Does the Elasticity of the Sales Tax Base Depend on Enforcement? Evidence from U.S. states' Voluntary Collection Agreements *

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Abstract

Sales taxes are an important source of revenue for U.S. states. A key parameter that determines the marginal excess burden associated with this tax is the elasticity of the consumption tax base with respect to the tax rate. We study empirically how an important development in U.S. sales tax policy - the requirement of online retailers to remit the sales tax instead of the consumer - impacts this elasticity using quasi-experimental variation from the staggered state-wise introduction of Voluntary Collection Agreements (VCAs). Using detailed purchase data from the Nielsen Consumer Panel and monthly, zip-code level information on local sales tax rates, we find that consumers reduce their online expenditure after the introduction of VCAs, consistent with an increase in compliance with sales taxes on online sales and suggesting that consumers took note of the tax change. We test whether consumers are less responsive to sales tax rate changes and more responsive to sales tax holidays as a results. On average, we do not find evidence of an impact of the remittance rule change on the elasticity of the tax base with respect to the tax rate.

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1 Introduction

In standard economic models, demand for a taxed good does not depend on which side of the market remits the tax. However, recent theoretical and empirical literature casts doubt on this equivalence; for example, if the tax is less salient than the tax exclusive price at the point of decision (Chetty (2009)), or if the tax can be mitigated by avoidance or evasion behavior in a way that a price increase could not (Slemrod and Yitzhaki (1996)). In the same vein, Slemrod and Kopczuk (2002) argue that the elasticity of taxable income is not a structural parameter. Rather, response is conditional on various parameters of the tax system such as enforcement. In this paper, we explore whether the behavioral response of consumers to a consumption tax is affected by whether consumers have the responsibility to remit. We do so in the context of U.S. states' voluntary tax collection agreements (VCAs), which are also known as the "Amazon laws". The VCAs constitute a structural change in remittance assignment from consumers to retailers for online transactions, which substantially increased compliance with state sales taxes for online purchases. If consumers become less price-elastic as a result of this enforcement measure, states can potentially raise more revenue while lowering excess burden. This question has attained new relevance with the recent Supreme Court decision on *South Dakota v. Wayfair*, which allows states to require remote sellers to remit sales taxes due on purchases by their residents.

Existing literature has established that consumers purchase online in part to evade sales taxes. Goolsbee (2001) was the first to suggest this channel of evasion. Einav et al. (2014) find evidence of consumption tax evasion in consumers' online shopping response to taxes on the Ebay marketplace. Baker et al. (2017) show that the internet is used as a means of evading the sales tax on a broader set of consumption goods, not just those subject to high sales and excise taxes. There is also evidence that the potential for evasion through online purchasing affects the price elasticity of taxed sales. Goolsbee et al. (2010) use data on state-level smoking rates and internet penetration from 1980 to 2005 to show that the price elasticity of taxed cigarette sales rose as ability to purchase cigarettes online increased. Consumer's online shopping response to the VCA would therefore shed light on whether this change in elasticity was because of the remittance structure and the associated ease of evasion, and to what extent the elasticity of a broader consumption tax base as opposed to particular goods like cigarettes is affected by remittance structure and tax compliance. One recent paper shows that the VCA agreements had a measurable impact on consumers' shopping behavior on Amazon. Baugh et al. (2018) show that this increase in tax on online purchases was salient to consumers, and that they reduced their Amazon purchases by about

9 %. We add to this evidence by examining consumer response in data that is a representative sample of the U.S population, and of online consumption at retailers other than Amazon. Furthermore, using detailed purchase data, we are able to separate the response in price and quantity and examine the effect of VCAs on the elasticity of the tax base.

Because the VCAs were negotiated separately by states, they were enacted and implemented at different times by different states. We exploit this temporal and geographic variation to test whether monthly online expenditure of households in states that enacted a VCA between 2010 and 2014 decreases following the VCA adoption. To understand the likely effects of VCAs on consumption elasticity, we first build a simple theoretical framework to predict what might happen to the elasticity of the effective tax base when tax-exclusive prices remain fixed and consumers choose to either purchase a commodity online or at a brick-and-mortar store. Next, we test the underlying assumptions and predictions of our framework using a large panel of household purchases from the Nielsen Consumer Survey. The rich information in the Nielsen data, which includes unique product identifiers, allows us to observe the elasticity of consumers' purchases with respect to tax changes at both online and brick-and-mortar retailers. Because there are very few instances of tax increases, particularly at the state-level following the VCAs (and possibly because of the revenue increase from the VCA), we test our hypotheses using sales tax holidays. We would expect that sales tax holidays are more important to consumers after the VCA when tax evasion through online purchasing is no longer feasible.

We show that consumers reduce their online taxable expenditure in response to a VCA, while maintaining consumption of tax-exempt items. Next, we decompose this reduction in total expenditure into a change in reported tax-exclusive prices of online goods and a change in quantity demanded by consumers. The decrease in tax-exclusive expenditure online comes from consumers who continue to purchase online, but switch to cheaper varieties and cheaper commodities; and from consumers who simply stop shopping online - an extensive margin response. Some households switch from purchasing the same products online to brick-and-mortar stores. Because online retailers typically price their goods for sale anywhere in the United States and the VCAs are implemented by state, it is reasonable that producers do not change their tax-exclusive price in response to a VCA and that any effective tax increase is passed through to the consumer. Finally, we show that the VCA did not significantly affect the tax elasticity of the consumption tax base.

2 Context

Forty-five U.S. states levy sales taxes on goods purchased for consumption within their physical borders, and require sellers in these transactions to assess and remit the tax. To mitigate the incentive to purchase products in low-tax jurisdictions, states with general sales taxes often levy parallel "use taxes" on goods consumed in their states by their residents, but purchased outside the state or online.

Use tax provisions require residents to declare and self-assess the value of goods purchased elsewhere that would have been subject to sales tax if purchased in-state, and then to remit the equivalent sales tax amount to the state tax authority[1]. In theory, this minimizes revenue loss and distortion by equalizing after-tax prices. However, in practice, very few residents remit use taxes from either purchases made online, or those made in other states. Often, states require use-tax liability to be reported and remitted at the time of filing state income tax returns and these reports give us some indication of use-tax compliance. In 2012, the percent of income tax returns reporting use tax (i.e. reporting tax liability on online purchases) ranged from 0.2 percent in Mississippi to 10 percent in Maine[2].

2.1 Collecting Use Tax on Online Sales

States may impose a sales or use tax on purchases made by their residents, even if the retailer is out of state[3]. However, the state cannot legally impel the retailer to remit said tax unless there is a constitutionally sufficient relationship (a "nexus") between the retailer and the state[4].

As internet sales have grown in volume, states have used a variety of strategies to recoup uncollected use taxes without running afoul of the constitution's nexus provision. Broadly, state actions can be divided into two categories; legislation, which tried to expand the

[1]States differ in their procedure for remitting use taxes. Several states require residents to report and remit use taxes annually, frequently via state income tax return. However, Vermont requires residents to report and remit each month. Additionally, most states allow residents to deduct any sales tax that was paid in the source state.

[2]See report published by Maine's tax authority: <http://www.house.leg.state.mn.us/hrd/pubs/usetax.pdf>

[3]The nexus requirement arises from two provisions in the U.S. Constitution: the Due Process Clause and the Interstate Commerce Clause. In the seminal case on this issue, Quill v. North Dakota (1992), the Supreme court held that a nexus exists only if the online retailer has a physical presence in the state (such as a store, office, warehouse or employees) or, if the retailer has purposefully solicited the state's residents.

[4]In addition to remittance, a state cannot impose any kind of "tax duty" (such as, requiring the retailer to report sales information to the state tax authority.)

definition of nexus to (large) online retailers, and voluntary collection agreements (VCAs), essentially agreements between a single retailer and the tax authority in which the retailer agreed to remit future sales tax in return for some benefit. Although collectively referred to in popular parlance as "Amazon Laws", this term is a misnomer; in most cases, states signed VCAs with Amazon and other large retailers either before or in conjunction with legislation.

Legislation, pioneered by New York and referred to as "click-through nexus," imposes a duty to remit sales taxes on any retailer with in-state affiliate or associate that directs residents to the retailer's website[5]. This extended the duty to remit to large retailers such as Amazon or BackCountry, unless they dropped all affiliated sellers in the state that sold through their platform. In several states, Amazon initially dropped affiliates to avoid nexus (CO, NC, TN), but in large states with hundreds of affiliates, Amazon acknowledged nexus and began remitting. In our study period, four states (California, New Jersey, Pennsylvania and Virginia) passed such legislation.

Fourteen states announced VCAs with Amazon during our study period. In general terms, a VCA is a non-standard contract between a business and a state or local tax authority in which the business "voluntarily" agrees to assess and remit taxes going forward, even if not legally required to do so. In the context of online sales, large retailers signed these agreements in exchange for some concession by the state, such as release from back taxes, or a commitment by the state not to require the retailer to disclose individual buyer data. For example, in July 2012, Amazon signed a VCA with the state of Texas promising to remit future taxes and to increase capital investment in the state. In exchange, the Texas State Comptroller agreed not to pursue collection of the estimated $269 million in sales tax that Amazon had not collected between 2005-2009.

Our design relies on variation in state sales tax rate, variation in VCA adoption (See Figure 1), and variation in the tax base to which the VCA applies (i.e. exemptions). Several states have also enacted temporary exemptions "sales tax holidays" for specific product categories (e.g. school supplies), which we exploit for further variation.

Sales taxes in the United States are set by states and local option sales taxes at the county or city level supplement these standard rates. Sales tax exemptions can vary by state. In addition, some goods are taxed at a special discounted or higher rate. Some goods like

[5] The language of the 2008 New York statute creates a rebuttable presumption of nexus "if the seller enters into an agreement with a resident of this state under which the resident, for a commission or other consideration, directly or indirectly refers potential customers, whether by a link on the Internet website or otherwise, to the seller." N.Y. Tax Law

alcohol and tobacco are also subject to additional excise taxes. We focus on goods taxed at the standard sales tax rate and exempt goods only for now, excluding items taxed at a special rate.

3 Data

Our analysis uses detailed consumption data from 2010 to 2014 from the Nielsen Consumer Panel, which is a nationally and regionally representative, stratified longitudinal panel of between 40,000-60,000 households[6]. We focus on the households observed between 2010 and 2014, which is the period when most VCA agreements were signed. Households self-report their purchasing behavior to Nielsen through in-home scanners for a set of "Nielsen-tracked" products, which cover goods that represent about 30 percent of household consumption (as compared to total consumption in BLS statistics), including purchases made online. Households record their purchases from each shopping trip, which includes information on total amount spent, retailer type, payment type, value of each item purchased and quantity of each item purchased. Items are identified by a unique product code (UPC) with details on brand variation, size, multi-packs, etc. This detailed product and quantity information allows us to more accurately measure the impact of the VCA on consumer purchase behavior than existing studies because we can separate taxable goods from exempt. We also use this information to decompose the expenditure response into that on price and quantity demanded, showing the pass-through of the VCA.

Because the Nielsen-tracked product groups capture approximately 30 percent of total household consumption, our estimates of consumption elasticity with respect to the tax rate mainly reflect the purchase elasticity of this subset of household consumption rather than total household consumption. Notably, Nielsen emphasizes fast-moving consumer goods over durables like washing machines or cars. Therefore, our price elasticity estimates are likely to be smaller than the elasticity of total consumption since durables consumption is generally more elastic.

