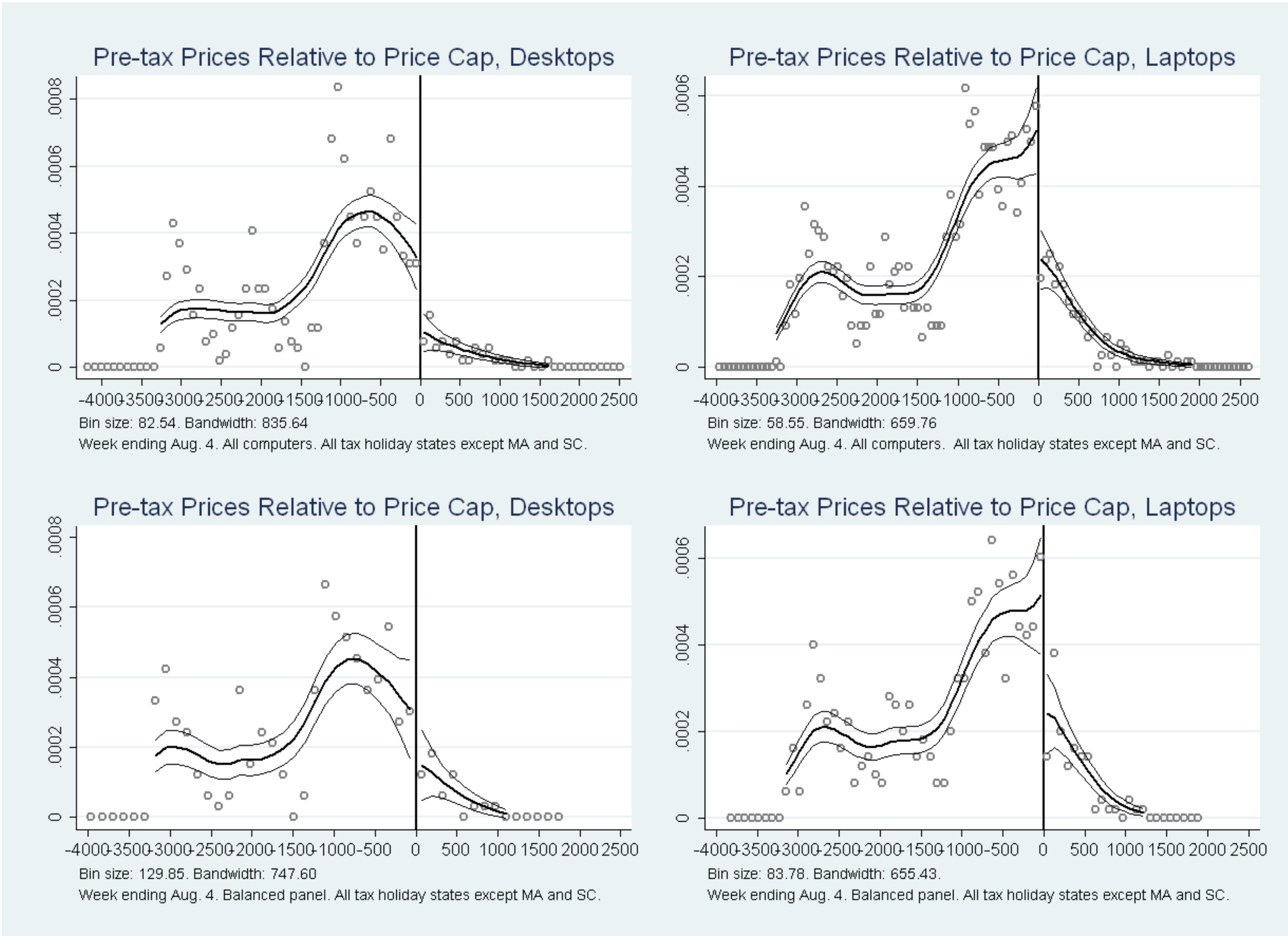


**Figure 1**: **By Computer Type, Price Densities Relative to Price Cap**

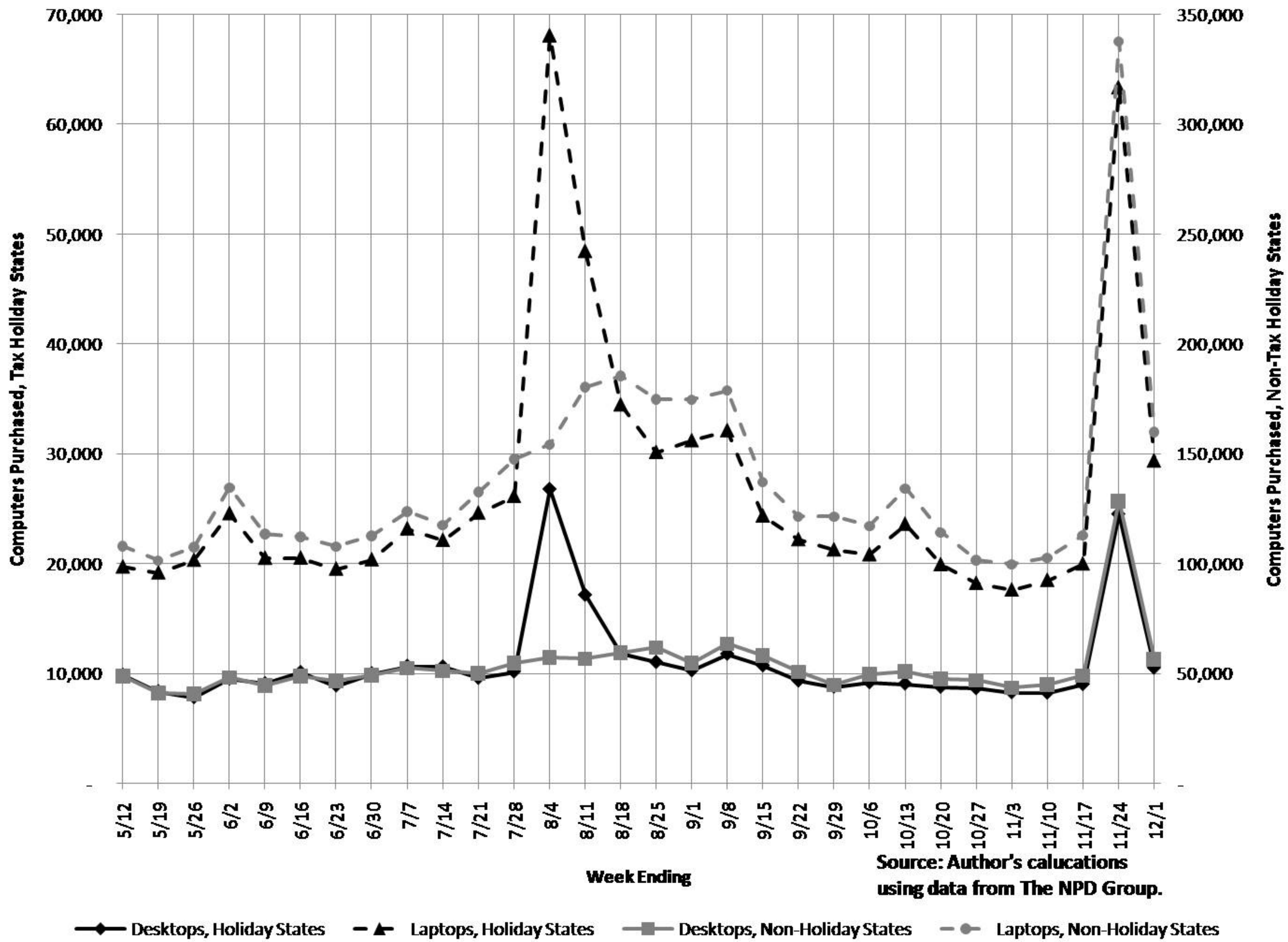


Figure 2: By Computer Type and State, Computers Purchased

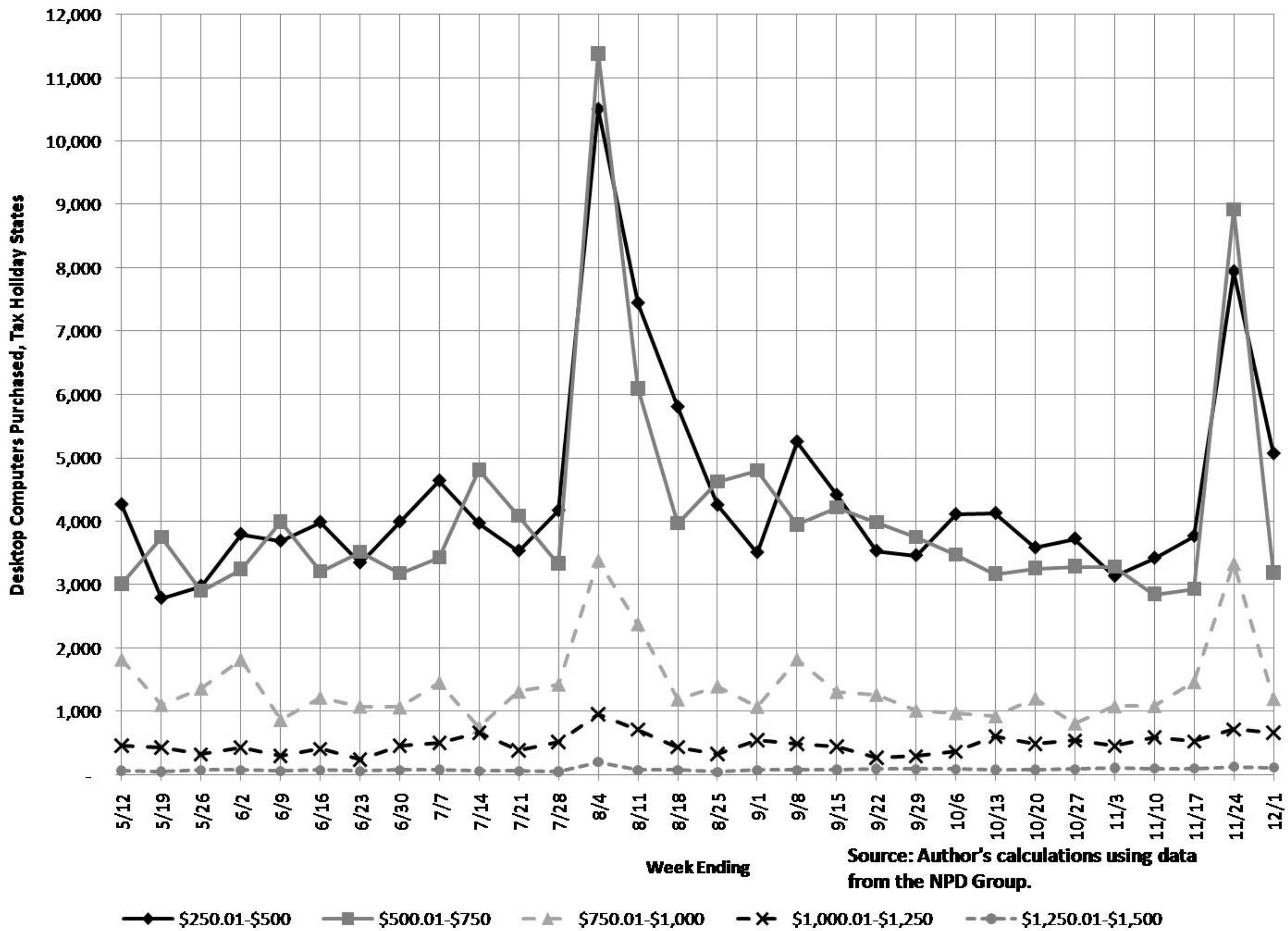


Figure 3: By Price Group, Desktops Purchased in Tax Holiday States

