Essays on Tax Evasion

by

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Dedicated to my parents, Neslihan Kaçamak and Seydi Kaçamak and my brother, Cihan Kaçamak

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ABSTRACT

The three essays in this dissertation aim to broaden our understanding of tax evasion and tax enforcement problems. First two essays develop theoretical models to understand how deviation from standard compliance theory affects our understanding of existing optimal audit rules. The third essay looks at consumer response to a change in the degree of enforcement.

Chapter 1, studies the influence of tax preparers on tax compliance. This work formalizes the role of tax preparers as information aggregators whom taxpayers can purchase information from that is not available to the public. The presence of tax preparers in such setting always reduces compliance. Moreover, strikingly, if demand for tax preparer services is high enough the government can mitigate evasion by fully revealing its audit strategy.

Chapter 2, examines how introducing lying aversion to taxpayer utility alters existing optimal audit rules. Specifically, this paper shows that cutoff audit rules, in which every taxpayer with a reported income below a certain threshold is audited with a fixed probability that ensures honest reporting, can perform worse than a random audit rule where all taxpayers are audited with a constant probability.

Chapter 3, joint with Tejaswi Velayudhan and Eleanor Wilking, tests the theory of statutory neutrality which predicts that structuring as a use taxwhere the consumer remitsor, as a sales taxunder which the retailer remitsshould have no effect on the fundamental parameters of the tax system. By using data from Nielsen Consumer Panel and monthly, zip-code level information on local sales taxes we show that consumers reduce their online expenditures in response to Voluntary Collection Aggreements (VCA) which changed tax collection structure from a 'use-tax' to a 'sales tax'.

CHAPTER I

The Role of Information Aggregators in Tax Compliance

Abstract

Fifty-six percent of the U.S. taxpaying population uses a paid tax preparer, but the effect of these tax preparation services on tax compliance is not well-understood. Although governments conceal the algorithms they use to determine which taxpayers to audit, tax preparation firms with large client bases may be able to infer these algorithms and therefore offer strategic advice to taxpayers. This paper formalizes this role, using a simple asymmetric information model where agents can purchase full information about the government's enforcement rules. In a competitive market for tax preparation services, demand for tax preparers is selective and increases in taxpayer income. Moreover, the presence of tax preparers always reduces compliance. Perhaps surprisingly, if the demand for strategic advice is high enough, the government can mitigate evasion by revealing full information about its audit rule.

JEL Codes: H26 , D21 ,D82

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1.1 Introduction

Each individual taxpayer is responsible for filing her own income tax return but, increasingly, individuals rely on paid preparers for assistance. The U.S. Internal Revenue Service (IRS) estimates that 56% of the 145 million individual returns in 2011 were prepared by a professional tax preparer, up from 49% of the 114 million individual tax returns in 1992. It is unlikely that use of tax preparers and taxpayer compliance are independent; indeed, empirical evidence documents a negative correlation between reported income and usage of tax preparers, conditional on observable characteristics. (Klepper and Nagin (1989), Long and Caudill (1987), Erard (1993), Erard (1997)). This negative correlation is likely to be due to the strategic tax planning provided by tax preparation firms. Firms' strategic advice has become even more valuable with the creation of large databases of taxpayer experience, and the analytical insights that can be drawn from such data. Despite the importance of tax preparation services and their ability to amass taxpayer information, there is no general theory of tax compliance that formalizes the role of tax preparers as information aggregators.

This paper characterizes the impact of tax preparers on tax compliance. To analyze the interaction of taxpayers and tax preparers, I develop a model in which tax preparers have perfect information about the government's audit rule, but taxpayers' information is imperfect. I show that the availability of tax preparers increases evasion. However, the tax agency can mitigate this outcome by strategically revealing information about the audit rule.

There are many factors that may influence a tax authority's decision to audit an individual's tax return. In the U.S., a computer scoring system is one method the IRS uses to select returns for audit. A program called the Discriminatory Inventory Function (DIF), which is a pre-configured set of scoring formulas, assigns different scores based on an individual's tax return. Usually, the higher the score assigned by DIF, the more likely the return is audited. [1] Reinganum and Wilde (1988), referring to the DIF stated that, "Some of the best-kept secrets in the U.S. Government are held by the Internal Revenue Service".[2]

Tax preparers, especially those with a large number of clients, collect vast amounts of data from taxpayers' individual returns. These data can be used to infer certain characteristics of the government's enforcement tools that are not publicly available to taxpayers. Specifically, it is likely that by aggregating information, tax preparers are able to predict

[1] https://www.irs.gov/irm/part4/irm$_0 4-001-003 idm140470279594032$

[2] In the past, IRS has been pressured to reveal this scoring formula. In one recent example, a taxpayer sued to compel the Service to disclose the formula under the Freedom of Information Act, the court ultimately ruled in favor of the tax agency.

the probability of an audit more accurately than an individual taxpayer. In the most extreme case, a tax preparer can use its amassed data to backward engineer some aspects of DIF scoring. Many taxpayers are likely to be willing to pay for this information, because it helps them optimize under uncertainty over the likelihood of being audited.

The predictions of the model I develop suggest that the demand for strategic tax planning is selective: not all agents find it optimal to hire a tax preparer. If evasion opportunities are increasing in taxpayer income, the net benefit of hiring a tax preparer firm is also non-decreasing in taxpayer income. This suggests that the demand for professional tax preparation services should be increasing in taxpayer income as well; however, this is only true as long as the fee for these services does not drastically increase with taxpayer income. In a competitive market, if the marginal cost of preparing a return is a constant, and the demand for professional tax preparation is positive, taxpayers with the highest income levels always hire a firm. In contrast, when the marginal cost increases with the taxpayer income, it is possible that only middle income agents demand strategic tax advice.

One of the main findings of this paper is that, in some cases, the government can counter the aforementioned increase in aggregate evasion by revealing more information about the rules governing the probability of tax audits. However, revealing information does not always increase compliance of each individual. Although aggregate noncompliance increases with the availability of preparers, the change is not unidirectional; some taxpayers actually *increase* their compliance. Because tax preparers update taxpayers' prior beliefs about their specific tax audit probability, some taxpayers learn that they are more likely to be audited than they suspected before hiring the tax preparer firm, which leads them to increase their reported incomes. On the other hand, some taxpayers learn that their audit likelihood is actually lower than they originally believed, causing them to lower their reported income. Conditional on a preparer hiring decision, under-reporting increases with income. Because demand for preparers determines which taxpayers will alter their reporting behavior, and revealing information about the audit rule will change the configuration of taxpayers who have access to information, the effect of publicly announcing the audit rule depends heavily on the nature of demand.

While this paper emphasizes the role of tax preparers as information aggregators, in reality a preparer firm might be providing other services that are not associated with helping agents illegally decrease income tax liability. A taxpayer might hire a tax practitioner in order to acquire or synthesize publicly available information about the tax system or to decrease the compliance cost (time, anxiety, etc). In contrast to the provision of information, which helps taxpayers evade more efficiently, because these services eliminate obstacles to voluntary compliance, greater solicitation of preparers may increase compliance, and therefore the government may consider these services desirable. Though clearly germane to understanding the effects of preparers on compliance, my model does not allow for these channels: I assume that preparers only offer strategic tax planning via information provision.

The rest of the paper is structured as follows. In the next subsection 1.1.1, I review the existing literature. Section 1.2 develops the model, and is divided into several subsections: in subsection 1.2.1, I solve the agents' problem; in subsection 1.2.2, I characterize the demand for preparers, and show how each parameter affects demand under perfect competition. In section 1.3, I analyze how the government can influence compliance levels. To do so, I first examine ex-post evasion levels in subsection 1.3.1 and then the effect of information revelation by the government in subsection 1.3.2. In the next section, 1.4, I consider the implications of an income dependent cost function. Section 1.5 discusses possible policy implications and section 1.6 delivers concluding remarks. Finally, the appendix **??** goes through omitted equations and proofs and it also includes an analysis of a monopolist preparers' behavior (A.1.6.1), a brief discussion of the effect of tax preparers when they have imperfect information and a short discussion of the change in results when agents are assumed to be risk-averse rather than risk-neutral(A.1.6.3).

1.1.1 Literature Review

Following Allingham and Sandmo (1972)'s model of tax evasion as an expected utility maximization problem, the subject has been widely analyzed, both empirically and in theory. Previous literature, especially the theory, has been predominantly centered on the taxpayer. Given the extensive reliance of taxpayers on preparers, the omission of tax preparers from these models is a potentially significant oversight. Though there was some interest in preparers in the late 1980s and early 1990s, most recent studies do not incorporate potential effects of tax preparer firms. Furthermore, although the information asymmetry among these preparers, the government, and taxpayers is frequently referenced in the literature, it has never been formalized. These asymmetries, in combination with the increase in prepared returns, underlines the necessity of a general theory that can model the role of tax preparer as information aggregators more comprehensively.

1.1.1.1 Theory

This paper is closely related to public finance literature on tax preparers. Starting in the late 1980s, a group of public finance theorists noticed the ever growing tax preparer market and its influence. Most theoretical studies in this literature focus on the service aspect of preparers, by analyzing their role as information providers or reducers of tax complexity to understand the underlying incentives of taxpayers when making the decision of whether to self-prepare or seek professional help.

The model presented in this paper most closely resembles Scotchmer (1989), who focuses on tax preparers' role as uncertainty reducers. She characterizes optimal audit strategies of a government whose sole objective is to maximize expected payments. In her framework, agents receive either a low or a high signal which provides them partial information about their own taxable income. Taxpayers can resolve the uncertainty by seeking professional tax advice. The optimal enforcement policy suggests that the enforcement agency raises the highest tax revenue when the taxpayers do not have more information about their own true tax liability than the enforcement agency. In this case, not all agents hire a tax advisor, hence the uncertainty works in favor of the agency. However, this result is driven by the underlying assumption that agents can and will over-report when subject to uncertainty. Additionally, in equilibrium, only agents who received a low signal end up seeking tax advice. This result heavily depends on the agents' prior signal structure, specifically that the true income distribution is the same for both income signal types. In contrast, in my model, over reporting is never an issue, higher income agents are more likely to hire a tax preparer firm and decreasing demand for tax preparers or increasing uncertainty does not always benefit the enforcement agency.

On the other hand, Reinganum and Wilde (1991) focus on the role of tax preparers as reducers of tax complexity, and firms providing this service alone- i.e, not playing any role in facilitating evasion- might decrease compliance levels. Taxpayers in this model have full information about the government's enforcement tools as well as the tax laws, yet they might prefer to hire a tax preparer to reduce return preparation costs and self-representation costs in case of enforcement proceedings. The presence of tax preparers lowers aggregate compliance regardless of who controls the reporting decision, but the compliance level is affected by who controls the reporting decision. Conditional on hiring a professional, the more influence a taxpayer has over her reported income, the lower tax compliance will be. Because my results suggest that when preparers sell privileged information evasion rates increase, Reinganum and Wilde's result may be amplified if the informational aspect of tax preparers were also included.

Slemrod (1989) also looks at the role tax preparers play in reducing compliance cost. In his paper, the taxpayer trades off between dedicating her own time and purchasing professional tax advice in order to uncover legitimate ways to reduce taxable income. Tax evasion of any form, such as claiming illegal deductions or misreporting taxable income, is not considered in this model. The model has two significant predictions; first an increase in marginal tax rate increases the marginal value of reducing taxable income, which in turn increases either own time spent on tax matters or the expenditure on professional tax advice; second, if these two are complements, the taxpayer will choose to increase both. Unlike Slemrod's model, my model features a binary hiring decision and allows for evasion.

Although this paper does not engage with optimal audit questions, it is informed by the literature on ”cutoff” rules. Reinganum and Wilde (1985) first introduced this class of audit rules, in which every taxpayer with a reported income below a certain threshold is audited with a fixed probability. They show that cutoff rules weakly dominate random audit rules. Cutoff, however, are thought to be unrealistic and not credible because they have the regressive result that the only taxpayers who get audited are low-income individuals who report truthfully. Scotchmer (1987) relaxed the assumption that a tax authority can only observe reported income and showed that if taxpayers are assigned into difference audit classes, a tax schedule with a cutoff audit rule will be regressive within an audit class but progressive overall. Finally, Sanchez and Sobel (1993) characterized all the conditions under which the optimal audit rule is a unique cutoff. Following this literature, my paper exogoneously assumes a cutoff audit rule.

1.1.1.2 Empirical

Empirical studies on the influence of professional tax preparation tend to focus on determinants of demand for the service rather than its effect on compliance, mainly due to the lack of compliance data on paid versus self-prepared returns. The main findings of this body of research suggests that the usage of professional tax services is positively correlated with income, self-employment, complexity, and age (Slemrod and Sorum (1984), Long and Caudill (1987), Slemrod (1989), Dubin et al. (1992)).