For tax rate changes, we use data on monthly sales tax rates at the state, county, and local (school district, etc.) level purchased from zip2tax. Table 1 shows the number of sales tax rate changes in our data at each administrative level. Most changes over this time period occur at the city level. One concern might be that the introduction of the VCAs changed

[6]The sample was increased from 40,000 to 60,000 in 2007.

how and when states change sales tax rates in a way that affects the elasticity estimate. For example, states may become less likely to increase rates because the VCAs raised revenue and therefore more likely to only increase rates when the local economy is faring poorly, which would lead to a higher estimated tax elasticity. We test for this policy endogeneity directly and find that there is only a small decrease in the probability that sales tax rates change after the VCA and no difference in the average magnitude of the change when they do. Table 2 shows that sales tax rates at the zip-code level change in about 1 percent of the zip-code months in our sample and that the average change is less than 0.2 percentage points when rates do change.

Using the Nielsen Consumer Panel, we construct a measure of total tax-exclusive expenditure at each household. Each shopping trip a household makes is assigned a retailer code and each retailer is assigned a "channel type". One of the channel categories is "Online Retailer", which allows us to distinguish online shopping trips[7]. We construct a measure of total monthly total online expenditure for each household by adding the reported item-level expenditure, which are exclusive of tax. Similarly, we measure total online taxable expenditure and exempt expenditure separately by adding up item-level expenditure of items within each category. To study the pass-through of the VCA, we measure UPC-level unit prices as the total price after any coupons divided by the quantity recorded for each purchase.

Finally, we turn to whether the reduction in online expenditure as a result of the VCA agreements, also translates to lower sensitivity of the effective tax base to sales tax changes. Assuming that use tax compliance prior to the VCA is zero and 100 percent afterward, we define the "effective tax base" as brick-and-mortar expenditure prior to the VCA and the sum of brick-and-mortar expenditure and online expenditure after the VCA. This definition is intended to capture the expenditure that is most likely reported to the tax authority.

4 Model

In this section, we present a model of how VCA adoption affects online and offline consumption elasticities and the elasticity of the effective sales tax base.

We assume consumers' choice set consists of four types of goods: taxable online (x_o), taxable

[7] Although the identity of individual retailers is unknown, we can identify "large online retailers" through the volume, diversity and ubiquity of sales recorded on Nielsen. One retailer code is a generic "Other" category but we believe we can identify this retailer code.

offline (brick and mortar) (x_b) goods; tax-exempt online (e_o) and tax-exempt offline (e_b) goods. Taxable goods are subject to an excise tax where q_j is the after-tax unit price of good j and the before-tax price is denoted by p_j.

For the tax-exempt goods before and after-tax prices are always equal, i.e., $q_{e^k} = p_{e^k}, k = o, b$. Whereas, after-tax price of taxable online goods differ before and after the VCA adoption; prior to the VCA, online sales were effectively treated as tax-exempt, i.e. $q_{x_o} = p_{x_o}$; after the VCA, they were subject to sales tax, i.e. $q_{x_o} = p_{x_o}(1+t)$. On the other hand, an ad valorem tax of t is always effective for taxable offline goods, i.e., $q_{x_b} = p_{x_b}(1+t)$. We also assume that the tax-exclusive prices are fixed and exogenously determined, i.e. perfectly elastic supply curves, an assumption we will justify in the next section.

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We first present an identity for tax elasticity of demand for taxable goods and then move to the consumer's problem. We conclude with three predictions that we can take to the data.

4.1 Tax Elasticity of Demand for Taxable Goods

We can calculate the tax elasticity of demand for taxable goods, given the setting- pre-VCA and post-VCA.

Total demand for taxable goods, D_x, is the sum of demand for taxable online goods, D_{x_o}, and taxable offline goods, D_{x_b}. So, the tax elasticity of demand for taxable goods, where t denotes the tax rate, is:

$$\begin{aligned} \epsilon_{x,t} &= \frac{\partial D_x}{\partial t}\frac{t}{D_x} = (\frac{\partial D_{x_o}}{\partial t} + \frac{\partial D_{x_b}}{\partial t})\frac{t}{D_x} = \frac{\epsilon_{x^0,t} D_{x_o} + \epsilon_{x_b,t} D_{x_b}}{D_x} \\ &= \epsilon_{x^0,t}\theta + \epsilon_{x_b,t}(1-\theta) \end{aligned} \tag{1}$$

Where $\theta = \frac{D_{x_o}}{D_x}$ denotes the online demand for the product as a share of the total demand. The smaller the θ is, the closer tax elasticity of total demand is to tax elasticity of demand for offline products. θ is also directly affected by the tax rate, whether the VCA is in place,

the relative price of the good online and offline, as well as consumers' relative preference for online and offline purchasing. We present a simple model below that illustrates how θ, $\epsilon_{x_o,t}$, and $\epsilon_{x_b,t}$ might change as a result of the VCA.

4.2 Consumer's Problem

We use a nested CES utility to represent consumer's preferences. Using a nested model rather than a regular CES model allows us to have a different elasticity of substitution within goods (online and offline) and across goods (taxable, exempt). However, we assume that the elasticity of substitution within goods is the same across goods. In other words, the elasticity of substitution between online and offline goods, given a type of good, i.e. taxable or tax-exempt, is the same.

$$X(x_o, x_b) = (\psi {x_o}^{\gamma} + (1-\psi){x_b}^{\gamma})^{\frac{1}{\gamma}} \tag{2}$$

$$E(e_o, e_b) = (\psi {e_o}^{\gamma} + (1-\psi){e_b}^{\gamma})^{\frac{1}{\gamma}} \tag{3}$$

$$U(x_o, x_b, e_o, e_b) = ((1-\alpha)E\left(e_o, e_b\right)^{\rho} + \alpha X\left(x_o, x_b\right)^{\rho})^{\frac{1}{\rho}} \tag{4}$$

Then the consumer problem can be stated as:

$$\max_{x_o,x_b,e_o,e_b} U(x_o, x_b, e_o, e_b) = \left(\alpha\left(\left(\psi\left(x_b\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} + (1-\psi){x_b}^{\gamma}\right)^{\frac{1}{\gamma}}\right)^{\rho}$$
$$+ (1-\alpha)\left(\left(\psi\left(e_b\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} + (1-\psi){e_b}^{\gamma}\right)^{\frac{1}{\gamma}}\right)^{\rho\frac{1}{\rho}}$$

such that

$$q_{x_o}x_o + q_{x_b}x_b + q_{e_o}e_o + q_{e_b}e_b \leq I. \tag{5}$$

Where x_o and x_b represent composite taxable online and brick-and-mortar goods, respectively and e_o and e_b represent composite tax-exempt online and brick-and-mortar goods. I denotes the income and q_j is the after-tax unit price of good j and the before-tax price is denoted by p_j^i.

A simplifying assumption we are making is that offline and online versions of the taxable and exempt goods are substitutes. This should hold generally -any individual consumer is

not likely to purchase the same good both online and offline.

We can do sequential maximization where we can define x_o and e_o in terms of x_b and e_b respectively.

$$\begin{aligned} x_o &= x_b \left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi} \right)^{\frac{1}{\gamma-1}} \\ e_o &= e_b \left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi} \right)^{\frac{1}{\gamma-1}} \end{aligned} \tag{6}$$

Substituting these expressions into the utility function and the budget constraint will produce the following reduced problem.

$$\begin{aligned} &U(x_b, e_b) = \left(\alpha \left(\left(\psi \left(x_b \left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi} \right)^{\frac{1}{\gamma-1}} \right)^{\gamma} + (1-\psi){x_b}^{\gamma} \right)^{\frac{1}{\gamma}} \right)^{\rho} \right. \\ &\left. + (1-\alpha) \left(\left(\psi \left(e_b \left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi} \right)^{\frac{1}{\gamma-1}} \right)^{\gamma} + (1-\psi){e_b}^{\gamma} \right)^{\frac{1}{\gamma}} \right)^{\rho} \right)^{\frac{1}{\rho}} \\ &\text{such that} \\ &x_b \left(q_{x_o} \left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi} \right)^{\frac{1}{\gamma-1}} + q_{x_b} \right) + e_b \left(q_{e_o} \left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi} \right)^{\frac{1}{\gamma-1}} + q_{e_b} \right) \leq I. \end{aligned} \tag{7}$$

To simplify the problem, define the following constants

$$\begin{aligned} s_{x_b} &= \left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi} \right)^{\frac{1}{\gamma-1}} \\ s_{e_b} &= \left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi} \right)^{\frac{1}{\gamma-1}} \\ z_{e_b} &= \left(\psi \left(\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi} \right)^{\frac{1}{\gamma-1}} \right)^{\gamma} - \psi + 1 \right) {s_{x_b}}^{\frac{1}{\gamma}} \\ z_{e_b} &= \left(\psi \left(\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi} \right)^{\frac{1}{\gamma-1}} \right)^{\gamma} - \psi + 1 \right) {s_{e_b}}^{\frac{1}{\gamma}} \end{aligned} \tag{8}$$

And finally define new prices

$$\begin{aligned} r_{x_b} &= q_{x_o} s_{x_b} + q_{x_b} \\ r_{e_b} &= q_{e_o} s_{e_b} + q_{e_b} \end{aligned} \tag{9}$$

The consumer problem can be stated in the simplified CES form

$$\begin{aligned} &U(x_b, e_b) = \left(\alpha \left(x_b s_{x_b}\right)^{\rho} + (1-\alpha)\left(e_b z_{e_b}\right)^{\rho}\right)^{\frac{1}{\rho}} \\ &\text{such that} \\ &x_b r_{x_b} + e_b r_{e_b} \leq I. \end{aligned} \tag{10}$$

Solving for x_b and e_b and substituting them into previously defined x_o and e_o provides us with the following Marshallian demand functions:

$$\begin{aligned} x_o &= \frac{s_{x_b} I \left(\frac{\alpha}{r_{x_b}}\right)^{\sigma}}{s_{x_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\ x_b &= \frac{I \left(\frac{\alpha}{r_{x_b}}\right)^{\sigma}}{s_{x_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\ e_o &= \frac{s_{e_b} I \left(\frac{1-\alpha}{r_{e_b}}\right)^{\sigma}}{z_{e_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\ e_b &= \frac{I \left(\frac{1-\alpha}{r_{e_b}}\right)^{\sigma}}{z_{e_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \end{aligned} \tag{11}$$

Where $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution between the taxable and tax-exempt goods.