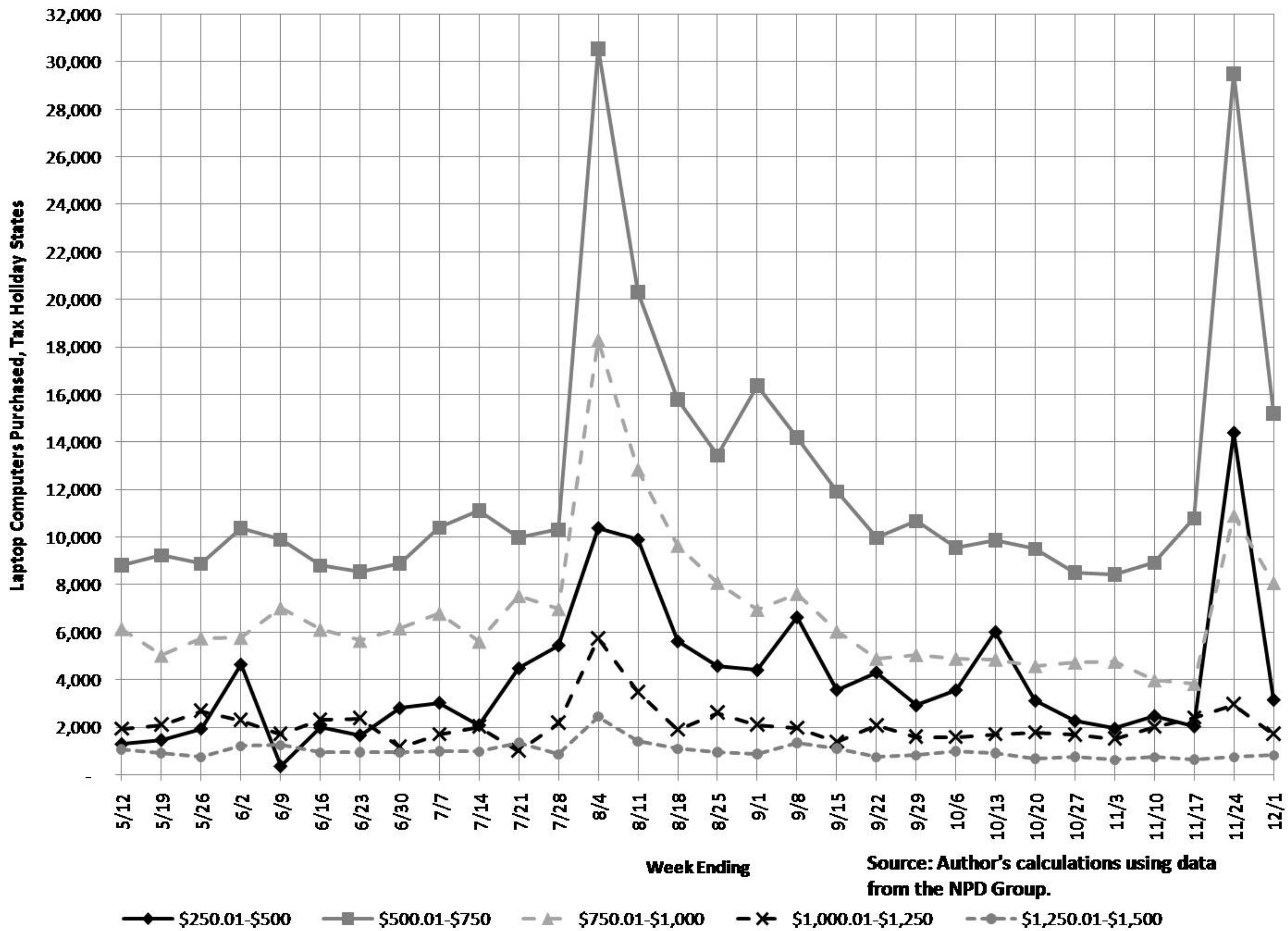


Figure 4: By Price Group, Laptops Purchased in Tax Holiday States

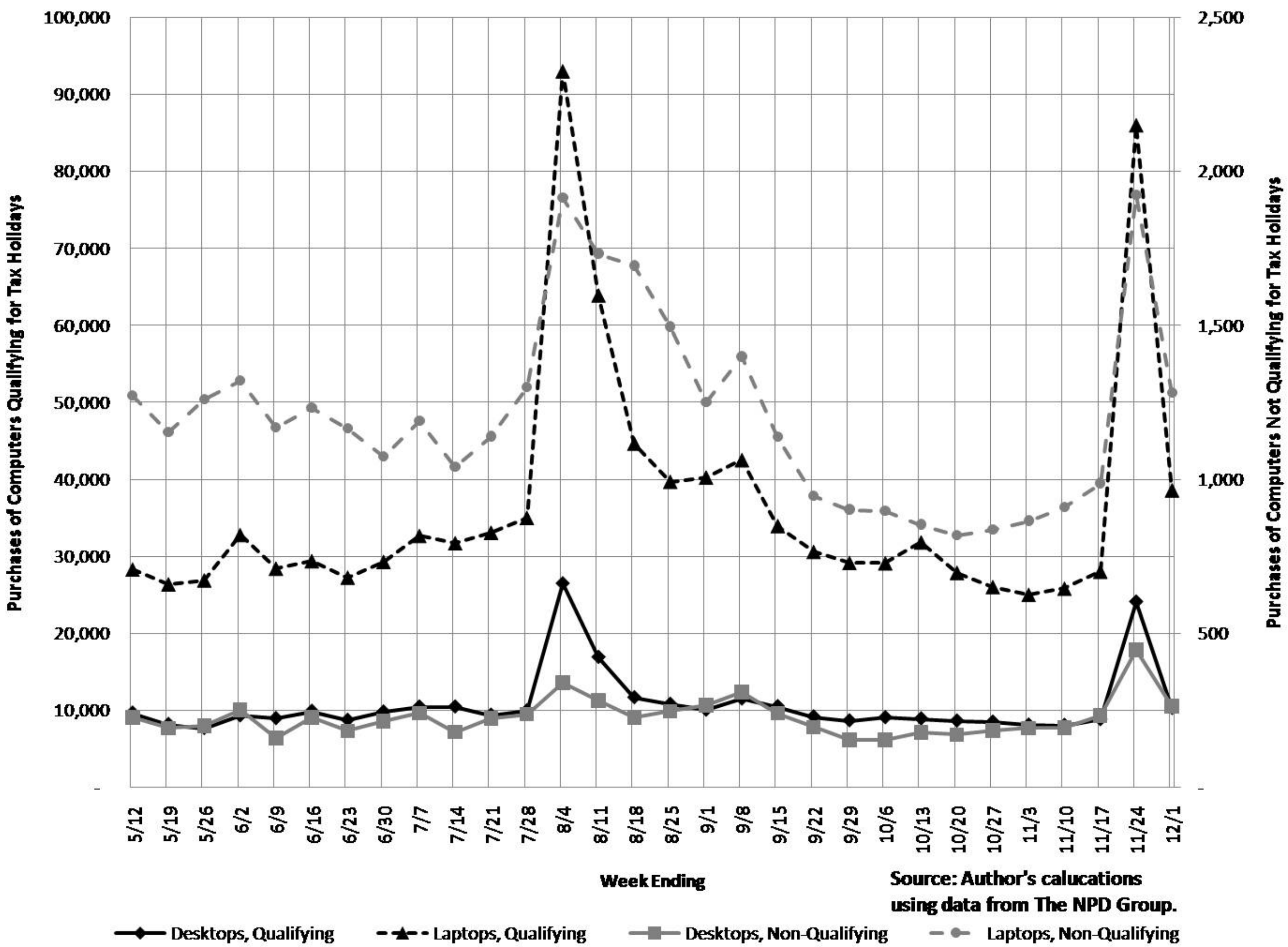


Figure 5: Qualifying vs. Non-qualifying Computer Purchases in Tax Holiday States

# A Appendix

In this appendix, I replicate Tables 3 and 4. The tax holidays in eight states include a Sunday. As such, they bleed over into a second reporting week in the data. For the holidays that last for two reporting weeks, roughly 3/5ths to 2/3rds of the computers purchased were purchased in the first of the two reporting weeks. In the tables below, I define the tax holiday to occur the week ending August 4th in Louisiana, the weeks ending August 11th and August 18th in Massachusetts, and the weeks ending August 4th and August 11th for the remaining states in Table 1.

The coefficients below are often greater than they are in Tables 3 and 4. I offer a possible explanation for the difference presently. If retailers had inventories of computers in excess of their optimal levels after the tax holiday and then reduced the prices of those computers immediately after the holiday ended (during the second reporting week of the holiday) so as to reduce inventory levels, this will tend to increase the coefficient estimates relative to what they would be when the tax holiday is defined for only one reporting week.