Measuring the extent of tax return preparers' influence on the tax compliance equilibrium is challenging, especially absent comprehensive noncompliance data. In addition, it is difficult to identify whether the noncompliance behavior is deliberate, and to determine whether this behavior should be attributed to the taxpayer or tax preparer. For example, Long and Caudill (1987) find evidence that income tax liability is relatively lower on professionally-prepared returns compared to self-prepared returns, but data limitations prevent assessment of how much of this reduction is due to legitimate or illegitimate activities. Despite these challenges, there are several empirical papers that tackle this question. Klepper and Nagin (1989) argue that tax preparers can serve two distinct roles, depending on the level of ambiguity that arises from the complexity of the tax code. In certain situations, they can increase noncompliance by exploiting ambiguity in favor of the taxpayer. Under different circumstances, they can increase compliance by enforcing legally transparent features of the tax code. To further analyze this claim, Klepper, Mazur and Nagin (1991) first develop a theoretical model where taxpayers have two sources of income: ambiguous and unambiguous. Detection of the former is harder, and the penalty from misreporting ambiguous income is also lower. Their empirical results support the aforementioned enforcer/ambiguity-exploiter effect. Erard (1993) analyzes tax preparation mode and tax compliance as a joint problem by defining three modes of preparations: by a Certified Public Accountant (CPA) or a lawyer, assistance from a non-CPA or a non-lawyer, and self-preparation. CPAs and lawyers provide a wider range of services including representation of their clients in legal proceedings with the IRS, and tend to have more qualifications than other preparers. He concludes that while tax return preparers do fulfill a socially beneficial role in reducing barriers to voluntary compliance, their use, especially the first mode of preparation, is associated with higher level of non-compliance. In a subsequent paper, Erard (1997) extends this research by attempting to differentiate between unintentional reporting errors and deliberate non-compliance. His results include that, while professionally prepared returns are less likely to contain unintentional mistakes and deliberate misreporting, the magnitude of non-compliance for professionally prepared returns is higher.

In summary, both the theoretical and empirical evidence suggest that tax preparers have a substantial influence over taxpayers' compliance decisions and that there exists a positive correlation between the usage of tax preparers and level of noncompliance. Yet, most of the existing models in the literature do not consider the information asymmetry between the IRS, tax preparer firms, and the taxpayer, nor how preparers can affect these asymmetries through information provision.

1.2 Model

In this section, I model the strategic interaction between taxpayers and tax preparer firms. The government, without observing true income, audits all taxpayers who report income below a pre-determined threshold. Taxpayers know that such a threshold exists but they do not know what income it is; they believe that it is uniformly distributed in an interval whose midpoint is the actual cutoff. In contrast, preparers know the actual threshold.

Though highly stylized, the "cutoff" audit rule in my model draws from real-life audit policy. For example, as mentioned before, in the U.S., the IRS uses a computer algorithm (DIF). Generally, the higher the score, the more likely it is that a return is audited. Even though there is no credible, publicly available information about how DIF scores are computed or how scores translate into audit probability, it is conceivable, if not plausible, that the structure resembles a cutoff rule based on observable characteristics. The audit rule in my model is a specialized case of such a policy: the only information observable to the government is reported income. Cutoff rules of this nature may seem counter-intuitive, as ultimately, only lower-income individuals get audited. However, similar to Scotchmer (1987), it is more appropriate to think of the income distribution assumed in my model as an audit *class* based on some observables, rather than as representative of the whole economy. [3] Moreover, Sanchez and Sobel (1993) show that the optimal audit rule is a unique cutoff under the following conditions were to hold; (i) taxpayers are risk-neutral, (ii) the penalty schedule is linear, and (iii) (if the tax is linear) the hazard function[4] for the income distribution decreases. In my model all three of these conditions are satisfied. Similarly, while in reality, taxpayers and government engage in a repeated game, I assume actors move simultaneously in one single period. Specifically, I assume that the government commits to the audit rule ex-ante, which is also consistent with the optimal audit rules studied in the theoretical literature. Scotchmer (1987), Sanchez and Sobel (1993).

I begin by assuming that the tax return preparer market is competitive, with each firm having the same constant marginal cost, c, of preparing another return. In the actual tax preparer market, even though there are industry leaders, non-employers and small firms constitute a plurality of the market therefore, the concentration of the market is low. In the appendix, I consider the alternative extreme case of a monopoly in the preparer market in order to provide insight into the relevance of market structure. The real world market for preparers falls somewhere between these two extremes.

I assume that firms have perfect information and taxpayers' beliefs are centered around the actual audit rule. This information structure enables presentation of closed form solutions while capturing the essence of the information asymmetry present in the economy.

In reality, tax preparer firms do not have perfect information and they do vary with respect to the type and/or quality of information they have, based on the taxpayer type. Section 5 relaxes the perfect information assumption and analyzes a case where firms also have beliefs that are a mean-preserving spread of the actual audit threshold, and shows that if their beliefs are more precise than what agents believe; all results from the simple case hold in this case as well.

The timing of the events is as follows:

[3]For example, an audit class can be all doctors living in the Detroit metropolitan area. Then a cutoff rule might dictate auditing all doctors living in metropolitan Detroit area who report below $\$50.000$.

[4]The hazard function in this context is $\frac{1-F(y)}{f(y)}$.

1. The tax rate (t) and the audit threshold (ω) are determined.

2. (ω) is revealed to the tax preparer firms; this revelation common knowledge.

3.1 Agents believe that the audit threshold is uniformly distributed in the interval $[\underline{\beta}, \overline{\beta}]$ without knowing the actual cutoff. They also know the tax preparer firms know the actual audit cutoff.

3.2 Given these beliefs, taxpayers choose whether to hire a firm or not.

3.3 Based on the hiring decision, taxpayers report income (r)

3.4 The government observes reported incomes and audits everyone with $r < \omega$. True income of all audited agents is revealed and a penalty rate of $\pi > 1$ is levied on the amount of evaded tax.[5]

1.2.1 Agents

Given their beliefs about the firm and about the government's enforcement tools, risk-neutral agents first decide whether to self-prepare or hire a firm. Because firms have perfect information, a taxpayer who hires a preparer has zero probability of being audited; she trades off between the risk of audit and the fee of paying a firm. Conditional on the hiring decision, agents choose reported income to maximize expected post-tax income.

The belief structure implies that an agent with income less than $\underline{\beta}$ correctly believes that she will be audited with certainty, hence she will report her true income accurately; she has no gains from hiring a firm. Moreover, all agents correctly believe that any reported income above $\overline{\beta}$ will not be audited, hence no agent will report income larger than $\overline{\beta}$ in any equilibrium.

First, consider an agent who doesn't hire a firm, and let *x* denote the random variable (the audit threshold).

The expected income of an agent with income greater than $\underline{\beta}$ when she doesn't hire a firm is as follows:

$$Pr(x < r)(y - tr) + (1 - Pr(x < r))(y - tr - \pi(y - r)t) \quad (1.1)$$

[5]In the U.S. the penalty is indeed levied on the amount of evaded tax. Many theoretical models, including the canonical work of Allingham and Sandmo (1972), assume that the penalty is proportional to the undeclared income. If this is the case, the effect of the marginal tax rate on evasion is driven by opposing substitution and income effects. If the penalty is on the evaded tax, the substitution effect vanishes. See Yitzhaki (1974) for a detailed analysis.

$$= \frac{r - \underline{\beta}}{\overline{\beta} - \underline{\beta}}(y - tr) + \frac{\overline{\beta} - r}{\overline{\beta} - \underline{\beta}}(y - tr - \pi(y - r)t) \tag{1.2}$$

Solving the FOC gives the following optimal report:

$$r^*(y) = \frac{\pi y + \pi\overline{\beta} - (\overline{\beta} - \underline{\beta})}{2\pi} \tag{1.3}$$

This function linearly increases in income and decreases in the belief spread, $(\overline{\beta} - \underline{\beta})$, i.e. uncertainty.

Notice that, it should be the case that $r^*(y) \leq \min\{y, \overline{\beta}\}$ because we are assuming an interior equilibrium. However, there might be agents who do not find it optimal to risk being audited. Moreover, as mentioned before, no agent will report income higher than $\overline{\beta}$. Taking this constraint into consideration, define $\overline{y}$ to be the lowest income level above which an agent always reports $\overline{\beta}$, and $\underline{y}$ to be the highest income level below which an agent always reports his true income. The optimal reporting schedule of an individual who does not hire the firm can then be stated as the following piece-wise function:

$$r_{self} = \begin{cases} y & \text{if} \quad y \leq \underline{y} \\ r^*(y) & \text{if} \quad y \in [\underline{y}, \overline{y}] \\ \overline{\beta} & \text{if} \quad y \geq \overline{y} \end{cases} \tag{1.4}$$

where $\underline{y} = \frac{(\pi-1)\overline{\beta}+\underline{\beta}}{\pi}$ and $\overline{y} = \frac{(\pi+1)\overline{\beta}+\underline{\beta}}{\pi}$.

The value of the expected income is as follows:

$$EI_{self} = \begin{cases} y(1-t) & \text{if} \quad y \leq \underline{y} \\ \frac{r^*(y)-\underline{\beta}}{\overline{\beta}-\underline{\beta}}(y - tr^*(y)) + \frac{\overline{\beta}-r^*(y)}{\overline{\beta}-\underline{\beta}}(y - tr^*(y) - \pi(y - r^*(y))t) & \text{if} \quad y \in [\underline{y}, \overline{y}] \\ y - \overline{\beta}t & \text{if} \quad y \geq \overline{y} \end{cases} \tag{1.5}$$

Now consider an agent who hires the firm. In this case, from the agent's point of view, her individual reporting strategy prescribed by the firm is as follows: [6]

$$r_{firm} = \begin{cases} y & \text{if} \quad y \leq x \\ x & \text{if} \quad y \geq x \end{cases} \tag{1.6}$$

[6] Note again that firms know the cutoff, and the agents know this.

The expected utility of an agent with income $\overline{\beta} > y > \underline{\beta}$ if she hires the firm is

$$Pr(x < y|\underline{\beta} < x < \overline{\beta})\mathbb{E}(y-tx|\underline{\beta} < x < min\{y,\overline{\beta}\})+(1-Pr(x < y|\underline{\beta} < x < \overline{\beta}))(y-ty) \quad (1.7)$$

$$= \frac{y-\underline{\beta}}{\overline{\beta}-\underline{\beta}}(y - t\frac{y+\underline{\beta}}{2}) + \frac{\overline{\beta}-y}{\overline{\beta}-\underline{\beta}}(y-ty) \quad (1.8)$$

Therefore, expected income under firm preparation, conditional on true income y, is

$$EI_{firm} = \begin{cases} y - ty - c & \text{if} \quad y \leq \underline{\beta} \\ \frac{y-\underline{\beta}}{\overline{\beta}-\underline{\beta}}(y - t\frac{y+\underline{\beta}}{2}) + \frac{\overline{\beta}-y}{\overline{\beta}-\underline{\beta}}(y-ty) - c & \text{if} \quad y \in [\underline{\beta},\overline{\beta}] \\ y - t(\frac{\overline{\beta}+\underline{\beta}}{2}) - c & \text{if} \quad y \geq \overline{\beta} \end{cases} \quad (1.9)$$

An agent will hire a firm if, given her true income, her expected income when in this case is greater than her expected income when she doesn't hire the firm i.e, when $EI_{firm} > EI_{self}$.

1.2.2 Demand

Let $EI_{dif} = EI_{firm} > EI_{self}$. As shown in the appendix, this difference increases in taxpayer income.

$$\frac{\partial EI_{dif}}{\partial y}|_{y>\underline{\beta}} > 0 \quad (1.10)$$

Because the marginal cost is constant, if an agent with income y decides to hire the firm, all agents with incomes above y will find it optimal to do so as well. Therefore, demand for tax preparation will be characterized by a single cutoff.

Let m be the highest possible true income in the distribution. Then demand, denoted by $D(m, c)$, is characterized by range of incomes, $(m - y_d(c))$, where $y_d(c)$ denotes the income level of the taxpayer who is indifferent between hiring a firm or not. Given the marginal cost, this cutoff income level can fall into four different intervals. Solving for each possible case gives the following cutoff function: [7]

$$y_d(c) = \begin{cases} y_y = \underline{\beta} + \sqrt{2} + \sqrt{\frac{c(\overline{\beta}-\underline{\beta})}{t}} & \text{if} \quad 0 \leq c \leq \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \\ y_r = \frac{\underline{\beta}+\sqrt{2}\sqrt{\frac{2c(\pi-2)\pi+(\pi-1)^2 t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}-\pi\overline{\beta}}{\pi-2} & \text{if} \quad \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \leq c \leq \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \\ y_{\overline{\beta}} = \frac{(-\underline{\beta}+\sqrt{2}\pi\sqrt{\frac{(2c+t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}+\pi\overline{\beta}}{\pi} & \text{if} \quad \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \leq f \leq \frac{(\overline{\beta}-\underline{\beta})t}{2} \\ m & \text{if} \quad c > \frac{(\overline{\beta}-\underline{\beta})t}{2} \end{cases} \tag{1.11}$$

Note that even though it is a piece-wise function, the demand function is continuous and concave in c as long as $c \leq \frac{(\overline{\beta}-\underline{\beta})t}{2}$; if $c > \frac{(\overline{\beta}-\underline{\beta})t}{2}$ the demand is zero.

1.2.2.1 Comparative Statics

Table 1 depicts how each parameter affects the cutoff point of demand, given all possible parameter specifications. The effect on demand for preparers has the opposite sign of the effect on the income cutoffs because the demand decreases one to one with the cutoff.

Table 1.1: Comparative static effects of parameters
on tax preparer demand cutoffs and aggregate demand of preparers

	y_y	y_r	$y_{\overline{\beta}}$	$D(m,c)$
$\underline{\beta}$	$+$	$+$	$+$	$-$
$\overline{\beta}$	$+$	$+$	$+/-$	$+/-$
$(\overline{\beta}-\underline{\beta})$	$-$	$-$	$-$	$+$
c	$+$	$+$	$+$	$-$
t	$-$	$-$	$-$	$+$
π	0	$-$	$-$	$+$

† The column y_y shows the sign of the effect of an increase in each parameter when taxpayers with income higher than y_y hire the firm. The next column shows the same when the demand cutoff is y_r. Column $y_{\overline{\beta}}$ depicts the sign of the effects when the demand cutoff is determined by the function $y_{\overline{\beta}}$. Finally, the last column, $D(m,c)$, shows the sign of the effects of parameters on the aggregate demand of preparers.