4.3 Predictions

Comparative statistics yield three testable predictions relevant to the effect of the policy on consumption elasticities:

Proposition 1. *If the VCA increases sales tax compliance for online purchases, the tax elasticity of online taxable goods changes sign and becomes negative.*

Proof. Using the Marshallian demand functions we can calculate the tax elasticity of taxable goods before and after the VCA. Let $\epsilon^{pre}_{x_o,t}, \epsilon^{post}_{x_o,t}$ denote elasticity of taxable online goods before and after respectively.

$$\epsilon^{pre}_{x_o,t} = -\frac{t}{1+t}\Big(\frac{tz_{x_b}^{-\gamma}(r_{x_b}\alpha^\sigma r^\sigma_{e_b}\left(z^\gamma_{x_b}\left(r_{x_b}-\gamma p_{x_b}(t+1)\right)+r_{x_b}(\psi-1)\right)}{(1-\gamma)r_{x_b}\left(r_{x_b}\alpha^\sigma r^\sigma_{e_b}+r_{e_b}(1-\alpha)^\sigma r^\sigma_{x_b}\right)} + \frac{r_{e_b}(1-\alpha)^\sigma r^\sigma_{x_b}\left(\sigma z^\gamma_{x_b}\left(r_{x_b}-\gamma p_{x_b}(t+1)\right)+r_{x_b}(\psi-1)\right))}{(1-\gamma)r_{x_b}\left(r_{x_b}\alpha^\sigma r^\sigma_{e_b}+r_{e_b}(1-\alpha)^\sigma r^\sigma_{x_b}\right)}\Big) > 0 \tag{12}$$

Notice that the denominator of the second term is always positive. The numerator can be positive or negative depending on the level of substitution between online and brick and mortar goods. However because online and offline goods are substitutes, the pre-VCA tax elasticity of taxable online goods is positive.

Now consider the after VCA tax elasticity of x_o where $q_{x^0} = p_{x_o}(1+t)$

$$\epsilon^{post}_{x_o,t} = -\frac{t}{1+t}\frac{\alpha^\sigma r^{1-\sigma}_{x_b}+\sigma(1-\alpha)^\sigma r^{1-\sigma}_{e_b}}{\alpha^\sigma r^{1-\sigma}_{x_b}+(1-\alpha)^\sigma r^{1-\sigma}_{e_b}} < 0 \tag{13}$$

□

Proposition 2. *Tax elasticity of brick and mortar taxable goods is negative before and after the VCA but becomes smaller in magnitude post-VCA*

Proof. Similar to the taxable online goods case, let $\epsilon^{pre}_{x_b,t}, \epsilon^{post}_{x_b,t}$ denote tax elasticity of taxable brick and mortar goods before and after respectively.

Prior to VCA, tax elasticity is as follows:

$$\epsilon^{pre}_{x_b,t} = -\frac{t}{(1+t)}\Big(\frac{z_{x_b}^{-\gamma}\left(\left(r_{x_b}\alpha^\sigma r^\sigma_{e_b}+r_{e_b}\sigma(1-\alpha)^\sigma r^\sigma_{x_b}\right)\left(-\gamma p_{x_b}(t+1)+r_{x_b}\right)+\psi s^\gamma_{x_b}\left(r_{x_b}\alpha^\sigma r^\sigma_{e_b}+r_{e_b}(1-\alpha)^\sigma r^\sigma_{x_b}\right)\right)}{(1-\gamma)r_{x_b}\left(r_{x_b}\alpha^\sigma r^\sigma_{e_b}+r_{e_b}(1-\alpha)^\sigma r^\sigma_{x_b}\right)} \tag{14}$$

After the VCA, a change in the tax rate does not change the relative price of online and offline products, and so it does not affect the share of online demand. The demand elasticity for online goods is the same as that of offline goods.

$$\epsilon^{post}_{x_b,t} = \epsilon^{post}_{x_o,t} = -\frac{t}{1+t}\frac{\alpha^\sigma r^{1-\sigma}_{x_b} + \sigma(1-\alpha)^\sigma r^{1-\sigma}_{e_b}}{\alpha^\sigma r^{1-\sigma}_{x_b} + (1-\alpha)^\sigma r^{1-\sigma}_{e_b}} < 0 \tag{15}$$

The first expression is smaller in magnitude than the second expression. This is in accord with standard models: $\epsilon_{(x_b,t)}$ is generally negative prior to the VCA since an increase in the local sales tax rate would induce individuals to switch to purchasing online, or to demand less offline.

After the implementation of the VCA, $\epsilon_{(x_o,t)}$, should become negative since an increase in the tax rate would also increase the relative after-tax price of online goods. $\epsilon_(x_b, t)$ will become smaller in magnitude as individuals will no longer switch from purchasing offline to online. How these changes in demand elasticity for online and offline products affects overall elasticity will depend on the relative importance of the online and offline demand for the product as well as the magnitude of the change in elasticity.

□

Proposition 3. *The elasticity of the effective tax base, defined as the value of goods on which tax is remitted, becomes smaller in magnitude after VCA.*

Proof. We define the effective tax base as purchases reported to the tax authority (and on which tax is remitted). Prior to the VCA, the base is simply the offline purchases as almost no online purchase is reported. After the VCA we assume full compliance on both online and offline purchases. Therefore, the effective tax base is now both online and offline purchases. Post VCA the tax-elasticity of the online and offline tax base is identical and the elasticity of the effective tax base is equal to $\epsilon^{post}_{x_b,t} = \epsilon^{post}_{x_o,t}$. Prior to the VCA, the base is equal to offline expenditure and therefore the elasticity is $\epsilon^{pre}_{x_b,t}$.

Therefore, by Proposition 2 we know that the elasticity of tax base became smaller in magnitude.

□

5 VCA Effect on Online Prices and Consumption

In this section, we establish several empirical facts assumed by our model. We find that the VCA decreased online expenditure by households, particularly at large online retailers, consistent with what we would expect following an increase in the after-tax price. We also show direct evidence that VCAs substantially increased the number of online purchases on which sales taxes were collected by online retailers. Together, these findings suggest that use-tax compliance was low prior the VCA and that compliance increased once retailers were required to remit. They also suggest that the resulting change in the tax-inclusive price (as the effective tax increase was fully passed-through) was noticed by the consumers, who decreased online consumption.

5.1 More Online Goods Are Taxed at Point of Sale After the VCA

Given that non-compliance with use taxes were low as we argued in Section 2 and that the tax enforcement measures are not always effective, we first verify that the VCA had the intended effect of raising compliance on retail taxes on online sales. To measure compliance, we test whether there is more likely to be a difference between the pre-tax and after-tax price post VCA. Nielsen records expenditure in two variables - *item-level* expenditure and *trip-level* expenditure. The *trip-level* expenditure is always tax-inclusive while the *item-level* is tax-exclusive[8]. If no sales tax is collected at the point of transaction, the aggregate of all item expenditures for a given trip will equal the *trip-level* expenditure. If the VCA induced retailer remittance, we expect the fraction of online transactions where no sales tax was apparently collected to fall.

Figure 2 shows that this is indeed the case. After restricting the data to trips in which only taxable items were purchased, we separately plot the share of trips where the sum of the *item-level* expenditure equals the *trip-level* expenditure for online and brick-and-mortar purchases, relative to the time of VCA adoption. Prior to the VCA agreements, about 25 percent of online trips have no tax collected, whereas only about 12 percent of offline trips have no tax collected (or report *item-level* tax-inclusive expenditures). We see a sharp drop in this fraction for online trips immediately following state-level VCA adoption, suggesting that online retailers began collecting sales taxes soon after implementation of the VCA.

[8] We discuss this crucial aspect of the data in detail in the data appendix.

Having established that online retailers remitted after the policy, we now turn to the consumer response. Standard incidence theory, which assumes full salience and compliance, would predict that shifting the remittance duty from the consumer to the retailer should have no effect on equilibrium quantities and prices. However, if, as we suspect, compliance with use taxes was low, for most consumers the policy increased the tax-inclusive price of online goods[9].

5.2 Consumers Reduced Total Online Expenditure on Taxed Goods

We estimate the effect of the policy on online purchasing behavior by estimating the following difference in difference specification:

$$Y_{hm} = \beta_0 + \beta_1 \text{Ever VCA}_h * \text{Post VCA}_{hm} + \beta_2 X_{hm} + \gamma_m + \delta_h + \epsilon_{hm} \tag{16}$$

where Y_{hm} is either (1) total online taxable expenditure or (2) total online exempt expenditure of household h in month m. The impact of the VCA on expenditure is captured by β_1 where *Ever VCA*$_h$ indicates whether the household h is in a state that adopts a VCA between 2010 and 2014 and *Post VCA*$_{hm}$ is an indicator for whether we are observing household h in a month m following adoption of VCA in that state. We also control for time fixed effects (γ_m) and household fixed effects (δ_h), as well as time-varying area-level characteristics (X_{hm}) such as a local cost of living index[10]. If the parallel trends assumption holds - that is, if the online purchasing habits of households in states that did not adopt VCAs seem to be a suitable counterfactual for the purchasing habits of households in states that adopted VCAs - then this parameter represents the difference-in-differences estimator of the effect of VCA adoption on the extensive and intensive margin of online sales. We would expect that online expenditure on taxable items falls as a result of the VCA, but that online expenditure on exempt items does not change.

We find that the introduction of the VCA reduced total monthly tax-exclusive expenditure online by about 8 percent relative to the mean (Table 3, column 1), about 25 cents per month. In contrast, there is close to no change in the purchase of exempt goods online (column 4). Nearly all of this decrease in online expenditure occurred at large retailers (column 2) and not at small retailers (column 3). Total monthly expenditure at brick and

[9]The exact amount that after tax prices increase depends on relative demand and supply elasticities, but, as most Nielsen tracked products are commodities, we think 0% pass through is unlikely.

[10]We create this measure following steps outlined in Baugh et al. (2018)

mortar stores increase by about one dollar but these effects are not statistically significant. Figure 3 shows, there is no anticipatory effect of the VCA in the quarter before and the parallel trends assumption holds. Figures showing parallel trends in other outcome variables are shown in Appendix B.

5.3 Pass-Through to Consumers

We decompose the decrease in tax-exclusive online expenditure into the change in the tax-exclusive price of goods and change in consumer demand using the following specification:

$$\log(P_{cmu}) = \beta_0 + \beta_1 \text{Ever VCA}_c * \text{Post VCA}_{cm} + \gamma_m + \delta_u + \alpha_c + \epsilon_{cmu} \tag{17}$$

where the coefficient of interest is again β_1, which represents the average percent change in the tax-exclusive price across all products due to the VCA. P_{cmu} is the unit price of UPC-level commodity u in county c in month m. We control for month, upc and county-level fixed effects $(\gamma_m, \delta_u, \alpha_c)$. This is similar to our baseline specification 16, except that the unit of observation is a purchase within households.

Similarly, we test the effect on consumer demand by estimating specification 17 with *Log(quantity demanded)* as the dependent variable. The coefficient of interest then is the estimate of average percent change in quantity demanded for product, conditional on purchase (i.e. intensive margin effect on quantity). The drawback of this specification is that a null effect could be consistent with three different interpretations: (1) Consumers do not reduce their quantity demanded on most goods, conditional on online purchase, as a result of the VCA, (2) Consumers reduce their quantity demanded of higher price goods and substitute to purchasing lower price goods (therefore increasing quantity demanded of these goods). On average, this would translate to no measured effect on quantity demanded. For example, if consumers switch from a higher-priced variety of household cleaner to a lower-priced variety, this would appear on average as no measured change in quantity demanded across UPC. Or, if consumers decide not to purchase an expensive kitchen appliance and instead spend more of their budget on other lower priced items - they would have decreased quantity demanded in one UPC but increased demand for another. (3) Consumers only respond on the extensive margin, i.e. they stop purchasing any amount of the product online.