**Table A.1: Effect of Sales Tax Holidays on Pre-tax Prices**

| Dependent variable: $ln$(pre-tax price) | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Sales Tax Rate | 0.1264** | 0.2159 | 0.0931 | 0.1296* | 0.3308** | 0.0484 |
| | (0.0620) | (0.1327) | (0.0673) | (0.0716) | (0.1596) | (0.0757) |
| $r^2$ | 0.0341 | 0.0358 | 0.0365 | | | |
| $F$ | 146.06 | 58.49 | 118.68 | | | |
| Wald $\chi^2$ | | | | 727.06 | 291.05 | 592.12 |
| Computers | All | Desktops | Laptops | All | Desktops | Laptops |
| Computer Models | 6,177 | 1,935 | 4,242 | 6,177 | 1,935 | 4,242 |
| Models in Holiday States | 1,262 | 377 | 885 | 1,262 | 377 | 885 |
| Qualifying Models | 1,171 | 358 | 813 | 1,171 | 358 | 813 |
| Observations | 30,885 | 9,675 | 21,210 | 24,708 | 7,740 | 16,968 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007. Columns I through III have computer model-state fixed effects and are estimated using the within estimator. Columns IV through VI are estimated using first differences for weeks endings July 28th, 2007 through August 18th, 2007. All specifications have week fixed effects. Robust standard errors, in parentheses, are clustered at the computer model-state level. A *, **, and *** represents statistical significance at the 10-, 5-, and 1-percent level, respectively.

**Table A.2: By Price Group, Effect of Sales Tax Holidays on Pre-tax Prices**

| Dependent variable: $ln$(pre-tax price) | \$250.01-\$500 | \$500.01-\$750 | \$750.01-\$1,000 | \$1,000.01-\$1,250 | \$1,250.01-\$1,500 | \$1,500.01-\$1,750 | \$1,750.01-\$2,000 |
|---|---|---|---|---|---|---|---|
| | | | | **All Computers** | | | |
| Sales Tax Rate | 0.1812 | 0.0402 | 0.1886** | 0.1283 | -0.0308 | -0.1013 | 0.0975 |
| | (0.2015) | (0.0847) | (0.0782) | (0.1047) | (0.0937) | (0.0709) | (0.2568) |
| Computer Models | 605 | 1,087 | 945 | 252 | 242 | 41 | 56 |
| Qualifying Models | 112 | 239 | 175 | 51 | 37 | 5 | 7 |
| Observations | 3,025 | 5,435 | 4,725 | 1,260 | 1,210 | 205 | 280 |
| | | | | **Desktop Computers** | | | |
| Sales Tax Rate | 0.3964* | 0.0726 | 0.2800** | 0.2241*** | -1.0280 | | |
| | (0.2379) | (0.1009) | (0.1111) | (0.0828) | (0.6187) | | |
| Computer Models | 449 | 456 | 257 | 48 | 18 | 14 | |
| Qualifying Models | 81 | 98 | 42 | 7 | 3 | 1 | |
| Observations | 2,245 | 2,280 | 1,285 | 240 | 90 | 70 | |
| | | | | **Laptop Computers** | | | |
| Sales Tax Rate | -0.4297 | 0.0202 | 0.1600* | 0.0837 | 0.0221 | -0.1940** | 0.0975 |
| | (0.3739) | (0.1203) | (0.0964) | (0.1212) | (0.0923) | (0.0868) | (0.2568) |
| Computer Models | 156 | 631 | 688 | 204 | 224 | 27 | 56 |
| Qualifying Models | 31 | 141 | 133 | 44 | 34 | 4 | 7 |
| Observations | 780 | 3,155 | 3,440 | 1,020 | 1,120 | 135 | 280 |

**Notes:** The data come from the NPD Group. The sample is a balanced panel of computers observed each week from the week ending July 21st, 2007 through the week ending August 18th, 2007. Each regression is estimated using the fixed effects within estimator. All specifications have computer model-state fixed effects and week fixed effects. Robust standard errors, in parentheses, are clustered at the computer model-state level. A *, **, and *** represents statistical significance at the 10-, 5-, and 1-percent level, respectively.

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