[7] These cutoffs are actually functions of marginal cost but I simplify by suppressing the notation.

The effects of c, t, and π on demand are intuitive. It is straightforward to see that the demand for preparers decreases with the marginal cost c because an increase in marginal cost decreases the expected income from hiring a firm without affecting the expected income of self-preparing. The result that demand is increasing in the income tax rate t follows from the fact that penalty is levied on the evaded tax (rather than on the evaded income); this relationship is in line with the results of empirical studies (Slemrod and Sorum (1984), Long and Caudill (1987), Slemrod (1989)). Finally, if the demand cutoff falls above $\underline{y}$, the highest income level of a taxpayer who reports truthfully, an increase in the penalty rate leads to a demand increase. If the cutoff demand is below $\underline{y}$, the cutoff is unaffected by the penalty rate because the agent who is indifferent does not have a risk of being audited, due to the fact that she always reports truthfully.

It is less straightforward and therefore more interesting to analyze the effect of a change in $\underline{\beta}$, $\overline{\beta}$ or in the spread of beliefs, $(\overline{\beta} - \underline{\beta})$. The variables $\underline{\beta}$ and $\overline{\beta}$ have a direct effect on the probability of audit and reported income. An increase in either always leads to a decline in expected income, no matter what preparation method an individual chooses. When there is an increase in $\underline{\beta}$, the decrease in expected income in the case where a firm is hired is larger than the decrease in expected income otherwise, causing a decrease in the net benefit of the firm to the agents. This implies that an increase in $\underline{\beta}$ always induces an increase in any possible cutoff and therefore a decrease in demand. Similarly, if the demand cutoff falls anywhere below $\overline{\beta}$, an increase in $\overline{\beta}$ causes a firm's net benefit to all agents to decrease and therefore causes the income cutoffs to rise.

However, if the demand cutoff is between $\overline{\beta}$ and $\overline{y}$, the effect is not obvious. Consider a taxpayer whose income falls into this range. She knows that if she hires a firm she'll successfully evade without facing any risk of audit, which dampens the negative effect of a $\overline{\beta}$ increase on expected income when a firm is hired. On the other hand, in the same interval a self-preparing agent is also evading and her optimal reported income is below $\overline{\beta}$; therefore, she still has a positive probability of an audit. Moreover, the self-preparing agent's expected income function is strictly convex in this region, which implies that the magnitude of the (negative) change in demand is increasing in the level of $\overline{\beta}$. Putting all these effects together, one can conclude that if the demand cutoff is between $\overline{\beta}$ and $\overline{y}$, an increase in $\overline{\beta}$ first causes a decrease in demand at a decreasing rate and after a threshold, it actually increases the demand. Finally, a higher spread of agent's beliefs is unambiguously associated with a higher demand for tax preparer services. This is because as the spread of the beliefs gets larger, uncertainty in the case of self-preparation increases, which in turn increases the expected net benefit of hiring a firm.

1.3 Information Revelation by Government as an Instrument of Compliance

The aim of this section is to understand how the government can influence compliance levels by strategically revealing information about the audit rule. In order to do that, I first analyze individual and aggregate reporting behavior and show how the total change in reported income depends on the demand for tax preparation services.

1.3.1 Evasion

Consider the following table, which summarizes reported income for each possible level of real income and each type of preparation (self-preparation or by a firm). Define y_ω to be the income level where an agent reports exactly ω whether she hires the firm or not.

Table 1.2: Reported income

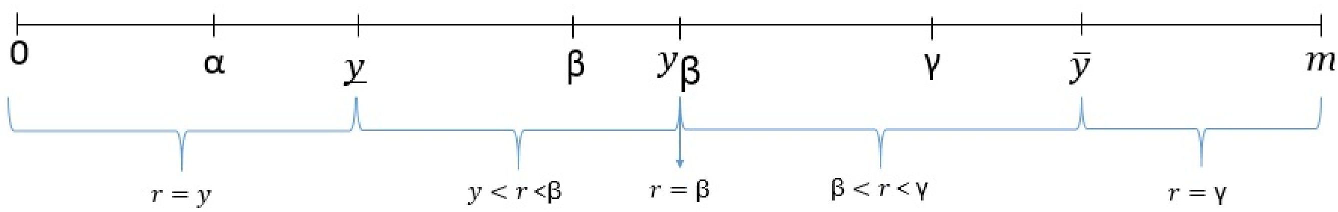
Real income	No Firm	With Firm	$\triangle$
$y \leq \underline{y}$	y	y	0
$\underline{y} \leq y \leq \omega$	$r^*(y)$	y	+
$\omega \leq y \leq y_\omega$	$r^*(y)$	ω	+
$y_\omega \leq y \leq \overline{y}$	$r^*(y)$	ω	-
$\overline{y} \leq y$	$\overline{\beta}$	ω	-

† The column Real Income depicts the real income ranges of the taxpayers. The No Firm column depicts the reported income of taxpayers if they do not hire a firm. The With Firm column shows ex-post reported income of taxpayers if they hire a firm. Finally, the column denoted by Δ represents the change in aggregate reported income when taxpayers hire firms.

†† y_ω denotes the income level of an agent who reports ω regardless of the preparation method.

To illustrate the equilibrium, Figure 1 depicts an example of reported income as a function of true income for a given parameter specification. The dashed line is the 45° line (i.e., truthful reporting), the blue line depicts reported income when agents hire a firm, and the orange line depicts reported income when agents self-prepare. The difference between each line and the 45° line will give the total evasion in each case. The green shaded area represents the increase in reported income when taxpayers within that income range hire a firm, whereas, the red shaded area depicts the decrease in reported income when taxpayers within that income range hire a firm. The difference between the green shaded area and the red shaded area gives the total change in reported income.

Figure 1.1: Reported income as a function of real income and preparation type



Parameter values: $\underline{\beta} = 100$, $\overline{\beta} = 550$, $c = 11$, $t = 0.2$, $\pi = 1.1$, $m = 1000$

One important observation is that, conditional on the hiring decision, evasion (the difference in height between the green dashed and the orange or blue line) is non-decreasing with income. Similarly, the change in reported income when a taxpayer chooses to hire a firm (the difference in height between the orange and blue lines) also increases with taxpayer income.

When $y < \underline{y}$, the agent's ex-post reported income is her true income whether she hires a firm or not; the change in reported income is unaffected. If her true income is greater than $\underline{y}$ but less than ω, her ex-post reported income is higher when she hires the firm. This is due to the fact that the firm knows that her real income is less than the audit threshold and she will be audited for sure, and so advises her to report her true income. However, if she does not hire the firm, she will be choosing her reported income with respect to the optimal reported income rule, defined in section 1.2.1, which is less than her true income. Similarly, if the true income is between ω and y_{ω}, an agent who chooses not to hire the firm will end up reporting less income than if she did employ the firm. Even though an agent with this level of income is evading, regardless of whether she hires a firm or not, the optimal report when she hires the firm is less than ω in this range. On the other hand, if an agent's true income exceeds y_{ω}, her optimal reported income will exceed ω and because the reported income increases in true income, all agents with higher income will also have higher reports. In contrast, if she hires the firm, she and everyone with income higher than hers will report ω. This implies that the change in evasion from hiring a tax preparer is increasing with income for agents with income greater than y_ω.

Inspection of the graph might suggest that the sign of the total change in evasion from the introduction of tax preparation firms may be ambiguous, depending on the demand cutoff point: it seems that if the cutoff point is low enough (less than y_ω), the decrease in evasion from low-income taxpayers can dominate the increase in evasion from high-income taxpayers, while, if the demand cutoff is high enough (greater than ω), those who choose to hire a firm will always decrease their reported income relative to self-preparation. The following proposition shows that, in fact, the former is never true: the aggregate change in evaded income when tax preparation services become available is unambiguously positive.

Tax preparation firms decrease total compliance.

By using Table 1.2 we can compute the greatest lower bound for the change evasion in any equilibrium. There are two possible candidates for the greatest lower bound; the first is defined by the change in reported income when everyone hires the firm, whereas the second is when only the agents with the highest income level $(y > \overline{y})$ hire a firm. In the first case, if the increase in the reported income for people with real income in $[\underline{y}, y_\omega]$ dominates the decrease in the reported income of people with real income above y_ω, then the first candidate (call it $\underline{\triangle r_1}$) will be the lower bound. However, if this offset is not strong enough, the second candidate ($\underline{\triangle r_2}$) might be the greatest lower bound. Formally, the two candidate lower bounds are

$$\underline{\triangle r_1} = \int_{\underline{y}}^{\overline{y}} r^*(y)dy + \int_{\overline{y}}^{m} \overline{\beta} dy - \int_{\underline{y}}^{\omega} ydy - \int_{\omega}^{m} \omega dy > 0 \tag{1.12}$$

$$\underline{\triangle r_2} = \int_{\overline{y}}^{m} (\overline{\beta} - \omega) dy > 0 \tag{1.13}$$

As shown in the appendix, given the assumptions of the model, both equations always yield positive values, and the second one always yields a lower value than the first one; the latter is the greatest lower bound. Because the greatest lower bound is always positive, the existence of firms always decreases compliance.

Notice that the above result depends on the income distribution. We have to this point been assuming a simple uniform distribution, which assigns the exact same mass for each income point. Because evasion increases with income, conditional on hiring decision, this result will hold for any distribution that has a thicker right end tail. However, the uniform distribution is not meant to be representative of the whole economy, but only of the income distribution within a specific audit class. If the income distribution within an audit class is such that the mass falls heavily on the lower end, this result might be reversed.[8]

1.3.2 The Impact of Revealing Full Information about the Audit Cutoff

In this section, I consider what would happen if the tax agency made its audit rule public. First, notice that in an economy with a competitive tax preparation industry, the government announcing the audit cutoff ω would have the same impact as if all taxpayers could suddenly obtain the firm's services for free. This is because anyone with an income below ω will report their true income, whereas anyone with an income above ω will report ω. If the demand cutoff falls below $\underline{y}$, the government's announcement will have no effect because all taxpayers who does not report true income when they self-prepare have access to the audit information already. However, if this is not the case, it is not immediately evident whether announcing the audit threshold will increase or decrease aggregate evasion. To see why, consider the case where demand for preparers starts with income y_ω, the least upper bound for evasion. If the government announces ω, then all agents with income $\in [\overline{y}, y_\omega]$ will increase their report, while everyone with income above y_ω will not change their behavior; therefore the total compliance rate increases. On the other hand, suppose that demand starts with the agent with true income $\overline{y}$; by the above proposition, this is the case where the lowest level of change in evasion occurs in an equilibrium. Therefore, if the government announces ω, the decrease in the reported income of people with real income above y_ω offsets the increase in reported income of agents with real income $\in [\underline{y}, y_\omega]$, so that overall compliance decreases. One important observation is that the government changing ω without an announcement will not have any impact on the agent's problem because agents do not know the actual threshold when they are making their decisions, and hence, they do not incorporate the actual cutoff in their problem.

If the demand for tax preparers is sufficiently high, the government can decrease noncompliance by revealing full information.

Consider the following two cases:

Case 1: Suppose $y_d = y_\omega$, which is the case with the highest possible increase in evasion. In this case, demand for tax preparation services consists of the agents who decrease their reported income when they hire a firm. If the government reveals full information, i.e. announces ω, all agents with income $y \in [\underline{y}, y_\omega]$ increase their reports. On the other hand, agents with income $y \in [y_\omega, m]$ do not change their behavior. Therefore in this case, evasion decreases. Thus, the folk wisdom hat revealing the audit rule would increase evasion is

[8]Interested readers should refer to the appendix for characterization of the upper bound on the change in evasion, and the characterization of reported income and changes in evasion given any parameter specification.

not necessarily correct, because the reasoning behind neglects the fact that some taxpayers, specifically the ones who are evading successfully, already have access to this information. *Case 2*: Now suppose $y_d = \overline{y}$. This is the case with the lowest possible change in evasion. If ω is revealed, all agents with income $y \in [\underline{y}, y_\omega]$ increase their reports. However, the agents with income $y \in [y_\omega, \overline{y}]$ decrease their reports, and agents with income $y \in [\overline{y}, m]$ do not change their behavior. From Proposition 1 we know that the decrease in reports offsets the increase in reports, hence evasion increases.

Because evasion is continuously decreasing in the demand cutoff in the interval $[y_\omega, \overline{y}]$, there exists an income level, say $\tilde{y}$, in that interval such that if $y_d = \tilde{y}$, the government's announcement has no effect on evasion. However, if $y_d < \tilde{y}$, announcing the audit rule will increase compliance and if $y_d > \tilde{y}$, this announcement will decrease compliance.

1.3.3 Reported Income Comparative Statics

In addition to affecting the demand for tax preparer services, changing any of the model parameters also has an effect on the reported income schedule of agents. Table 3 summarizes these effects conditional on cutoff income levels for demand.

Table 1.3: Comparative static effects of parameters on reported income

$y_d =$	y_y	$y_r\|_{y_r<y_\omega}$	$y_r\|_{y_r>y_\omega}$	$y_{\overline{\beta}}$	m
c	0	$-$	$+$	$+$	0
t	0	$+$	$-$	$-$	0
π	0	$+$	$+$	$+$	$+$
$(\overline{\beta} - \underline{\beta})$	0	$+/-$	$-$	$-$	$+/-$

† The column y_y shows the change in reported income when taxpayers with income higher than y_y hire the firm. The next two columns show the change in reported income when the demand cutoff is y_r, for the two sub-cases when the cutoff is less than or greater than y_ω. Column $y_{\overline{\beta}}$ depicts the change when the demand cutoff is determined by the function $y_{\overline{\beta}}$. Finally, the last column, m, shows the change when in reported income when no one hires the firm.