To distinguish between (1) and (2), we examine the effect of the VCA on quantity interacted

with the average price of each UPC across purchases from all states in 2011, a year in which no state introduced a VCA. This price is by definition, unaffected by the VCA. In this way, we can examine heterogeneous effects on demand due to the VCA across high and low-price commodities.

$$\begin{aligned}\log(Q_{cmu}) =& \beta_0 + \beta_1 \text{Ever VCA}_c * \text{Post VCA}_{cm} * P_{2011cu} \\ &+ \beta_2 \text{Ever VCA}_c * P_{2011cu} + \beta_3 \text{Ever VCA}_c * \text{Post VCA}_{cm} \\ &+ \gamma_m + \delta_u + \alpha_c + \epsilon_{cmu}\end{aligned} \tag{18}$$

Now β_1 measures the average decrease in consumer demand across UPC, scaled by the price of each UPC. If consumers behave as described in (2), we would expect β_1 to be negative. On the other hand, if consumers behave as described in (1), we would expect β_1 to be zero.

5.3.1 Effect of VCA on tax-exclusive prices.

We find that tax-exclusive prices do not change after the VCA. Table 4 decomposes the effect on total online expenditure into the effect on prices and quantity separately. Columns 3-6 shows the effect on log of prices. We find that the VCA reduced prices by 0.9 percent, but this reduction is coming mostly from purchases of video products. We find no evidence of a statistically significant change in the tax-exclusive price of most goods purchased online, suggesting that any effective tax increase due to the VCA was fully passed through to consumers.

5.3.2 Quantity Purchased Online - Intensive Margin

Columns 1-3 in Table 4 show no effect of the VCA on quantity, which is surprising at first given that we see a decrease in total expenditure. We find no evidence of an intensive margin effect on quantity on average. That is, conditional on an online purchase, we do not see a decrease in quantity on average across all commodities. However, as discussed, this result could be consistent with a decrease in quantity purchased of some goods and an increase in quantity purchased of others. For example, if consumers substituted away from a more expensive to a less expensive variety, we would not find evidence of a decrease in quantity

on average. Table 5 shows the heterogenous impact on quantity demanded by price of the commodity prior the VCA as a proxy for quality. Column 1 shows that quantity demanded decreases as a result of the VCA by more for higher price taxable goods, suggesting that consumers substitute away from higher price varieties to lower price varieties or lower price goods.

6 VCA Effect on Tax Elasticities

To test the impact of the VCA on elasticity of the consumption tax base with respect to the sales tax rate, we augment specification 16 by adding interaction terms for the sales tax rate application at the household's zip-code. This is the tax rate that is likely to prevail at most of the household's brick-and-mortar consumption and is the tax rate applied on online sales. We estimate the following specification at the household-month level:

$$\begin{aligned}\Delta log(e_{ht}) = \beta_0 + \beta_1 \Delta\tau_{ht} + +\beta_2 \Delta\tau_{ht} * \text{Ever VCA}_h + \beta_3 \Delta\tau_{ht} * \text{Post VCA}_{ht} \\ + \beta_4 * \text{Post VCA}_{ht} + \pi X_{ht} + \gamma_h + \gamma_t + \epsilon_{ht}\end{aligned} \tag{19}$$

The tax elasticity of the tax base in untreated states is estimated captured by β_1 while β_2 captures any difference in this elasticity in states that ever adopt the VCA, and β_4 represents the tax rate-invariant effect of VCA adoption on the base. The coefficient of interest, β_3, captures how a VCA impacts the tax elasticity of the base[11]. X_{ct} is a vector of time-varying county-level controls, including the unemployment rate. Household and time fixed effects are included to control for any time-invariant household characteristics and time trends,

[11] Let the sales tax base in jurisdiction of household h at time t be defined as

$$B_{ht} = \sum_{i}^{I} p_{iht}(\tau) X_{iht}(q_{iht}(p_{iht}(\tau), \tau)) \tag{20}$$

where I is the set of all taxable goods in the jurisdiction of household h, and τ is the sales tax rate. The first term, $p_{iht}(\tau)$, denotes the tax exclusive price; X_{ict} is the aggregate demand for product i in jurisdiction c at time t, and is a function of the tax inclusive price $q_{iht} = p_{iht}(\tau)(1+\tau)$. The effect of the VCA on tax rate elasticity of demand can be expressed as

$$\frac{d_{ht}}{dVCAd\tau} = \frac{d_{ht}}{d\tau}|_{VCA=1} - \frac{d_{ht}}{\tau}|_{VCA=0} \tag{21}$$

which is the difference in the derivative of tax base with respect to the tax rate when a VCA is in place.

respectively.

Specifying at the household-month level has two advantages: we can include household effects which absorb idiosyncratic variation in expenditures within a household, thus making our estimates considerably more precise; and it further mitigates omitted variable concerns by partially controlling for endogenous sorting of households into local tax jurisdictions. After transformation, the coefficient estimate for β_3 in Col. 3 suggests that households' taxed expenditures became somewhat less elastic to a tax rate change, but this change is not statistically significant.

In Table 6, we estimate the above equation over three tax bases: first, the effective tax base, second the subset of the effective tax base that is purchased both online and offline, and finally, the brick-and-mortar tax base.

Contrary to what Goolsbee et al. (2010) find in response to the spread of the internet, we do not find strong evidence that consumption of non-durable consumption goods is less elastic after the VCAs, which remove the sales tax evasion channel presented by the initial introduction of the internet. We estimate the effect of the VCA on the elasticity of the "effective tax base", which we define as the expenditure that is reported to the tax authority. Prior to the VCA, this base is only expenditure at brick-and-mortar retailers. We assume that no online expenditure is reported, which we feel is reasonable given the near zero compliance rate on use taxes. After the VCA, the base is the sum of both online and offline expenditure. In column 1, we estimate the elasticity of the tax base with respect to the tax rate for all goods that are subject to the standard sales tax rate over all time periods. This base excludes goods like soda, alcohol or cigarettes and other goods that may be taxed at special rates. It also excludes goods that are tax exempt. We estimate that a one percent increase in the tax rate leads to a 0.02 percent decrease in the sales tax base on average. Prior to the VCA, the elasticity is higher in absolute value at -0.05 (column 2) and the change in the elasticity due to a VCA is large in magnitude and positive (0.05), although not statistically significant.

We also test the effect of the VCA on a subset of this base - expenditure on goods that are purchased online between 5 and 95 percent of the time. Since the change in elasticity is expected to come from consumers who no longer purchase the good online in response to a tax change, we would expect that the effect is strongest on goods that can be purchased both online and at brick-and-mortar retailers. We estimate that the average elasticity of this base is higher at -0.5 but that the different between the pre-VCA and post VCA elasticity

(0.062) is not statistically significant. However, the size of this tax base does increase by 14.5 percent because online consumption is added. Finally, when we focus solely on brick-and-mortar purchases of goods that are purchased online at least some of the time (column 6), we estimate a smaller tax base elasticity overall and statistically significant change after the VCA.

These results suggest that although the VCA increased the overall size of the tax base and decreased online consumption, it did not change the overall responsiveness of non-durables consumption with respect to the tax rate. This might be because online consumption of these goods is a smaller share of total consumption and therefore does not significantly impact the elasticity, which itself my be smaller than the elasticity of durables consumption with respect to the tax rate.

7 VCA Effect on Sales Tax Holidays

In this section, we use a second source of variation to study the impact of the VCA on responsiveness of consumption to tax rate changes.

About 23 U.S. states hold sales tax holidays annually, often in the month of August, when sales of certain goods are exempt from regular sales taxes. Items that are made exempt during tax holidays include clothing, footwear and school supplies, although some holidays are intended to encourage the consumption of specific items like energy-efficient electronics. We examine whether consumers become more responsive to tax holidays when sales tax evasion through online purchases is no longer viable because of VCAs.

Tax holidays could be thought of as a tax avoidance channel rather than a decrease in the tax rate. Cole (2009) showed that although tax holidays lead to an overall increase in the expenditure on exempted goods, nearly 90 percent of the response is due to re-timing of purchases. That is, consumers wait to make purchases during a sales tax holiday that they would have otherwise purchased at a different time. After the VCAs, because consumers can no longer evade use or sales taxes by purchasing online instead of at brick-and-mortar stores, the tax holiday channel may become more attractive.

To test the impact of the VCA on responsiveness during sales tax holidays, we estimate the elasticity of consumption with respect to tax holidays before and after the VCA of goods that are and are not exempt during the holiday. We estimate the following specification:

$$\log(y_{hcst}) = \beta_1 \text{Tax Holiday}_{st} + \beta_2 \text{Post VCA}_{st} + \beta_3 \text{Tax Holiday}_{st} * \text{Post}_{st} \\ + \beta_4 \text{Tax Holiday}_{st} * \text{Ever VCA}_s + \pi X_{ct} + \gamma_h + \delta_t + \eta_s * t + \nu_c + \epsilon_{hcst} \tag{22}$$

where Tax Holiday$_{st}$ is a dummy for whether at least one day of the week t in state s, where the household resides, had a tax holiday. Post VCA$_{st}$ is a dummy for whether the VCA has been implement in state s in week tm and Ever VCA is a dummy for whether the state enacts a VCA between 2010 and 2014. The dependent variable y_{hcst} is total household consumption in product group c at time t. As a placebo check, we estimate this specification separately on products that are exempt during sales tax holidays and those that are not. We control for time-varying local characteristics such as a county-level price index and also include time (δ_t), household (γ_h), and commodity (ν_c) fixed effects.

The coefficient of interest is β_3, which captures the effect of the VCA on expenditure during sales tax holidays. We would expect $\beta_3 > 0$ as some consumers who may have purchased the same goods online switch to purchasing during sales tax holiday or increase their consumption during tax holidays.

Table 7 reports the results from estimating specification 22. As expected, sales tax holidays raise consumption of goods that are exempted during the sales tax holiday, but not others. The coefficient on *Tax Holiday* is positive and statistically significant in column 1 where the sample is restricted to goods that are exempt during holidays but not in column 3, which is a sub-sample of goods that are not exempt. However, the coefficient of interest on the interaction between *Tax Holiday* and *Post VCA* is close to zero and not statistically significant. Although household consumption increases by 10 percent during sales tax holidays, there is almost no change in this increase after the VCA. Similarly, on the extensive margin, there is no change in the likelihood that households make a purchase during a sales tax holiday week after the VCA (column 2). This is consistent with the earlier analysis that showed that there was no measurable change in the elasticity of the tax base due to the VCA.

We might expect the attractiveness of sales tax holidays and the change after the VCA to vary by the sales tax rate faced by the household. Those in areas with higher sales tax rates experience a bigger shock to their effective tax rate due to the VCA and might be more likely to wait to shop during tax holidays. A second dimension of heterogeneity might be that the VCA is more likely to impact households that actually made online purchases prior to the VCA. We test these dimensions of heterogeneity by augmenting specification 22 with

interaction terms for the sales tax rate applicable at the household's zip code and a dummy for whether the household had made any online purchase prior to the VCA. We report the coefficient of interest from these specifications in Table 8. Overall, we do not find strong evidence that the VCA had an impact on responsiveness during sales tax holidays in states with higher tax rates (column 1), nor do we find strong evidence that it had a differential impact on households that had made online purchases prior to the VCA (column 2).

Together, these results suggest that the elasticity of the consumption tax base captured in the Nielsen data (which excludes large durables) was not significantly changed by the change in remittance rules introduced by the VCA.

8 Conclusion

With the share of consumer purchases made online expected to grow, policymakers are understandably focused on ways of ensuring that online retailers remit sales taxes. In this paper, we study the impact of states adopting VCAs with Amazon, the largest online retailer, on the prices and purchases of online goods. We are also interested in the effect of VCA adoption, which makes it more difficult for consumers to purchase products online from non-remitting retailers, on the sales tax elasticity. To investigate these questions, we exploit variation in the location and timing of VCA adoption by states between 2010 and 2014, and we use data from the Nielsen Consumer Panel.

First, we find that VCA adoption increases the share of online goods sold that are taxed at the point of sale. To establish this, we measure the percentage of taxable sales where the after-tax item price is equal to the pre-tax item price, implying that sales taxes were not being remitted by the online retailer. The proportion of online sales meeting this criterion falls by nearly half in response to the VCA, with the most pronounced changes at the largest retailers who are likeliest to comply; the analogous proportion for brick-and-mortar sales remains constant. Second, we find that consumers respond to VCA adoption by reducing their online consumption. On average, households in VCA-adopting states reduce online purchases by 8%, similar to the findings of Baugh et al. (2018) that households reduce purchases on Amazon following VCA adoption by 9-12%. The discrepancy in these estimates is likely caused by the fact that, in our data, we capture all online expenditures, rather only those for Amazon, and many small retailers did not sign VCAs.

Finally, we show that although online consumption decreased as a result of the VCAs, its

impact on the elasticity of the overall (non-durables) tax base was not significant. We do not find evidence that the elasticity of the sales tax base estimated from sales tax rate changes at the zip-code level, changed significantly after the VCA. To address concerns of policy endogeneity, we also examine where households' response to sales tax holidays change after the VCA. Although we would expect sales tax holidays to have become even more attractive after the VCA since households can no longer evade taxes at other times by shopping online, we do not find strong evidence of a change. These results suggest that although the change in remittance rules was effective at raising the overall size of the tax base, it did not have a large impact on the sensitivity of consumption to the sales tax rate.

9 Figures

Figure 1: Date of Implementation of Amazon VCAs

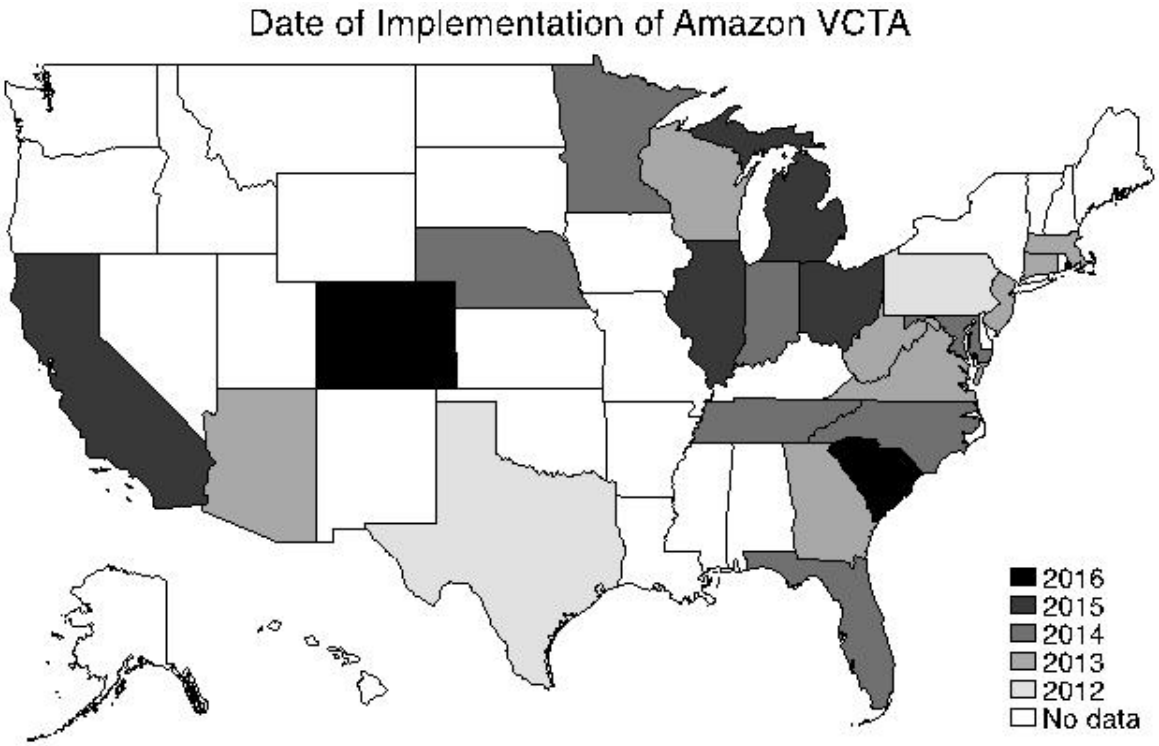


Figure 2: Fraction of Trips with Only Taxed Items that Paid No Sales Tax

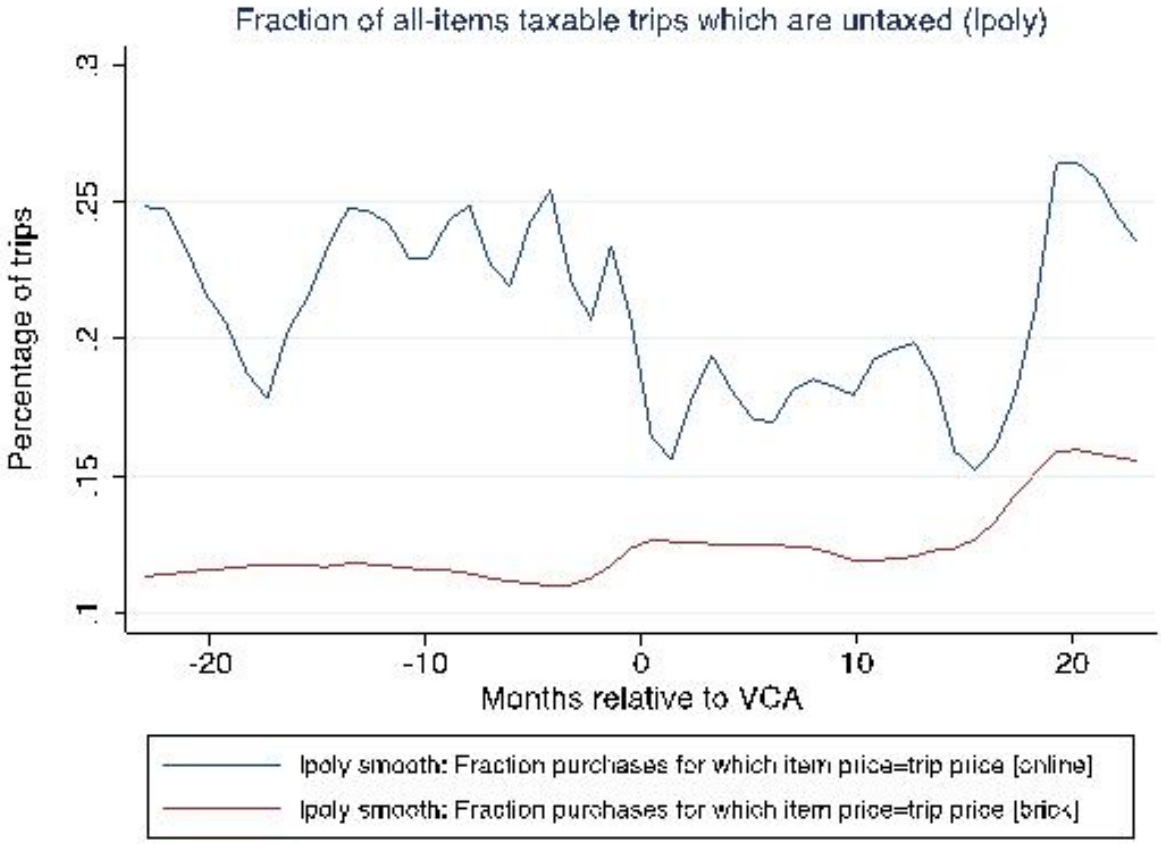
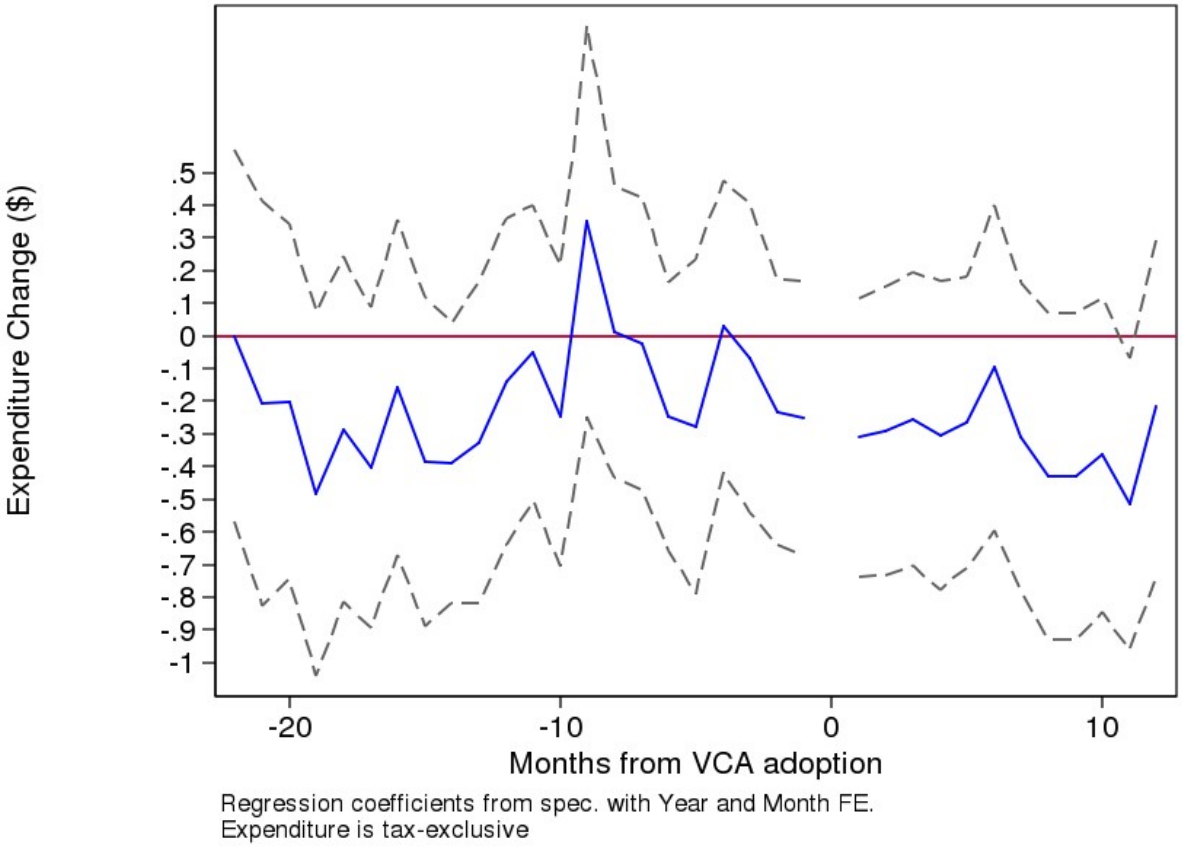


Figure 3: Change in Average Monthly Household Expenditure on Taxable Goods Online



10 Tables

Table 1: Tax Rate Changes by Administrative Unit and Year

	2010	2011	2012	2013	2014	Total
State	65	3	0	8	0	78
County	73	185	103	146	103	751
City	233	454	496	307	249	2029
Total	371	642	599	461	352	2858

Notes: Author's calculation based on data from zip2tax

Table 2: Tax Rate Changes Before and After the VCA

	Pre VCA		Post VCA
Any Rate Change:			
Mean	0.011		0.009
		(.028)	
Conditional on Rate Change:			
Mean	-0.143		0.186
		(.571)	
s.d.	0.818		0.505
Median	-0.150		0.250
Min	-3.000		-7.000
Max	2.000		7.000
N	877350.000		613522.000

Notes: Each observation is a zipcode-month in states that introduced a VCA between 2010 and 2014. T-statistics of difference in means calculated using wild bootstrap and clustering by state are reported in parentheses below the means.