In the case where the demand cutoff is determined by the function y_y, all agents who do not report income truthfully have access to the audit information already. Therefore, a change in any parameter does not affect reported income.

The analysis of evasion in section 1.3.1 suggests that reported income increases in demand when the income cutoff is less than y_ω and it decreases in demand when the cutoff is above y_ω. An increase in marginal cost decreases the demand for preparation services without affecting any other variable, so an increase in c will increase aggregate reported income if the demand cutoff is less than y_ω and decrease it otherwise. Similarly, an increase in the marginal tax rate increases the demand for preparation services without affecting any other variable. Therefore, when t increases, aggregate reported income increases if the demand cutoff is less than y_ω, and it decreases otherwise. However, a change in π not only affects the demand, but also affects reporting behavior of self-preparers. An increase in the penalty rate unambiguously increases the reported income of self-preparers while also increasing the number of taxpayers who choose to hire a preparer. When the demand cutoff is less than y_ω, these two effects work in the same direction and increase aggregate reported income. On the other hand, when the demand cutoff is greater than y_ω, an increase in demand causes aggregate reported income to fall. However, this effect is dominated by the increase in self-prepared reported income so that the aggregate reported income increases. Finally, an increase in the belief spread decreases reported income but increases demand. When the demand cutoff is below y_ω, it is not obvious which effect dominates the other. However, when the demand cutoff is above y_ω, these two effects work in the same direction and aggregate reported income decreases.

1.4 Effect of Tax Preparation Firms When Tax Preparation Costs are Increasing in Income

In the previous sections, the marginal cost to a firm of preparing an additional tax return was assumed to be constant across all individuals. Now suppose the cost increases proportionally with income. Specifically, assume that firms face the marginal cost function $c(y) = cy : 0 < c < 1$. This assumption captures the fact that on average it is likely that complexity increases with income,[9] which in turn might increase the effort a tax preparer has to spend preparing an individual's return. Furthermore, even though in fact the taxpayer is usually the sole party who is liable in case of an audit, there are cases where the tax preparer is penalized as well. Because within this model's framework, evasion increases with income conditional on the hiring decision, an increasing cost function might also capture the potential fines an evasion-enabling firm might be subject to.

Because the tax preparer market is competitive, the price will be equal to marginal cost. As before, a taxpayer will hire a firm if her net benefit from doing so is greater than the fee she has to pay for the firm: $EI_{dif} = EI_{firm} - EI_{self} > cy$. In other words, demand

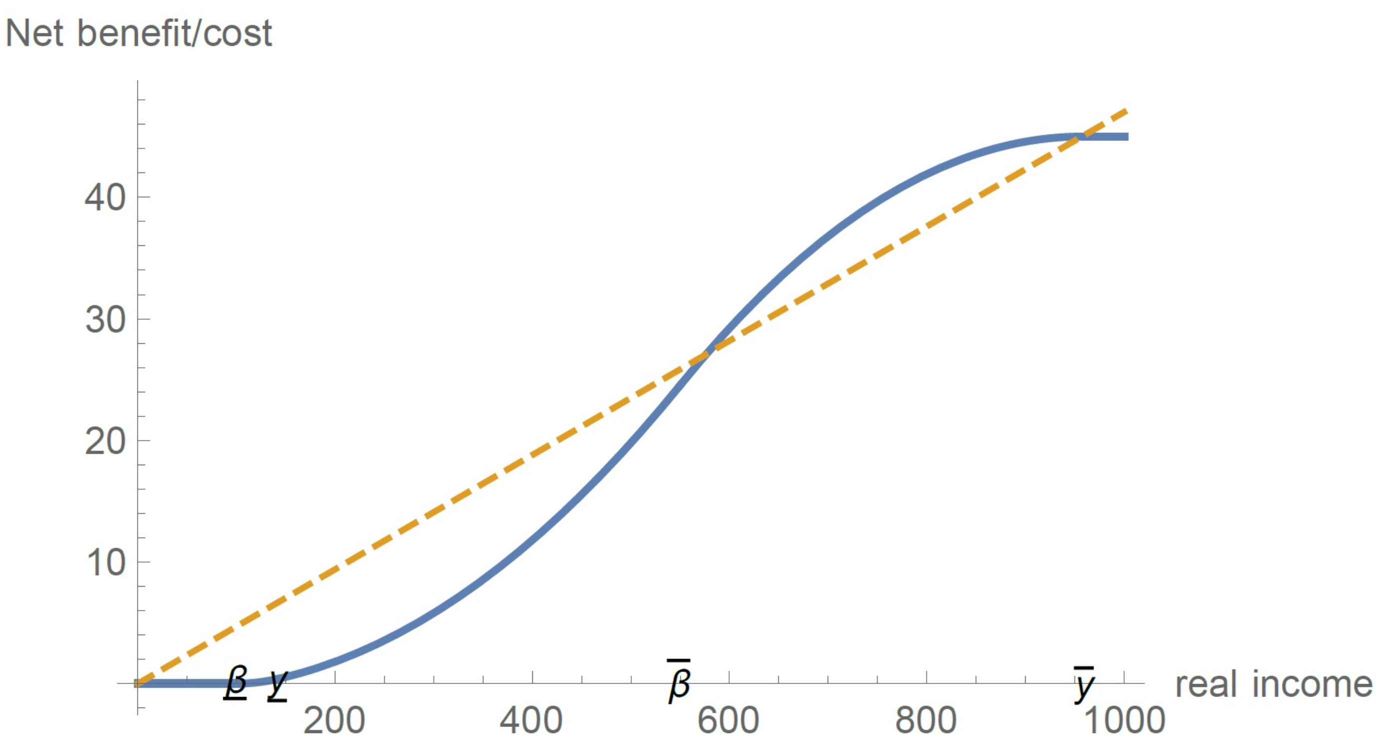
[9]This is generally true in the absence of credits. For example, claiming credits like EITC might cause the tax return to become quite complicated for low levels of income

is comprised of all income levels such that the EI_{dif} curve is above the $c(y)$ curve. In the constant marginal cost case, because of the fact that EI_{dif} increases in income, once it exceeds the cost curve it always stays above it. Therefore, if a taxpayer found it optimal to hire a firm, everyone with a higher income would also find it optimal to do so. However, if marginal cost is also increasing in income, this is not necessarily true. A sufficient condition for all the results from the previous analysis to hold is that the derivative of the cost function with respect to income to is bounded everywhere by the minimum derivative of the EI_{dif} curve. This guarantees that the EI_{dif} and cost curves cross only once, so that everyone with an income after the point of crossing benefits from hiring the firm.

If the EI_{dif} and $c(y)$ curves cross each other more than once, then it is possible that some people at the top of the income distribution do not hire a firm, whereas some people with lower income are doing so.

To see this consider the example illustrated in Figure 2.

Figure 1.2: Value of hiring a firm and the cost of hiring a firm

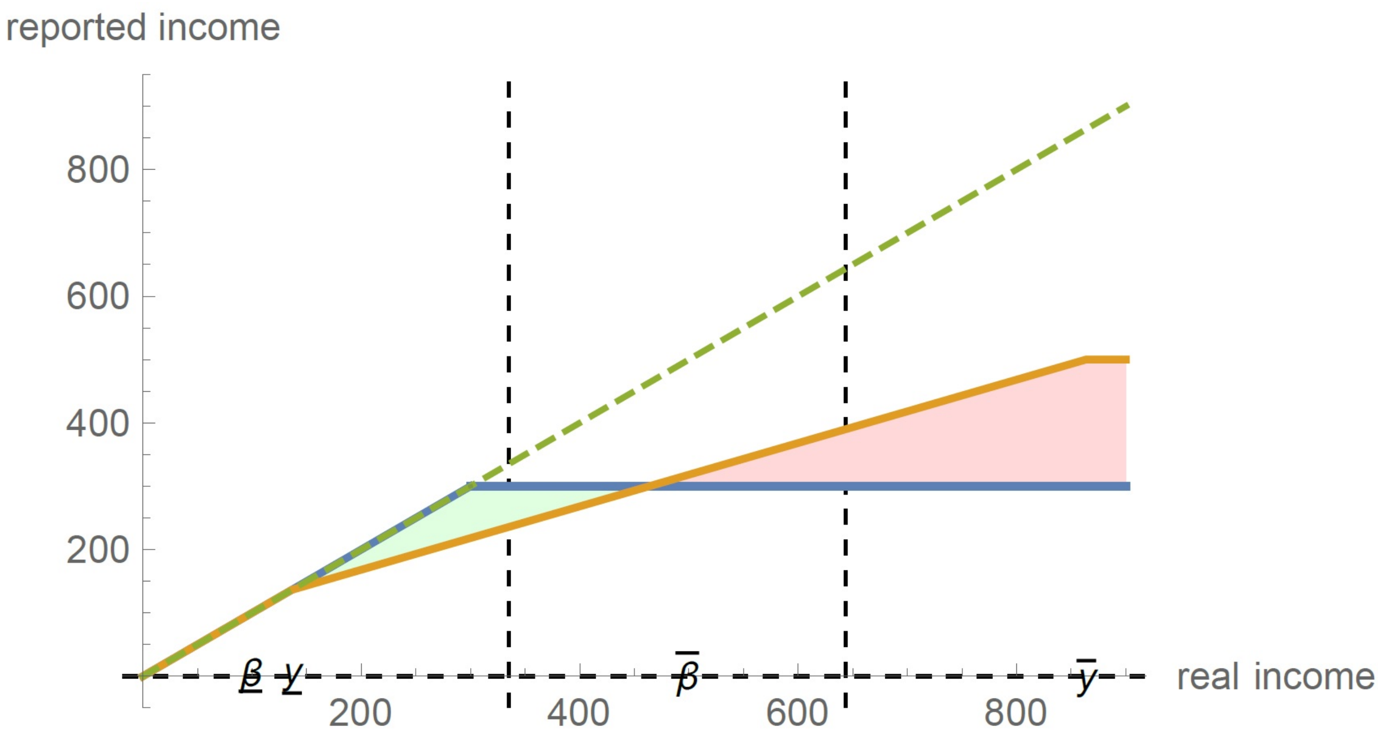


Parameter values: $\underline{\beta} = 100$, $\overline{\beta} = 550$, $c = 0.047$, $t = 0.2$, $\pi = 1.1$, $m = 1000$

In this example, the cost curve (thick orange line) crosses the expected income difference curve (dashed blue line) twice: first at income 586, and then at income 953. This means that only people in the interval $[586, 953]$ will seek professional assistance.

If the demand for preparers ends short of the top income, depending on where the interval falls, it is possible that firms decrease evasion. To see this, consider a hypothetical reported income graph below where demand for tax preparers is characterized by the interval between the black dotted lines. In this case, it is not straightforward to see whether the increase in reported income (green shaded area) will offset the decrease in reported income (red shaded area).

Figure 1.3: Reported Income when demand is not characterized by a single cutoff



Parameter values: $\underline{\beta} = 100$, $\overline{\beta} = 550$, $c = 0.047$, $t = 0.2$, $\pi = 1.1$, $m = 1000$, $D(m, c) = [335, 643]$

Similar to the constant cost case, solving for demand gives us four intervals that each demand cutoff can fall into. The full cutoff schedule is presented in the appendix, due to the large number of equations and conditions.

$$y_d(c(y)) = \begin{cases} y_y \in [\underline{\beta}, \underline{y}] \\ y_r \in [\underline{y}, \overline{\beta}] \\ y_{\overline{\beta}_1}, y_{\overline{\beta}_2} \in [\overline{\beta}, \overline{y}] \\ y_m \in [\overline{y}, m] \end{cases} \tag{1.14}$$

Cross checking the conditions where two cutoffs can co-exist gives us following cases:

- There is a single cutoff
- There are two cutoffs:
  - Demand is the interval $[y_y, y_m]$
  - Demand is the interval $[y_r, y_m]$
  - Demand is the interval $[y_{\overline{\beta}}, y_m]$
  - Demand is the interval $[y_{\overline{\beta}_1}, y_{\overline{\beta}_2}]$

When the marginal cost is characterized by cy, the availability of tax preparers increases evasion. In the first case, where there is a single-cutoff, all results from the constant cost case follows. Consider the cases in which the demand does not span the top income taxpayer. First notice that, in contrast to the case where there are no firms, only taxpayers who hire the firm might change their behavior. Moreover, looking at the reported income from Table 3 above, total reported income can increase only if a portion of demand falls below y_ω. Then in the last two cases, when demand is the interval $[y_{\overline{\beta}}, y_m]$ or $[y_{\overline{\beta}}, y_{\overline{\beta}}]$, firms will always increase evasion. Furthermore, in the first case, a bigger portion of taxpayers increase their reported income. Therefore, if firms increase evasion in the first case, they will also increase evasion in the second case; it is enough to show that noncompliance increases in the first case. As shown in the appendix, given the conditions that demand is the interval $[y_y, y_m]$, it is not possible for the change in reported income to be positive. Therefore firms increase evasion.

1.5 Policy Implications

In this theoretical framework, there are several tools available to an evasion-minimizing government to influence compliance levels. Depending on the demand cutoff, the government can fully reveal its audit rule to increase compliance levels. In cases, where this is not feasible, another option is to reveal partial information that decreases the belief spread. Alternatively, even though both the penalty rate and marginal tax rate are assumed to be exogenous, a higher penalty rate is always associated with a higher aggregate reported income, so another option is to raise the penalty rate. If the demand for tax preparation services is sufficiently high, increasing the tax rate will increase compliance levels; if demand is not sufficiently high, lower tax rates are associated with higher compliance. It is important to note that, the analysis conducted here is entirely positive; and does not speak to the about optimal level of regulation.

Because tax preparers always increase evasion in the model presented here, in the extreme, outlawing tax preparer firms might have a significant positive effect on total compliance. However, recall that this model considers only the influence of tax preparers as information aggregators. As mentioned before, a body of literature has highlighted tax preparers' role in reducing taxpayers' compliance costs. When incorporated, this role of a tax preparer can have a dampening effect over the influences of a tax preparer as information sellers. Therefore, the total effect of outlawing tax preparers without further analysis is not obvious. On the other hand, regulating tax preparers to limit the extent to which they can use taxpayer data to infer certain characteristics of the enforcement rules governed by the tax agency, and the preparers' ability to pass this information to the taxpayer, might increase compliance levels.

Even though total compliance levels fall with the presence of tax preparers, making them accessible to low-income individuals always increases compliance compared to a case where these individuals do not seek professional help. This is because for taxable income below the audit threshold ω, the incentives of the taxpayer and the government are aligned. A taxpayer who earns less than ω might be willing to risk under-reporting based on her prior belief. However, her decision is not ex-post optimal because she will be facing an audit with certainty. Both the tax agency and the taxpayer herself will prefer the case in which the agent reports her true income. In other words, it would be a Pareto improvement for the tax agency to reveal its audit rule to this specific agent. But the tax agency cannot selectively reveal information. In this case, if the government can target and incentivize the taxpayers who fall into this category to hire a firm, the compliance levels in the economy will unambigiously increase. One way to do this might be to tie firm profits to tax revenue. This will make taxpayers who report truthfully or increase their income when they hire a firm more valuable to the firm, therefore incentivizing the firm to cater to this group more than taxpayers who are evading.

1.6 Conclusion

By developing a model of taxation that accounts for the intermediary role of tax preparation firms, I have shown that the presence of these firms decreases the information gap between the taxpayer and the tax agency in favor of the former, and thus increases non-compliance levels in the economy. In certain cases, by decreasing this information gap itself, the tax agency can bypass the firms and counter this effect. One of the more striking ways to do this is to announce the actual audit rule. This is at odds with conventional wisdom as well as the behavior of IRS and, every tax agency in the world.

The model also implies that an alternative, less dramatic mechanism to affect compliance without publicizing the audit rule would be to incentivize lower-income individuals to hire tax preparation firms.

While this model has provided important insights about the effects of strategic information revelation and other possible policy tools of the tax agency, further analysis is required to discuss optimal behavior.

CHAPTER II

Tax Enforcement with Somewhat Honest Taxpayers

Abstract

Standard compliance theory assumes that individuals evade to the extent it benefits them monetarily. However, a growing empirical literature suggests that many underlying cognitive considerations, including lying aversion, may play a non-trivial role when individuals make decisions. This study aims to analyze whether optimal audit rules that are the result of standard models survive a model with agents that are lying averse. I show the canonical cut-off audit rule where above a certain threshold no reported income is audited (introduced by Reinganum and Wilde (1986*a*) and further developed by Sanchez and Sobel (1993)) is not optimal in this setting. Moreover, a Bayesian incentive compatible audit probability does not need to be monotone in reported income.

JEL Codes: H26, D91, D82

Keywords: Tax Evasion;Tax Enforcement; Behavioral Public Finance; Lying Aversion, Optimal Audit Rule, Mechanism Design

2.1 Introduction

2.1.1 Motivation

Many of the canonical models in the tax evasion literature assume that taxpayers will under-report their income as long as they have material gains, and their preference for risk allows it. However, a growing empirical literature on honesty suggests that some individuals might be influenced by non-monetary incentives when they make their compliance decisions. This literature also suggests that this type of behavior might be attributed to individuals potentially incurring a psychological cost when they lie. Current models of optimal enforcement and auditing rely on the standard models where all individuals are prone to dishonesty. However, if taxpayers are averse to lying, previous results from the literature might not apply. Even though the previous literature mentions that some taxpayers are inherently honest, the effect of such taxpayers on enforcement strategies, namely the audit rule, is not further analyzed.

This paper analyzes whether the optimal cutoff audit rule that is introduced by Sanchez and Sobel (1993) and Scotchmer (1987) survives a setting where taxpayers are lying averse. In addition, this study also further analyzes the characteristics of an optimal audit rule in this setting.

A cutoff audit rule is such that, given an audit threshold income, only taxpayers who report below that threshold are audited. In a standard model, the audit probability for the reported incomes below the threshold is chosen so that no taxpayer with true income below the threshold evades, whereas, all the taxpayers with true incomes above the threshold evade and report the threshold. Furthermore, the threshold is chosen such that the tax agency audits as many low reports as its budget allows. Even though they are widely used in the literature, cutoff audit rules seem counter-intuitive as, ultimately, only lower-income individuals, who report honestly, get audited. However, a simple alteration to the standard model where taxpayers incur an intrinsic cost that increases in the size of the lie, i.e. evasion, changes the characteristics of the cutoff rule.

One interesting result is that, contrary to what standard enforcement theory suggests, the audit probability does not have to be non-increasing in reported income to ensure incentive compatibility. To see this consider a setting where all agents to prone to evading as long as it benefits them monetarily, then if higher reported incomes were audited more frequently, by reporting less taxpayers can decrease their tax liability without increasing expected penalty too much. In a cutoff rule setting this implies that once the tax agency defines a threshold where the audit probability is zero, the audit probability should be zero for all reported income above that threshold. However, introducing lying costs into the utility function of the taxpayer gives more freedom in choosing the audit probability. A lying averse taxpayer not only trade-offs decreasing tax liability and decreasing expected tax payments but also by reporting less he risks incurring a higher lying cost. Therefore, it is sufficient but not necessary to have a non-increasing audit probability in reported income to deter taxpayers from mimicking each other. To see this consider the taxpayer who has the top income. Given a cutoff audit rule, this taxpayer will report the cutoff and will not get penalized for cheating. However, in the presence of a high degree of lying aversion, this taxpayer might not report the cutoff. Applying the same logic to other taxpayers with high levels of true income implies that not all taxpayers with true income above the cutoff will end up bunching at the cutoff. This lack of significant bunching at the threshold suggests that the tax authority can now audit some individuals above the threshold and collect revenue.

An important aspect of the model is that I assume the tax agency chooses its optimal audit rule in order to maximize government revenue. In the standard model where all taxpayers are prone to evading and therefore they only aim to minimize their expected tax payments, maximizing revenue and a social welfare function can have similar results. However, in this case, assuming the tax agency only maximizes revenue implies that the agency ignores a part of individuals' utility function- lying costs. Maximizing revenue instead of a social welfare function suggests that the approach taken here is more positive rather than normative, however, this approach is consistent with the "yield" criteria used by the tax agency for selection of returns for audit (Graetz, Reinganum and Wilde (1986)). This approach is also not too distinct from the approach taken by Sanchez and Sobel (1993) where they assume a hierarchical setting between a revenue-maximizing tax agency and a social welfare maximizing government. The tax agency chooses the optimal audit rule subject to a budget constraint, whereas the government chooses the tax agency's budget and the tax rate. Therefore, the analysis conducted in this study can be considered as the first step of a sequential maximization problem. It is important to note that defining a social welfare function in this setting can be tricky. Firstly, the fact that lying costs depend on evaded income implies that for the government to directly include these utility costs in their objective function, it has to know exactly how much each taxpayer evades. This is not only an unreasonable assumption that would change the model completely.

Another important caveat is that even though it is assumed that all taxpayers are lying averse, this is might not be true in the real world. There is evidence that suggests that compliance rates are a lot higher than we expect, yet, it is important to distinguish the compliance rates based on income type. According to Bankman, Nass and Slemrod (2015) compliance for individuals who earn wage income is 99%, however, for business income, it is around 40%. They also suggest that if given the opportunity individuals will actually evade more, the only reason we see high compliance rates is because a big proportion of income is subject to third-party reporting. These statistics can have many implications. One of the implications that is related to this study is that even though all taxpayers evade given the opportunity they might still shy away from evading to the extreme extent.

The rest of the paper is structured as follows. In the next subsection 2.1.2, I review the relevant existing public finance and behavioral/experimental economics literature and Section 2.2 introduces the model and analyzes the taxpayer's problem (subsection 2.2.1) as well as the tax agency's problem (subsection 2.2.2). Finally, section 3.7 delivers concluding remarks.

2.1.2 Context and Literature Review

This section has four parts: the first part explains why lying aversion may matter by providing evidence from select works from the behavioral and experimental economics literature, the second part looks at how previous literature incorporated different levels of lying aversion into models, and finally the last part briefly discusses the literature on optimal cutoff audit rules.

The majority of lying aversion literature consists of experimental studies. Even though the external validity of laboratory experiments are a concern when it comes to real-world reporting behavior, they do provide information about the extent of the effect of non-rational aspects of an individuals' behavior. One of the most comprehensive works that study lying costs is by Abeler, Nosenzo and Raymond (2016). They combine data from 72 studies in different fields, including economics, psychology and sociology and confirm that people do in fact lie very little compared to what has been widely assumed in economic theory. They present several possible explanations for the behavior in the data and conclude that only a combining preference for being honest and a preference for being seen honest can explain the data. Even though they focus on a setting where there are no strategic interactions, including audits, they do briefly discuss an "audit model" where they find evidence of intrinsic lying aversion on top of possible reputational concerns to be found out as a liar. Abeler, Nosenzo and Raymond (2016) only consider a binary choice set- lying and not lying-, however, an individuals' choice set for reported income is likely to have more than two alternatives. On the other hand, Gneezy, Kajackaite and Sobel (2018) design a framework where individuals have more than one choice; therefore they do not only answer the question "do people lie?" but also focus on the question "how much do people lie?". Their results suggest that when individuals make the decision to lie, they lie to the extreme, however, partial lies do occur if there are reputational concerns and/or individuals care whether they are seen as honest or not, which is relevant to the tax audit case. Even though they do not formally address the question, Fischbacher and Föllmi-Heusi (2013) imply that individuals are more likely to partially lie because the marginal cost of lying is likely to increase with regards to the size of the lie. Mazar, Amir and Ariely (2008) predict the same result, however, they theorize that the underlying reason for partial lying is due to the fact that individuals trade-off maintaining a positive self-concept as honest versus gaining a monetary benefit from dishonesty. In summary, although it is agreed upon that individuals are averse to lying, the lying aversion literature do not have a consensus on whether individuals lie partially or to the extreme. It is important to note that in order to isolate pure lying aversion from monetary considerations, the models in the aforementioned papers are such that cheating always increases monetary payoff and the only disutility incurred is from a variant of a lying cost. However, in the context of tax evasion cheating, i.e. evading, does not unambiguously increase the monetary payoff because of the penalty incurred in case of an audit. This implies that individuals might not lie to the extreme extent (report 0 income) even if there is no lying aversion.

As stated by Erard and Feinstein (1994), there are some works in the public finance literature that recognize the fact that some taxpayers can be inherently honest (Graetz, Reinganum and Wilde (1986), Alm, McClelland and Schulze (1992), Erard and Feinstein (1994)), not enough attention has been given to how these type of taxpayers can change our analysis of optimal enforcement tools.

Graetz, Reinganum and Wilde (1986) is one of the first works to consider an honest type of taxpayer- ”habitual compliers”- individuals who always report their tax liability correctly. Habitual compliers comprise both taxpayers who do not have an opportunity to cheat on their taxes, i.e. wage earners, people subject to third party reporting etc., and taxpayers who disregard the potential monetary benefits of non-compliance. They develop ”an interactive model” which is a signalling game played between the tax agency and the taxpayers. The most relevant result of their model is that as the proportion of habitual compliers increases the probability that ”strategic non-compliers” cheat decreases, leaving the optimal audit strategy and all other aspects of the model unchanged. This result heavily depends on the assumption that there are only two income classes, high and low, therefore, the IRS will never audit a taxpayer who reports high income. In contrast, the model presented here will assume a continuum of incomes, therefore, the optimal audit policy changes when there are individuals who are averse to lying.

To show that honest taxpayers do have a significant effect on tax agency policies, Erard and Feinstein (1994) extend the game theoretic compliance model developed by Reinganum and Wilde (1986*a*,*b*) by adding an explicit budget constraint for the tax agency.

In a model where there is a continuum of agents who have different income levels and two possible behavioral types- honest and dishonest-, they reach a separating equilibrium among dishonest taxpayers where each report is associated with a specific income level. Because each report can be attributed to both dishonest and honest taxpayers, the tax agency cannot infer the ex-post true income. Finally, in contrast with previous similar models, the underlying true income distribution plays a role in their model. Because they find it not possible to analytically solve the model they pursue doing computer simulations and show that incorporating honest taxpayers alter the equilibrium calculation results and these results fit with empirical facts. Their most relevant result from the simulations is that, as the portion of the honest taxpayers increases and if the true income range is sufficiently wide, the audit function gains a convex upper tail. In other words, even the wealthiest taxpayers face a positive audit probability. However, they do not formally define what an optimal audit rule in this setting will look like.