Table 3: Effect of VCA on Taxable Expenditure

	Online Expenditure				Brick and Mortar Expenditure	
	(1) Taxable	(2) Taxable	(3) Taxable	(4) Exempt	(5) Taxable	(6) Exempt
Post VCA	-0.252**	-0.245**	-0.007	0.107	0.015	0.250
	(0.119)	(0.092)	(0.103)	(0.090)	(0.640)	(1.060)
Sample	Total	Large Retailer	Small Retailer			
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,591,230	3,591,230	3,591,230	3,591,230	3,591,230	3,591,230
State Clusters	49	49	49	49	49	49

Notes: Reports results from specification 16. *Post VCA* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state. Samples vary in each column according to what is indicated in the "Sample" row. The first four columns show results on online expenditure of households while the last two show results on brick and mortar expenditure. Each regression includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by state. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effect of VCA on Prices and Quantity

	Log(Quantity)			Log(Tax Exclusive Price)		
	(1)	(2)	(3)	(4)	(5)	(6)
Post VCA	-0.006	-0.007	-0.002	-0.007	0.001	0.005
	(0.006)	(0.008)	(0.009)	(0.005)	(0.005)	(0.007)
UPC FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Yr FE	Yes	Yes	Yes	Yes	Yes	Yes
Taxable?	Taxable	Taxable	Exempt	Taxable	Taxable	Exempt
Incl. Video?	Yes	No	–	Yes	No	–
Observations	884,647	778,420	888,773	879,392	773,596	885,008
State Clusters	49	49	48	49	49	48

Notes: Reports results from specification 17. Each observation is a purchase. *Post VCA* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state. Each regression includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by state. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Effect of VCA on Quantity by Quality

	Taxable		Exempt
	(1)	(2)	(3)
Post VCA X 2011 Price	-0.001**	-0.002**	-0.009***
	(0.001)	(0.001)	(0.003)
Post VCA	-0.004	-0.004	0.006
	(0.007)	(0.009)	(0.011)
Ever VCA X 2011 Price	-0.000	-0.000	0.002
	(0.000)	(0.000)	(0.002)
UPC FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Month of Yr FE	Yes	Yes	Yes
Incl. Video?	Yes	No	–
Observations	884,647	778,420	888,773
State Clusters	49	49	48

Notes: Results from specification 17 augmented with price of the good (UPC) in 2011 are reported. *Post VCA* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state and *2011 Price* is the average price for the UPC in the period before VCA is introduced. Each regression includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by state. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Effect of VCA on the Elasticity of the Consumption Tax Base

	Effective Base		Effective Base-Select		Brick and Mortar Base	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax Rate	-0.017	-0.046**	-0.559*	-0.710*	-0.035	0.009
	(0.011)	(0.018)	(0.299)	(0.404)	(0.036)	(0.043)
Δ Tax Rate X Treat		0.053**		0.296		-0.085
		(0.025)		(0.683)		(0.080)
Δ Tax Rate X Post VCA		0.047		0.062		-0.102
		(0.034)		(1.049)		(0.163)
Post VCA		0.002		0.145***		0.010
		(0.002)		(0.047)		(0.011)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Month of Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,316,704	3,316,704	3,435,106	3,435,106	536,488	536,488
County Clusters	2,863	2,863	2,864	2,864	2,726	2,726

Notes: Results from specification 17 are reported. *Post* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state. Each regression includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by household and state X year. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Effect of VCA on Responsiveness to Sales Tax Holidays

	Exempt During Holiday		Not Exempt During Holiday	
	(1) Log(HH Weekly Expenditure)	(2) Any Expenditure	(3) Log(HH Weekly Expenditure)	(4) Any Expenditure
Post VCA	0.019	0.001	-0.004	0.001
	(0.016)	(0.001)	(0.003)	(0.001)
Tax Holiday	0.108***	-0.002	0.000	-0.002
	(0.035)	(0.003)	(0.009)	(0.003)
Tax Holiday X Post VCA	-0.015	0.002	0.007	0.002
	(0.034)	(0.003)	(0.012)	(0.003)
Tax Holiday X Ever VCA	0.013	0.002	0.011	0.002
	(0.035)	(0.003)	(0.010)	(0.003)
Household FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
Week of Year FE	Yes	Yes	Yes	Yes
County X Year FE	Yes	Yes	Yes	Yes
Observations	629,857	634,805	21,300,558	634,805
Household Clusters	1,296	1,297	1,431	1,297

Notes: Results from specification 7 are reported. *Post VCA* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state. *Tax Holiday* is an indicator for whether there is a tax holiday in place on any day during a given week in a given state, and *Ever VCA* is a dummy for whether the state enacted a VCA between 2010 and 2014. The first two columns are restricted to consumption of goods that are exempted during sales tax holidays and the last two are restricted to consumption of goods that are taxed but not exempt during holidays. Each regression includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by household and state X year. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Effect of VCA on Responsiveness to Sales Tax Holidays, By Tax Rate and Online Purchasing Behavior

	(1) Log(HH expenditure)	(2) Log(HH expenditure)
Tax Holiday X Post VCA X Tax Rate	0.037	
	(0.032)	
Tax Holiday X Post VCA X Any Online		-0.055
		(0.062)
Household FE	Yes	Yes
Product FE	Yes	Yes
Week of Year FE	Yes	Yes
County X Year FE	Yes	Yes
Observations	629,850	629,850
County Clusters	1,296	1,296

Notes: Table reports the estimates of a regression where specification 22 is augmented with interaction terms for the *Tax Rate* (column 1) and *Any Online* (column 2). *Tax Rate* is the prevailing sales tax rate inclusive of state, county and local rates at the household's zip-code in a given week. *Any Online* is an indicator for whether the household made any online purchase in a given week prior to the VCA. Each regression also includes interaction terms of *Tax Rate* with *Tax Holiday* and *Post VCA*. *Post VCA* is an indicator variable that equals 1 after the first week that the VCA is introduced in a state. *Tax Holiday* is an indicator for whether there is a tax holiday in place on any day during a given week in a given state. Each regression also includes includes a full set of household, week, product and county X year fixed effects. Standard errors, reported in parentheses, are robust to heteroskedasticity and clustering by county. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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A Appendix

Measuring Tax-Exclusive and Tax-Inclusive Price in the Nielsen Data

This appendix describes our investigation of Nielsen's price data to determine the accuracy with which tax-exclusive and tax-inclusive prices are recorded.

A.1 Are Nielsen's Recorded Prices and Expenditure Tax-inclusive or Tax-exclusive?

The distinction between tax-inclusive and tax-exclusive price is crucial for an analysis of incidence or other impacts of taxation. Nielsen does not explicitly request consumers to enter the tax-exclusive price. Two variables provide information on expenditure. One is the *trip-level* total expenditure, the other is *item-level* expenditure given separately for each item purchased in the trip. Nielsen's documentation states that the *trip-level* total expenditure is tax inclusive but that the *item-level* expenditure is generally exclusive of tax. We test how often this is true by imputing our own measure of total *trip-level* tax inclusive expenditure from the *item-level* expenditure by adding up expenditure on each item, along with our measure of the applicable tax. If the *item-level* expenditure is always tax exclusive, and we are able to accurately impute the tax then the *imputed* measure of the *trip-level* expenditure should match the *actual trip-level* expenditure.

In the Nielsen documentation, they specify a number of reasons the *imputed trip-level* expenditure might not equal the actual *trip-level* expenditure ("total spent"). These include the trip price is generally tax inclusive, whereas the item prices are not; not all items in the trip are recorded by the panelist[12]; not all items purchased by the panelist are tracked by Nielsen (only "fast moving" goods tracked)[13]; the scanner malfunctioned; and item price is censored (capped) at $999.99 for non-magnet items.

[12]Nielsen Documentation, p66. "The panelist didn't scan all products purchased. Some items never make it into the home to get scanned. Consider items purchased at a hardware store that might get stored in the garage rather than being brought into the home, or a candy bar that was purchased and eaten before the consumer got home."

[13]Nielsen Documentation, p66. "Some items aren't "coded" by Nielsen - Nielsen mostly tracks fast-moving consumer goods (e.g. not most apparel, electronics or home furnishings, etc.)."

A.2 Analysis of discrepancy: Predicted vs. Actual Tax-inclusive Expenditures

Applicable tax rates on items are estimated using zip-code level information on local sales tax rate and the exemption status of products recorded in LexisNexis. Any errors in *item-level* expenditure makes it more likely that there are discrepancies between *imputed* and *actual trip-level* expenditure in trips where more than one item was purchased, we separately analyze trips with one item versus multiple items (See Figure 4 for the respective distributions of items per trip).

We generate two measures of discrepancies in tax inclusive expenditure. First, we calculate the difference between the *imputed trip-level* expenditure and the *actual trip-level* expenditure ("tax discrepancy"). We plot the densities of this measure separately for online and brick-and-mortar purchases. For both markets, there are mass points at common sales tax rates, suggesting an error in correctly applying the tax rather than an error in item price recording (See Figure 5).

Next, because the *imputed tax-inclusive* expenditure may not have accurately assigned the tax rate, we restrict the sample to trips in which no exempt items were purchased and identify trips in this sample where *imputed* expenditure equals *actual* expenditure.

We collapse the total number of such purchases separately for online and BM retailers, from the trip level to the state -treatment month level (approximately 40 periods *50 states= 2080 observations), and plot weighted kernel smoothers for online and BM separately relative to VCA passage (See Figure 2). As expected, the number of online purchases with no sales tax is much higher than for brick purchases in the pre-treatment period, and fall sharply after VCA passage. However, the drop in online purchases without sales tax belies a minimal change in the levels: up to 30 months after a VCA, approximately 1 out of 4 purchases are untaxed compared to 1 out of 10 for brick purchases.