Lastly, because this paper deals with cutoff audit rules it is important to have a brief summary of the existing literature. Reinganum and Wilde (1985) first introduced this class of audit rules, in which every taxpayer with a reported income below a certain threshold is audited with a fixed probability. They show that cutoff rules weakly dominate random audit rules. Cutoff audit rules, however, are thought to be unrealistic and not credible because they have the regressive result that the only taxpayers who get audited are low-income individuals who report truthfully. Scotchmer (1987) relaxed the assumption that a tax authority can only observe reported income and showed that if taxpayers are assigned into different audit classes, a tax schedule with a cutoff audit rule will be regressive within an audit class but progressive overall. Finally, Sanchez and Sobel (1993) characterized all the conditions under which the optimal audit rule is a unique cutoff.

2.2 Model and Framework

Taxpayers are characterized by their true income, i, independently and identically drawn from a known distribution, F, from an interval $[l, h]$. All taxpayers have the same lying aversion parameter θ. The lying aversion parameter is common knowledge whereas income, i, is private knowledge. Each taxpayer reports income, r, to maximize her utility. The tax agency observes reported income and taxes everyone, using an increasing tax function $t(r)$ and chooses an audit probability, $p(r)$, to maximize its revenue subject to a budget constraint. Auditing is costly, denoted by k per audit, and the budget, B, is not large enough for the tax agency to audit everyone with a probability that ensures truthful reporting. In case of an audit, real income is revealed and taxpayers who are caught cheating have to pay a penalty, π, levied on the evaded tax.

2.2.1 Taxpayer's Problem

After observing their true income, taxpayers choose reported income, r, to maximize the reduced form of utility function defined below. [1]. Maximizing this function is same as maximizing $u(i, r; \theta)$.

$$\max_r u(i, r; \theta) = -t(r) - \mathbf{I_{r \leq i}}[p(r)(1+\pi)(t(i) - t(r))] - c(i, r; \theta) \tag{2.1}$$

The first term is the tax owed on the reported income and the second term is the expected payment in case of an audit. The third term, $c(i, r; \theta)$ is the cost of lying, scaled by the parameter θ. The higher θ is, the higher the cost of lying. The cost of lying is also assumed to increase in the degree of lying downwards, i.e. evasion, and non-decreasing in the degree of lying upwards, i.e. over-reporting, and is equal to zero when the taxpayer reports her income truthfully.

$$\frac{\partial c(i, r; \theta)}{\partial \theta} > 0, \quad \frac{\partial c(i, r; \theta)}{\partial (i - r)}|_{i>r} > 0, \quad \frac{\partial c(i, r; \theta)}{\partial (i - r)}|_{i<r} \leq 0, \quad c(i, r; \theta)|_{i=r} = 0, \quad c(i, r; \theta)|_{\theta=0} = 0$$

For brevity, without loss of generality, θ will be suppressed for the rest of the paper.

Let $r^*(i)$ denote the optimal report of the taxpayer with income i. The following are the sufficient and necessary conditions:

$$r^*(i) = \arg\max_r u(i, r) \tag{IC}$$

$$\begin{aligned} \frac{\partial u(i, r)}{\partial r} &= 0 \\ -t'(r) - p'(r)(1+\pi)(t(i) - t(r)) + p(r)(1+\pi)t'(r) - \frac{\partial c(i, r)}{\partial r} &= 0 \end{aligned} \tag{local IC}$$

$$\begin{aligned} \frac{dU(i)}{di} &= \frac{\partial u(i, r)}{\partial i} + \underbrace{\frac{\partial u(i, r)}{\partial r}|_{r=r^*(i)}}_{=0} \frac{\partial r^*(i)}{\partial i} \\ &= -p(r^*(i))(1+\pi)t'(i) + \frac{\partial c(i, r)}{\partial i} \end{aligned} \tag{EC}$$

Where $g'(.)$ denotes the derivative of the function g, and U denotes the indirect utility function. The first expression is the standard incentive compatibility constraint that suggests that the optimal report should be the solution to the taxpayer's maximization problem. The

[1] The actual utility is $i - (t(r) + \mathbf{I_{r \leq i}}[p(r)(1+\pi)(t(i) - t(r))] + c(i, r; \theta))$

second is the first order condition resulting from the taxpayer's maximization condition. Finally, the third one is the envelope condition.

Below is a simple result that's an adaptation from Scotchmer (1987).

No taxpayer reports more than her true income. A sufficient condition for a taxpayer to report honestly is $p(r) \geq \frac{1}{1+\pi}$ $\forall r \in [l, h]$

The first claim follows from the fact that t(.) is increasing in reported income and there are no rewards from over-reporting. Moreover, $c(.)$ is non-decreasing in the over-reported income, hence, over-reporting is strictly dominated by reporting truthfully. To prove the second claim, consider the utility comparison between reporting truthfully, i, and evading $r < i$

$$\begin{aligned} t(i) &\leq t(r) + p(r)(1+\pi)(t(i) - t(r)) + c(i, r) \\ t(i)(1 - p(r)(1+\pi)) &\leq t(r)(1 - p(r)(1+\pi)) + c(i, r) \end{aligned} \tag{2.2}$$

$i > r$ implies that $c(i, r) > 0$. Therefore a sufficient condition for the left-hand-side to be smaller than the right-hand-side is that $p(r) \geq \frac{1}{1+\pi}$. Notice that unlike the result in Scotchmer (1987) and Sanchez and Sobel (1993), we can find $p(.)$, such that $p(r) < \frac{1}{1+\pi}$ but still high enough to deter evasion.

First, notice that the tax agency's problem presented here is very similar to an optimal mechanism design problem, especially, the optimal auction design model introduced by the seminal work of **?**. The tax agency has to come up with an optimal mechanism, i.e. audit rule, in order to maximize its tax revenue. In a way, the tax agency's problem is similar to an auction of a "bad" instead of a good. The "bad", i.e. being audited, is awarded to taxpayers with a probability function, i.e. audit rule, that takes reported type, i.e. income, as an input.

For a mechanism to be optimal it has to be feasible and efficient. A feasible mechanism has to be in the set of all Bayesian incentive compatible mechanisms. (**?**). A Bayesian incentive compatible mechanism, i.e. audit rule, has to ensure that in equilibrium no taxpayer has an incentive to change her report to an income another taxpayer is reporting in equilibrium. The following proposition 2.2.1 gives us the conditions for an audit rule to be feasible which is a necessary but not a sufficient condition for it to be optimal.

[Bayesian Incentive Compatibility] Given any $p(.)$, and $c(.)$, if $r^*(i)$ and $r^*(j)$ maximize taxpayer i and j's utility respectively and without loss of generality $r^*(j) < r^*(i) < j < i$ [2], then

[2] Assuming $i > j$ will indeed not cause any loss of generality. Moreover, by Lemma 2.2.1, it should be the case that $r^*(i) < i$ and $r^*(j) < j$ and therefore $r^*(j) < i$. For the same reason, a taxpayer with income j will never report $r^*(i) > j$, therefore we do not need to consider that case.

(a)

$$p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \tag{2.3}$$

(b)

$$U(i,r) = -t(l) - \int_l^i (p(r^*(j))(1+\pi)t'(j) + c(\theta, j, r^*(j))dj \tag{2.4}$$

Part (a) follows from the incentive compatibility constraint of taxpayers. To see this consider the incentive compatibility constraint of a taxpayer with income i where $i > j$.

$$\begin{aligned} u(i,r^*(i)) &\geq u(i,r^*(j)) \\ t(r^*(i) + p(r^*(i))(1+\pi)(t(i) - t(r^*(i)) + c(i,r^*(i)) &\leq t(r^*(j)) + p(r^*(j))(1+\pi)(t(i) - t(r^*(j)) \\ -u(i,r^*(i)) &\leq -u(j,r^*(j)) + p(r^*(j))(1+\pi)(t(i)-t(j)) + c(i,r^*(j)) - c(j,r^*(j)) \\ -(u(i,r^*(i)) - u(j,r^*(j)) &\leq p(r^*(j))(1+\pi)[t(i)-t(j)] + c(i,r^*(j)) - c(j,r^*(j)) \\ p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} &\geq \frac{-(u,r^*(i)) - u(j,r^*(j))}{t(i)-t(j)} \end{aligned} \tag{2.5}$$

The expression above implies that if $r^*(i)$ maximizes the utility function of the taxpayer with true income i, this taxpayer should not prefer reporting $r^*(j)$, which is the report that maximizes the utility of taxpayer with true income j, instead. Following the same steps using the incentive compatibility constraint of a taxpayer with true income j will give us the following expression.

$$\frac{-(u(i,r^*(i)) - u(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \tag{2.6}$$

Combining these two inequalities we get

$$\begin{aligned} p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq \frac{-(u(i,r^*(i)) - u(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \\ p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \end{aligned} \tag{2.7}$$

Now for the second part recall the envelope condition (EC)

$$\frac{dU(i)}{di} = -p(r^*(i))(1+\pi)t'(i) + \frac{\partial c(i,r^*(i)}{\partial i}$$

Then using the fundamental theorem of calculus we get

$$U(i,r) = U(l, r(l)) - \int_l^i (p(r^*(j))(1+\pi)t'(j) + c(\theta, j, r^*(j))dj \tag{2.8}$$

Moreover, $U(l, r(l)) = -t(l)$ because the agent with the lowest income cannot evade.

Without lying aversion, a feasible audit probability function has to be non-decreasing in reported income. However, the audit probability function does not have to be monotone in reported income in the presence of lying aversion.

This corollary is a direct result of the part (a) of Proposition 2.2.1.

For the first part of Corollary 2.2.1[3], can be shown by setting $\theta = 0$, hence $c(i,r) = 0 \ \ \forall i, r$, and rewriting Inequality 2.3 in part (a) of the Proposition 2.2.1.

$$p(r^*(j))(1+\pi) \geq p(r^*(i))(1+\pi) \tag{2.9}$$

Because $(1+\pi) > 0$, the inequality above implies that

$$p(r^*(j)) \geq p(r^*(i)) \quad \forall i > j > r(i) > r(j)$$

The prove the second part of Corollary 2.2.1, notice that because $i > j > r^*(i) > r^*(j)$ the following is true.

$$\begin{aligned} \frac{c(i, r^*(j)) - c(j, r^*(j))}{t(i) - t(j)} > 0 \\ \frac{c(i, r^*(i)) - c(j, r^*(i))}{t(i) - t(j)} > 0 \end{aligned} \tag{2.10}$$

However, it is possible to have a lying cost function such that

$$\frac{c(i, r^*(j)) - c(j, r^*(j))}{t(i) - t(j)} < \frac{c(i, r^*(i)) - c(j, r^*(i))}{t(i) - t(j)} \tag{2.11}$$

Which in turn allows for $p(r^*(j)) < p(r^*(i))$

The monotonicity of the audit probability is a necessary condition in Sanchez and Sobel (1993), and a crucial one in characterizing the cutoff policy. Intuitively, this is because of the fact that if lower reports are audited less frequently, then taxpayers have more incentives to report them because, in this case, reporting a lower report not only decrease tax liability but also decreases the chances of being audited. The monotonicity requirement, in turn, implies that if a report is never audited then all other reports that are greater should

[3] This part is a result in Sanchez and Sobel (1993).

also not be audited, i.e. if $\exists\, \overline{r}$ s.t. $p(\overline{r}) = 0$, then $p(r) = 0\ \forall r > \overline{r}$.

In contrast, the above result suggests that, depending on the rate the cost function changes in the size of evasion, it might be optimal to audit a higher income with higher probability than a lower income.

2.2.2 Tax Agency's Problem

In a similar fashion to Sanchez and Sobel (1993), let $E(i, r; p(.)) = t(r) + p(r)(1 + \pi)(t(i) - t(r))$ denote the expected tax of an individual with income i and report r, given the audit function $p(.)$. Also, let and $T(i, p(.)) = E(i, r^*(i); p(.))$ be the expected tax payment of this taxpayer, given that her optimal report is $r^*(i)$[4]. Finally, let k denote the cost of audit.

Then the tax agency's problem can be stated as follows:

$$\begin{aligned}
&\max_{p(.)} \int_l^h T(i, p(.)) dF(i) \\
&\text{subject to} \\
&\int_l^h kp(r^*(i)) dF(i) \leq B \\
&\text{where } \forall i \\
&r^*(i) = \arg\min_r E(i, r; p(.)) - c(i, r)
\end{aligned} \tag{2.12}$$

One thing to notice is that, contrary to Sanchez and Sobel (1993), the tax agency's objective function does not have a one-to-one relationship with the taxpayer's objective function because the tax agency does not care about taxpayers' lying cost. However, it is still possible to simplify the tax agency's problem using the taxpayer's maximization problem.

$$\begin{aligned}
\frac{dT(i)}{di} &= \frac{\partial E(i,r)}{\partial i} + \frac{\partial E(i,r)}{\partial r}\Big|_{r=r^*(i)} \frac{\partial r^*(i)}{\partial i} \\
&= \frac{\partial E(i,r)}{\partial i} + \underbrace{\frac{\partial U(i)}{\partial r}\Big|_{r=r^*(i)}}_{=0} - \frac{\partial c(i,r)}{\partial r}\Big|_{r=r^*(i)} \frac{\partial r^*(i)}{\partial i} \\
&= -p(r^*(i))(1+\pi)t'(i) - \frac{\partial c(i,r)}{\partial r} \frac{\partial r^*(i)}{\partial i}
\end{aligned} \tag{EC-TA}$$

[4]Notice that $r^*(i)$ does not minimize possible tax payments of taxpayer i, but it minimizes possible tax payment plus the cost of lying.