Figure 4: Histogram of Number of Items Purchased per Trip

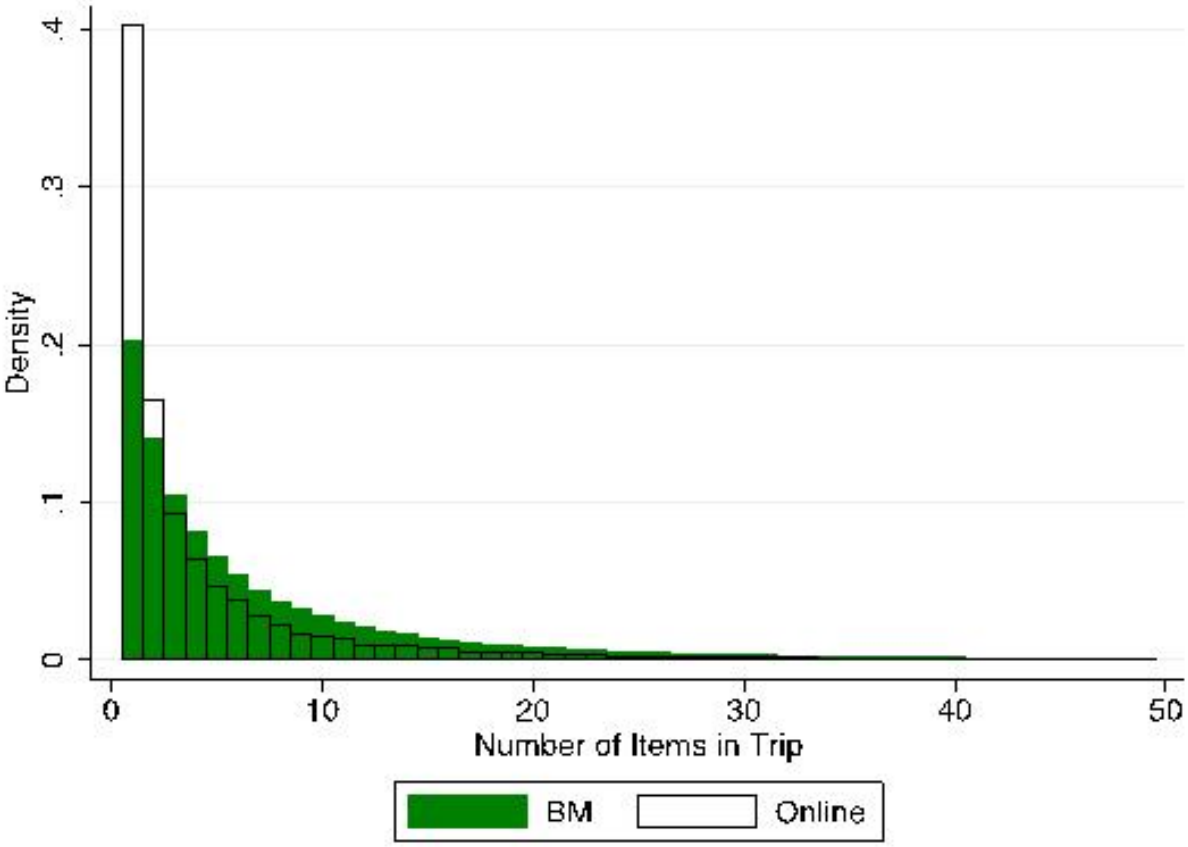
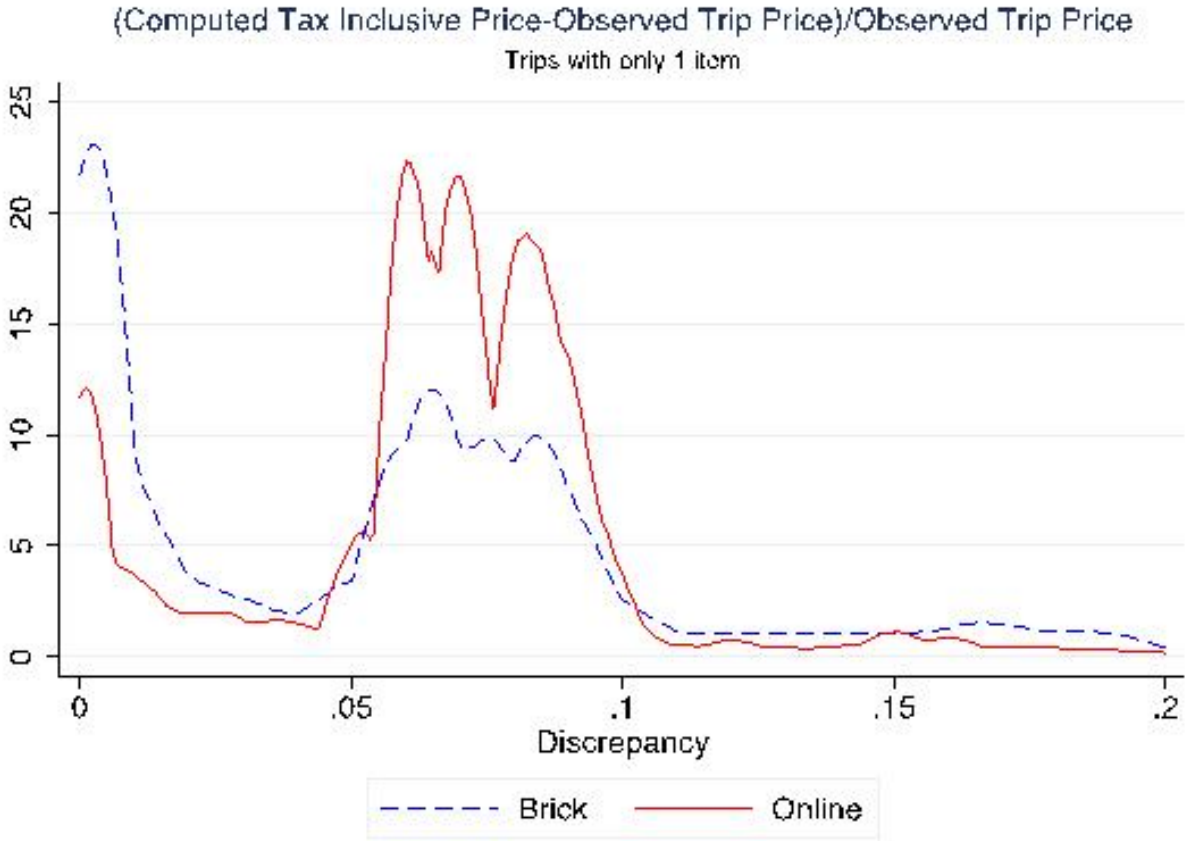
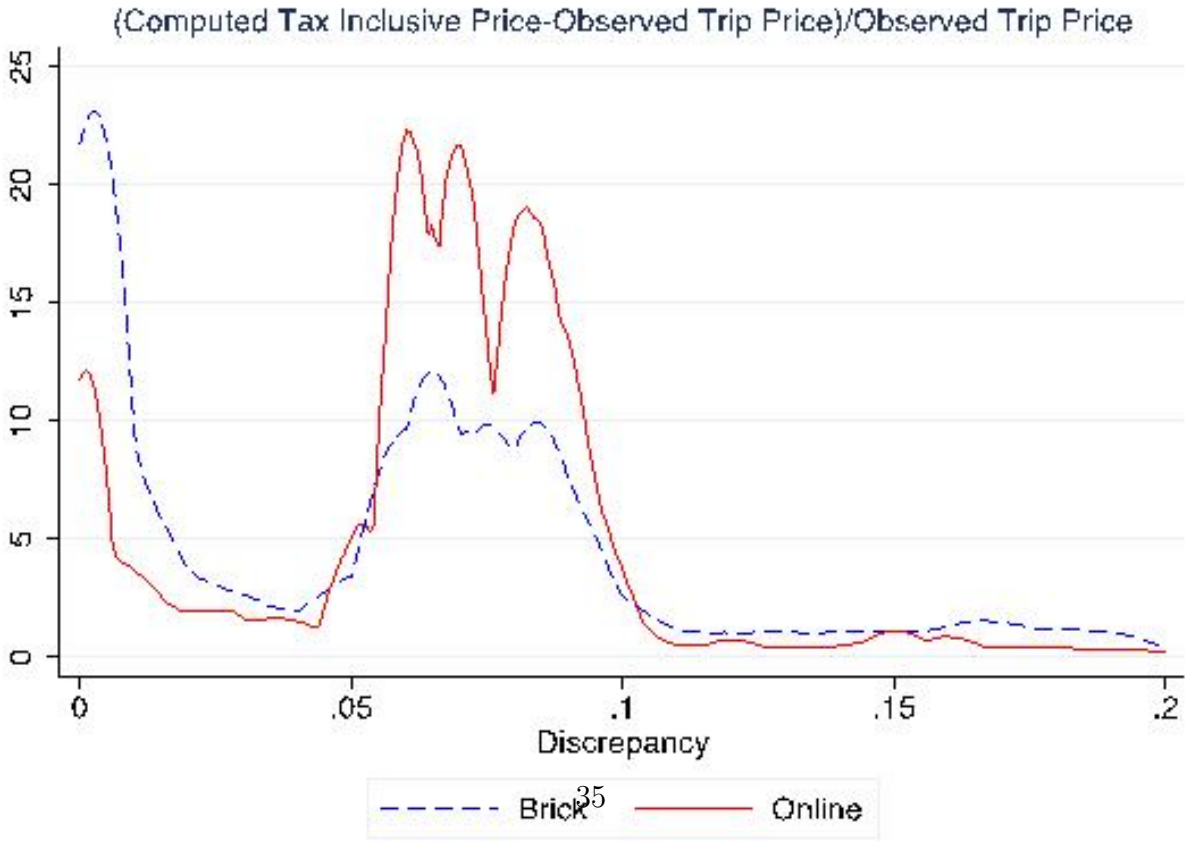


Figure 5: Discrepancy between Computed and Observed Tax-inclusive Prices





B Appendix Figures

Figure 6: Change in Average Monthly Household Expenditure on Taxable Goods Online at Large Retailers

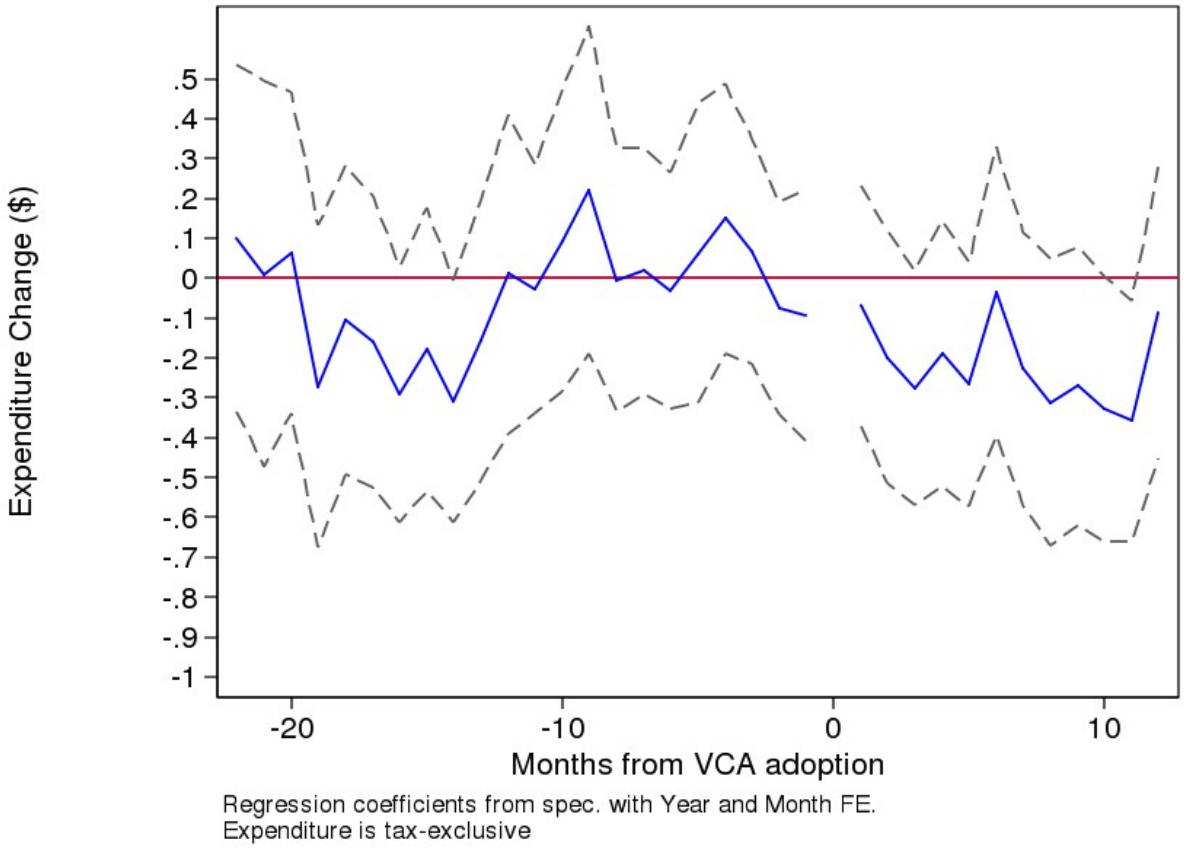


Figure 7: Change in Average Monthly Household Expenditure on Taxable Goods Online at Small Retailers