Then the objective function of the tax agency can be rewritten in the following form:

$$\int_l^h T(i,p(.))dF(i) = \int_l^h [T(l,p(.)) + \int_l^i (p(r^*(j))(1+\pi)t'(j) - \frac{c(j,r^*(j))}{\partial r^*(j)}\frac{\partial r^*(j)}{\partial j})dj]dF(i)$$
$$= \int_l^h (p(r^*(i))(1+\pi)t'(i) - \frac{c(i,r^*(i))}{\partial r^*(i)}\frac{\partial r^*(i)}{\partial i})\frac{1-F(i)}{f(i)}dF(i) + \underbrace{T(l,p(.))}_{t(l)} \tag{2.13}$$

Moreover, because Lemma Equation 2.2.1 suggests that any $p(r) > 1/(1+\pi)$ is enough to deter evasion, no budget constraint tax agency will ever choose an audit probability higher than $1/(1+\pi)$. Therefore the optimization problem can be restated as follows:

$$\max_{p(.)} \int_l^h (p(r^*(i))(1+\pi)t'(i) - \frac{c(i,r^*(i))}{\partial r^*(i)}\frac{\partial r^*(i)}{\partial i})\frac{1-F(i)}{f(i)}dF(i) + T(l,p(.))$$

such that

$$p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \quad \forall i > j > r^*(i) > r^*(j)$$

and $p(r^*(i)) \in [0, 1/(1+\pi)] \quad \forall i$

subject to

$$\int_l^h kp(r^*(i))dF(i) \leq B$$

where $\forall i$

$$r^*(i) = \arg\min_r E(i,r;p(.)) - c(i,r) \tag{2.14}$$

The model presented in Sanchez and Sobel (1993) is a limiting case of the model presented here.

First, recall the following properties of $c(i,r;\theta)$.

$$\frac{\partial c(i,r;\theta)}{\partial \theta} > 0, \quad c(i,r;\theta)|_{\theta=0} = 0$$

Then the following must be true

$$\lim_{\theta\to 0} c(i, r^*(i)) = 0 \lim_{\theta\to 0} \frac{c(i, r^*(i))}{\partial r^*(i)} = 0$$
$$\lim_{\theta\to 0} \frac{c(i, r^*(j)) - c(j, r^*(j))}{t(i) - t(j)} = 0 \tag{2.15}$$
$$\lim_{\theta\to 0} \frac{c(i, r^*(i)) - c(j, r^*(i))}{t(i) - t(j)} = 0$$

Then the tax agency's problem reduces to

$$\begin{aligned}
&\max_{p(.)} \int_l^h p(r^*(i))(1+\pi)t'(i)\frac{1-F(i)}{f(i)}dF(i) + T(l, p(.)) \\
&\text{such that} \\
&p(.) \quad \text{is non-increasing} \\
&\text{and } p(r^*(i)) \in [0, 1/(1+\pi)] \quad \forall i \\
&\text{subject to} \\
&\int_l^h kp(r^*(i))dF(i) \leq B \\
&\text{where } \forall i \\
&r^*(i) = \arg\min_r E(i, r; p(.))
\end{aligned} \tag{2.16}$$

Which is equivalent to the tax agency's problem in Sanchez and Sobel (1993). Therefore, as θ converges to zero, i.e. lying aversion diminishes, the problem presented here converges to the one presented in Sanchez and Sobel (1993).

As lying aversion diminishes, the optimal audit rule converges to a cutoff rule.

The above is a result we get by direct application of Lemma 2.2.2. By Lemma 2.2.2, we know that as lying aversion diminishes, both the taxpayer's and tax agency's problem converges to the counterparts of the same problems presented in Sanchez and Sobel (1993). Moreover, Sanchez and Sobel (1993) show that in their setting an optimal audit rule has to be in the form of a cutoff rule. Therefore, as lying aversion diminishes, optimal audit rule converges to a cutoff rule.

In order to show that a cutoff rule in this setting might not be optimal, consider the simplified problem where $t(r) = tr \ \forall r$ and $c(i, r) = \frac{\theta}{2}(i - r)^2 \ \forall i, r$. Moreover for simplicity assume that $i \sim U[0, h]$

A general cutoff rule such that

$$p^*(r) = \begin{cases} 1/(1+\pi) & \text{if} \quad r \in [l, a) \\ 0 & \text{if} \quad r \in [a, h] \end{cases} \tag{2.17}$$

where $F(a) = \frac{B(1+\pi)}{k}$, is not optimal for the simplified problem with lying aversion.

We start by deriving the optimal reported strategy of taxpayers, given that the audit rule is $p^*(i)$. In Sanchez and Sobel (1993) setting there are two types of reports- taxpayers who report truthfully and taxpayers who report the cutoff. In contrast, in this setting, there are three types of reports: (i) taxpayers who report truthfully, (ii) taxpayers who report exactly the threshold, a, (iii) taxpayers who evade by a constant amount.

By Lemma 2.2.1 we know that all taxpayers with real income less than a report truthfully.

First, consider all taxpayers who have real income above the audit threshold, a. The utility from reporting any income, r, above the threshold is as follows.

$$u(i, r) = -tr - \frac{\theta}{2}(i - r)^2 \tag{2.18}$$

Because this function is continuous we can maximize it with respect to r[5].

$$\begin{aligned} \frac{\partial u(i, r)}{\partial r} &= -t + \theta(i - r) = 0 \\ r^*(i) &= i - \frac{t}{\theta} \end{aligned} \tag{2.19}$$

Notice that even if there's no risk of auditing, taxpayers still do not evade to the extreme extent.

Finding the taxpayer who is indifferent between reporting the cutoff or evading by a constant amount will characterize the interval of taxpayers who report truthfully.

$$\begin{aligned} r^*(i) = a &= i - \frac{t}{\theta} \\ i &= a + \frac{t}{\theta} \end{aligned} \tag{2.20}$$

Then the following expression characterizes the optimal reported income of taxpayers

[5]Assuming $r^*(i) \in [0, i]$.

given $p^*(i)$

$$r^*(i) = \begin{cases} i & \text{if} \quad i \in [l, a] \\ a & \text{if} \quad i \in [a, a + \frac{t}{\theta}] \\ i - \frac{t}{\theta} & \text{if} \quad i \in [a + \frac{t}{\theta}, h] \end{cases} \tag{2.21}$$

Tax revenue in this case is equal to the following expression where $a = \frac{B(1+\pi)}{k}$

$$\begin{aligned} TR_a &= \int_0^a i dF(i) + \int_a^{a+\frac{t}{\theta}} a dF(i) + \int_{a+\frac{t}{\theta}}^h (i - \frac{t}{\theta}) dF(i) \\ &= \frac{1}{2} \left(\frac{a^3}{h} - a^2 + \frac{2at}{\theta} + \frac{(t - h\theta)^2}{\theta^2} \right) \end{aligned} \tag{2.22}$$

On the other hand, consider a constant audit probability, which is used to audit all taxpayers, that exhausts the government's budget.

$$p(r) = \overline{p} = \frac{Bh}{k} \quad \forall r^6$$

Given the probability of audit, the taxpayer's first order condition can be characterized by the equation below.

$$\begin{aligned} -t + p(1 + \pi)t - \theta(i - r) = 0 \\ r^*(i) = i - \frac{t(1 - p(1 + \pi))}{\theta} \end{aligned} \tag{2.23}$$

Then the tax agency's expected revenue in the case where $p(r) = \overline{p}$ is

$$\begin{aligned} TR_{\overline{p}} &= \int_0^h (tr^*(i) + \overline{p}(1 + \pi)t(i - r^*(i)))dF(i) \\ &= \frac{t\,(h\theta - 2t(1 - (1 + \pi)\overline{p})^2)}{2\theta} \end{aligned} \tag{2.24}$$

It is enough to show that there exists one case where $TR_{\overline{p}} > TR_a$ To see that consider following parameter values:

$$\theta = 2, \;\; \pi = 0.5, \;\; p = 0.375, \;\; t = 0.8$$

[6]Notice that this probability function satisfies the monotonicity condition defined in part(b) of Proposition 2.2.1.

which implies that

$$TR_{\overline{p}} = 1.91 > 1.9 = TR_a$$

The previous proposition shows that a random audit with a constant probability can perform better than the cutoff rule suggested by the previous literature. One main reason behind this result is that, in the standard model, higher income individuals have a greater opportunity for evasion compared to lower income individuals. By consistently auditing lower reported incomes and making them unattractive to report, the tax agency limits the extent of evasion caused by higher income individuals. When lying aversion is introduced into the model, the previous observation is not necessarily true anymore. Equation 2.19 shows that even in the case where no one is audited, taxpayers will not lie to the extreme extent. In other words, evasion opportunities do not vary drastically with respect to real income. Therefore, the tax authority can treat all reported income the same and increase tax revenue by choosing a constant audit probability. One caveat of Proposition 2.2.2 is the assumption of a uniform income distribution. If income is not distributed uniformly, then the tax authority might want to focus on income intervals where the income distribution is heavier.

2.3 Conclusion

By developing a model of taxation and tax compliance where taxpayers are homogeneously lying averse, I have shown that the frequently used cutoff optimal rules do not survive this modification of the standard model. Although this paper does not claim that the lying aversion model introduced here captures the actual way individuals behave, it does provide insights about how current models of optimal enforcement rules are not robust.

Seemingly counter-intuitive at first, cutoff rules are optimal in the standard models, especially in settings where higher income individuals have a better opportunity for hiding their income than lower-income individuals. Therefore, in these models, it is intuitive to audit lower incomes more frequently than higher incomes. However, if individuals' willingness to evade as well as their opportunity to evade does not increase in income, it is possible that higher-income individuals are also audited in equilibrium. In the case of this model, under certain parameter specifications, auditing all reports with a constant probability performs better than applying a cutoff audit rule.

This paper assumes that the tax agency's objective is to maximize net revenue. Even though it will be interesting to see if there are other audit rules that deliver higher social welfare than the cutoff rules, defining a social welfare in this setting is tricky because the government has to know the true income and the report of all taxpayers. One way to circumvent this problem is to use a variant of the revelation principle. If one can find an optimal audit rule that can implement revelation principle, then the government can trivially solve the lying problem by asking taxpayers to report their true income and assigning them the expected utility they receive in equilibrium.

A natural extension to this paper will be to solve for the optimal audit rule in this setting. Even though, the actual rule itself might no be implementable in the real world, doing comparative statics can provide insights about how the rule changes with respect to the level of lying aversion.

CHAPTER III

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

From a work with Tejaswi Velayudhan and Eleanor Wilking

Abstract

In addition to taxpayer preferences, elasticity of taxable income has been shown to depend on parameters of the tax system -including the costs and expected penalty of tax evasion, and the costs of tax avoidance. However, less is known about how consumption elasticities change in response to enforcement. The theory of statutory neutrality predicts that structuring the as a "use tax"-where the consumer remits -or, as a sales tax-under which the retailer remits, should have no effect on the fundamental parameters of the tax system. We test this in the context of U.S. state restructuring of the remittance regime governing online sales shipped to state residents. 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 in response to Voluntary Collection Agreements (VCA). However, we do not find evidence of a large change in elasticity of the tax base with respect to tax changes. We conclude that shifting the remittance duty to the party with fewer evasion opportunities, akin to an enforcement increase, could affect the responsiveness of the tax base to future tax rate changes but that the effect of the enforcement on online retailers is too small to measure.

JEL Codes: H24; H26; D12; E21; H71; L81
Keywords: Sales Tax; Consumer Spending; Tax Elasticity

3.1 Introduction

In standard economic models, demand for a taxed good is solely a function of utility function parameters and the good's tax inclusive price. Implicitly, this assumes that a change in the log of the tax-exclusive price and changes in the tax rate have identical effects on behavior. However, recent 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), Finkelstein 2004), or if the tax increase 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 - in particular, enforcement. In this paper, we explore whether the behavioral response of consumers and producers to a consumption tax change similarly varies with evasion opportunity in the context of U.S. states' voluntary tax collection agreements, a structural change in remittance assignment 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. Existing literature has established that consumers purchase online to avoid sales taxes. Goolsbee (2001) was the first to suggest this channel of evasion. Einav et al. (2014) find evidence of this evasion in consumers' online shopping response to taxes on the Ebay marketplace. Goolsbee, Lovenheim and Slemrod (2010) use data on state-level smoking rates and internet penetration from 1980 to 2005 to show that the price elasticity of cigarette sales rose as ability to purchase cigarettes online increased. Baker, Johnson and Kueng (2017) show using the Nielsen data 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. Policies that increase online sales tax compliance are thus a natural setting to study the effect of enforcement on consumption elasticities. We exploit time and geographic variation in adoption of Voluntary Collection Agreements (VCAs) which dramatically increased online sales tax compliance by shifting the duty to remit from the buyer to the seller. One recent paper shows that the VCA agreements had a measurable impact on consumers' shopping behavior on Amazon. Baugh et al (2017) show that this increase in tax on online purchases was salient to consumers, and that they reduced their Amazon purchases by about 9 %. However, to our knowledge, this is the only paper to have so far examined the consequences of VCA agreements on the elasticity of the sales tax base. 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.