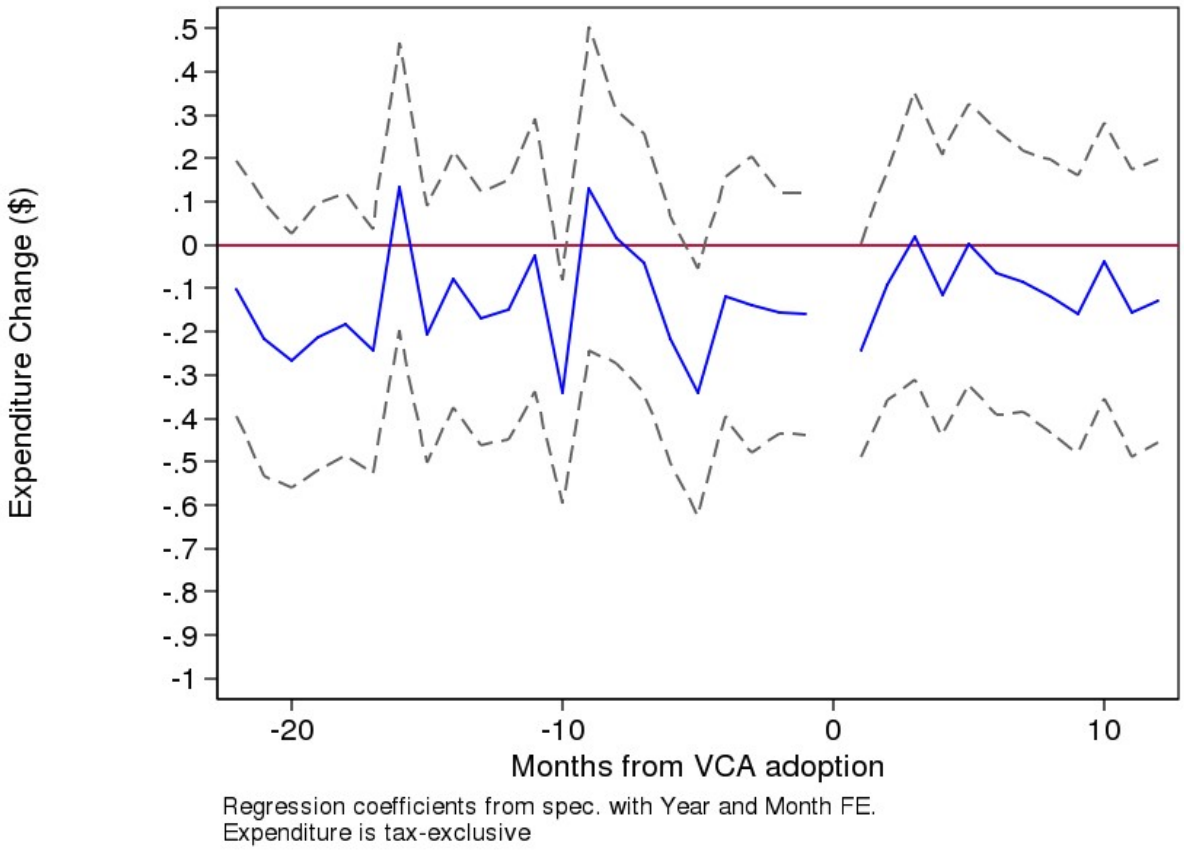


Figure 8: Change in Average Monthly Household Expenditure on Exempt Goods Online

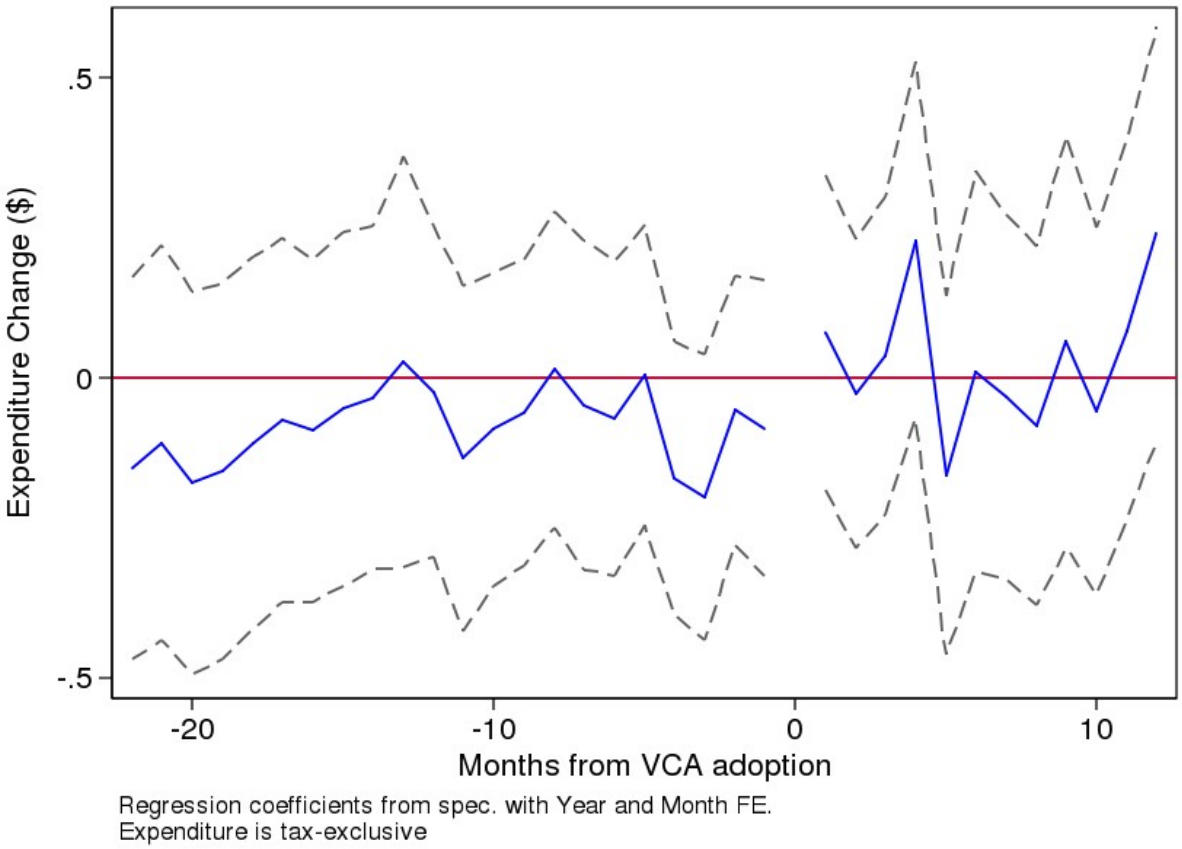
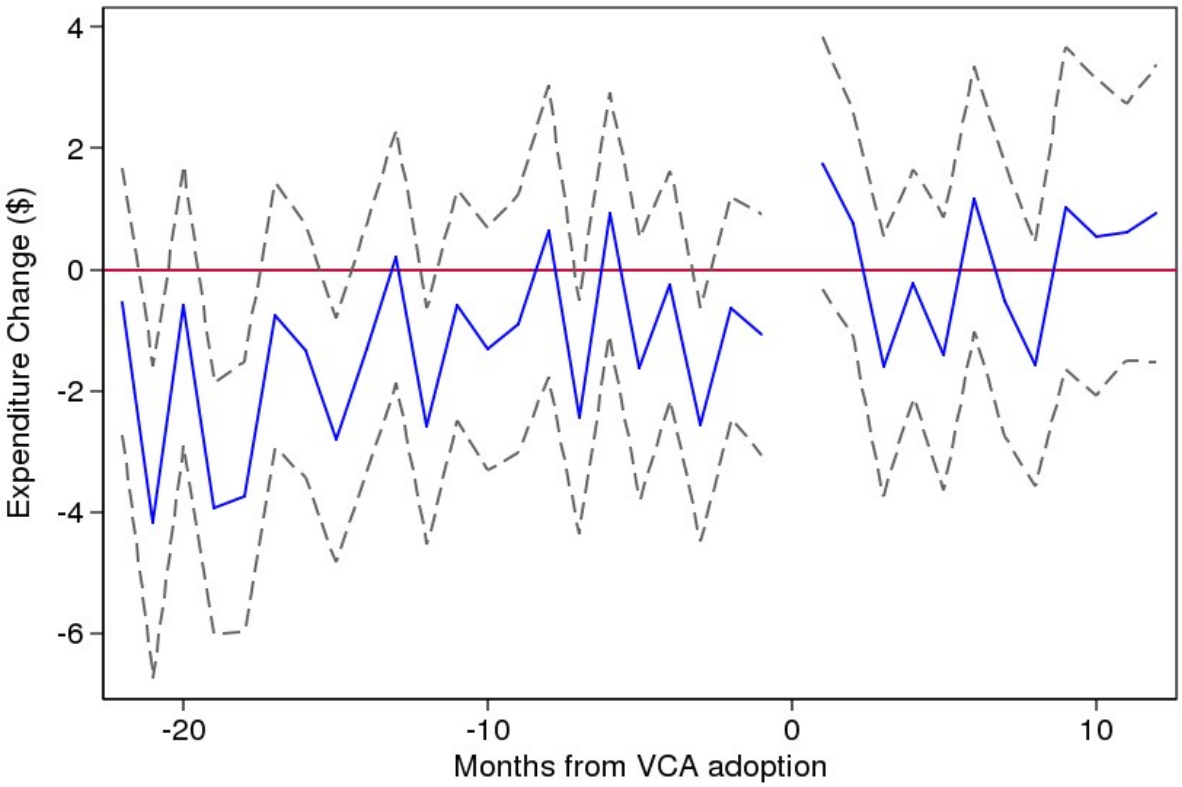


Figure 9: Change in Average Monthly Household Expenditure on Taxable Goods at Brick-and-Mortar Stores



Regression coefficients from spec. with Year and Month FE.
Expenditure is tax-exclusive