We show that consumers reduce their online taxable expenditure in response to the VCA, while maintaining consumption of tax exempt items. We use an event-study design to test whether monthly online expenditure of households in states that enacted a VCA between 2010 and 2014 decreases following the VCA adoption relative to states which do not have a VCA. In line with the findings of Baugh, Ben-David and Park (2016) for online expenditure on Amazon, we find that expenditure at large online retailers fell in response to the VCA. 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. Households switch from purchasing the same products online to brick-and-mortar stores. Since 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 the VCA and that any effective tax increase is passed through to the consumer. Finally, we test whether the price elasticity of purchases at brick-and-mortar stores decreases because of the effective tax increase on online purchases resulting from enforcement. While these results are still very preliminary, we find limited evidence that enforcement significantly reduced the elasticity of the tax base.

3.2 Context

In this section, we discuss why states collect use taxes on online sales, and variation in state strategy to collect these taxes.

Forty-five U.S. states levy sales taxes on goods purchased for consumption within their physical borders, and require sellers, usually retailers, in these transactions to assess and remit the tax. To mitigate the tax arbitrage 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. 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].

3.2.1 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 utilized 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 definition of nexus to (large) online retailers in a manner consistent with Quill, and voluntary collection agreements (VCAs), essentially contracts 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

[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, i.e. if Michigan has x % sales tax, and Michigan resident purchases a taxable item from Wisconsin and consumes it in Michigan, and pays a y % sales tax on her purchase, she need only pay the difference in use taxes to Michigan.

[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. Cite CO case.

[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

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, three states (CA, NJ, PA and VA) passed such legislation.

In contrast, 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 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 3.1), 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 can potentially exploit for further variation. Consumers differ in propensity to purchase online; Figure 3.4 shows that the ratio of total expenditures online to total expenditures is rising in household consumption.

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 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.

3.3 Data

The Nielsen Consumer Panel is a nationally and regionally representative, stratified longitudinal panel of between 40,000-60,000 households from 2004-2014[6]. For this draft, we focus on the sample of households observed between 2010 and 2014, which is the

consideration, directly or indirectly refers potential customers, whether by a link on the Internet website or otherwise, to the seller.” N.Y. Tax Law

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

period when most VCT agreements were signed, to keep the dataset of a manageable size. Households self-report their purchasing behavior to Nielsen through in-home scanners for a set of ”Nielsen-tracked” products. These products include both food and non-food items purchased at any outlet, 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, multipacks etc. This detailed product and quantity information allows us to more accurately measure the impact of the VCA on consumer purchase behavior. Unlike Baugh et al., we are able to separately analyze the response of taxable and exempt consumption. We also decompose the expenditure response into the price and quantity demanded response to the VCA.

The Nielsen-tracked product groups capture approximately 30 percent of total household consumption. Our estimates of consumption elasticity with respect to the tax rate therefore only reflects consumption 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 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 3.9 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 (2089). Figure 3.8 shows that the distribution of tax changes before and after the VCA are not very different.

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.

Our predictions about the effect of the VCA on elasticity of the tax base assumes that the effective tax increase due to the VCA is fully passed through to the consumer. We test the pass-through of the VCA to the consumer directly as the effect on tax-exclusive price

[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.

at the UPC-level. We create unit-level price of each purchase as the total price after any coupons divided by the quantity recorded.

Next, 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 likely reported to the tax authority.

3.4 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 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.

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 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.

3.4.1 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:

$$\begin{aligned}\epsilon_{x,t} &= \frac{\partial D_x}{\partial t}\frac{t}{D_x} = (\frac{\partial D_{x_o}}{\partial t} + \frac{\partial D_{x_b}}{\partial t})\frac{t}{D_x} = \frac{\epsilon_{x^0,t}D_{x_o} + \epsilon_{x_b,t}D_{x_b}}{D_x} \\ &= \epsilon_{x^0,t}\theta + \epsilon_{x_b,t}(1-\theta)\end{aligned} \tag{3.1}$$

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.

3.4.2 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.

$$X(x_o, x_b) = (\psi {x_o}^{\gamma} + (1-\psi){x_b}^{\gamma})^{\frac{1}{\gamma}} \tag{3.2}$$

$$E(e_o, e_b) = (\psi {e_o}^{\gamma} + (1-\psi){e_b}^{\gamma})^{\frac{1}{\gamma}} \tag{3.3}$$

$$U(x_o, x_b, e_o, e_b) = ((1-\alpha)E\left(e_o, e_b\right)^{\rho} + \alpha X\left(x_o, x_b\right)^{\rho})^{\frac{1}{\rho}} \tag{3.4}$$

Then the consumer problem can be stated as:

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

such that

$$q_{x_o}x_o + q_{x_b}x_b + q_{e_o}e_o + q_{e_b}e_b \leq I. \tag{3.5}$$

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^i_j.

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.

$$\begin{aligned} x_o &= x_b\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}} \\ e_o &= e_b\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}} \end{aligned} \tag{3.6}$$

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

$$U(x_b,e_b) = \left(\alpha\left(\left(\psi\left(x_b\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} + (1-\psi){x_b}^{\gamma}\right)^{\frac{1}{\gamma}}\right)^{\rho}\right.$$
$$\left.+(1-\alpha)\left(\left(\psi\left(e_b\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} + (1-\psi){e_b}^{\gamma}\right)^{\frac{1}{\gamma}}\right)^{\rho}\right)^{\frac{1}{\rho}} \tag{3.7}$$

such that

$$x_b\left(q_{x_o}\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}} + q_{x_b}\right) + e_b\left(q_{e_o}\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}} + q_{e_b}\right) \leq I.$$

To simplify the problem, define the following constants

$$
\begin{aligned}
s_{x_b} &= \left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}} \\
s_{e_b} &= \left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}} \\
z_{e_b} &= \left(\psi\left(\left(\frac{q_{x_o}(1-\psi)}{q_{x_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} - \psi + 1\right) s_{x_b}{}^{\frac{1}{\gamma}} \\
z_{e_b} &= \left(\psi\left(\left(\frac{q_{e_o}(1-\psi)}{q_{e_b}\psi}\right)^{\frac{1}{\gamma-1}}\right)^{\gamma} - \psi + 1\right) s_{e_b}{}^{\frac{1}{\gamma}}
\end{aligned} \tag{3.8}
$$

And finally define new prices

$$
\begin{aligned}
r_{x_b} &= q_{x_o} s_{x_b} + q_{x_b} \\
r_{e_b} &= q_{e_o} s_{e_b} + q_{e_b}
\end{aligned} \tag{3.9}
$$

The consumer problem can be stated in the simplified CES form

$$
\begin{aligned}
& U(x_b, e_b) = \left(\alpha \left(x_b s_{x_b}\right)^{\rho} + (1-\alpha)\left(e_b z_{e_b}\right)^{\rho}\right)^{\frac{1}{\rho}} \\
& \text{such that} \\
& x_b r_{x_b} + e_b r_{e_b} \leq I.
\end{aligned} \tag{3.10}
$$

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:

$$
\begin{aligned}
x_o &= \frac{s_{x_b} I \left(\frac{\alpha}{r_{x_b}}\right)^{\sigma}}{s_{x_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\
x_b &= \frac{I \left(\frac{\alpha}{r_{x_b}}\right)^{\sigma}}{s_{x_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\
e_o &= \frac{s_{e_b} I \left(\frac{1-\alpha}{r_{e_b}}\right)^{\sigma}}{z_{e_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)} \\
e_b &= \frac{I \left(\frac{1-\alpha}{r_{e_b}}\right)^{\sigma}}{z_{e_b}\left(\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}\right)}
\end{aligned} \tag{3.11}
$$

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

3.4.3 Predictions

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

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

$$\epsilon^{pre}_{x_o,t} = -\frac{t}{1+t}\Big(\frac{t z_{x_b}^{-\gamma}(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma}\left(z_{x_b}^{\gamma}\left(r_{x_b} - \gamma p_{x_b}(t+1)\right) + r_{x_b}(\psi - 1)\right)}{(1-\gamma) r_{x_b}\left(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma} + r_{e_b}(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\right)} + \frac{r_{e_b}(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\left(\sigma z_{x_b}^{\gamma}\left(r_{x_b} - \gamma p_{x_b}(t+1)\right) + r_{x_b}(\psi - 1)\right))}{(1-\gamma) r_{x_b}\left(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma} + r_{e_b}(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\right)}\Big) > 0 \tag{3.12}$$

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 $q_{x^0} = p_{x_o}(1+t)$

$$\epsilon^{post}_{x_o,t} = -\frac{t}{1+t}\frac{\alpha^{\sigma} r_{x_b}^{1-\sigma} + \sigma(1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}}{\alpha^{\sigma} r_{x_b}^{1-\sigma} + (1-\alpha)^{\sigma} r_{e_b}^{1-\sigma}} < 0 \tag{3.13}$$

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

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:

$$\epsilon^{pre}_{x_b,t} = -\frac{t}{(1+t)}\Big(\frac{z_{x_b}^{-\gamma}\left(\left(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma} + r_{e_b}\sigma(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\right)\left(-\gamma p_{x_b}(t+1) + r_{x_b}\right) + \psi s_{x_b}^{\gamma}\left(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma} + r_{e_b}(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\right)\right)}{(1-\gamma) r_{x_b}\left(r_{x_b}\alpha^{\sigma} r_{e_b}^{\sigma} + r_{e_b}(1-\alpha)^{\sigma} r_{x_b}^{\sigma}\right)} \tag{3.14}$$

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.

$$\epsilon_{x_b,t}^{post} = \epsilon_{x_o,t}^{post} = -\frac{t}{1+t}\frac{\alpha^\sigma r_{x_b}^{1-\sigma} + \sigma(1-\alpha)^\sigma r_{e_b}^{1-\sigma}}{\alpha^\sigma r_{x_b}^{1-\sigma} + (1-\alpha)^\sigma r_{e_b}^{1-\sigma}} < 0 \tag{3.15}$$

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.

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

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 $\epsilon_{x_b,t}^{post} = \epsilon_{x_o,t}^{post}$. Prior to the VCA, the base is equal to offline expenditure and therefore the elasticity is $\epsilon_{x_b,t}^{pre}$.

Therefore, by Proposition 3.4.3 we know that the elasticity of tax base became smaller in magnitude.

3.5 VCA Effect on Online Prices and Consumption

In this section, we establish several preliminary empirical facts implicitly assumed by our model. We find that the VCA had an effect on online purchasing by households, and that these effects are consistent with an after tax price increase in online goods. First, we evidence that VCAs substantially increased the number of online purchases on which sales taxes were collected by online retailers. Next, using two measures of consumer behavior, we show that consumers reacted to this change in remittance policy akin to a tax increase, suggesting that use tax compliance was low prior to VCAs.

3.5.1 More Online Foods are Taxed at Point of Sale After the VCA

A prima facie question is ”Did the Amazon Laws actually induce online retailers to collect and remit sales taxes?” Given the difficulty and expense state authorities face in enforcing remittance obligations against out of state retailers, we do not assume that VCA were efficacious. Instead, we establish that retailers began collecting tax on online purchases from the data. 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 collected to fall.

We visually test whether 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 offline purchases, relative to the VCA adoption (see Figure 3.2). 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, suggesting that online retailers began collecting sales taxes soon after implementation of the VCA.

Having established that online retailers remitted after the policy, we now turn to the consumer response. Classical tax 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].

3.5.2 Consumers Reduced Total Online Spending on Taxed Goods, Though Not Tax-Exempt Goods

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

$$y_{hm} = \beta_0 +_1 T_h * Post_{hm} + \beta_2 X_{hm} + \gamma_m + \delta_h + \epsilon_{hm} \tag{3.16}$$

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

[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.

where y_{hm} is either (1) total online taxable expenditure or (2) total online exempt expenditure of household h in month m. β_1 is the parameter of interest where T_h indicates where household h is in a state that adopts the VCA between 2010 and 2014 and $Post_{hm}$ 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 are 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 20 cents on average, which represents an 8 percent decrease relative to the mean (Table 3.10, column 1). In contrast, we see no statistically significant effect of the VCA on online expenditure on exempt goods and the estimated magnitude is close to zero. These estimates control for household, year and month fixed effects and standard errors are clustered by state. Total monthly expenditure at brick and mortar stores increase by about one dollar but these effects are not statistically significant. Note however, that monthly expenditure at brick-and-mortar stores also include expenditure on goods that are never purchased online even prior to the VCAs. It is therefore possible that expenditure on goods that were previously purchased online increases while there is no change in other expenditure. Figure 3.3 shows, there is no anticipatory effect of the VCA in the quarter before and the parallel trends assumption holds. Figure 3.6 shows that online tax-exclusive expenditure on taxable goods falls in months following the VCA. In months before the VCA we do not see any anticipatory effects on online expenditure. Prior to the VCA, although we see fluctuation in expenditure from month to month, on average the difference in expenditure in these months relative to month just prior to the VCA is 0. After the VCA, we see that on average the expenditure is about 20 to 30 cents lower each month. We also separately estimate the effect of the VCA on large versus small retailers. Nielsen lists a unique retailer code that identifies where each purchase was made. We define ”large” retailer as the two retailer codes that together represent about 50 percent of all online purchases. We find that the expenditure decline comes largely from declines at these large online retailers. Expenditure at these retailers declines by nearly 20 percent (Table 3.10, column 2). Expenditure at small retailers on the other hand shows a small

[10]We create this measure following steps outlined in Baugh et al. (2017)

but statistically insignificant increase (Table 3.10, column 3). Similarly, we find small and statistically insignificant increases in taxable and exempt expenditure at brick-and-mortar stores (Table 3.10, columns 4 and 5). In Figure 3.6 we see a small and possibly delayed effect on monthly online tax-exclusive expenditure of households on exempt goods. However, on average this is a statistically significant expenditure change. Again, there does not seem to be evidence of anticipatory effects or differential trends in online expenditure between households in states that do and do not adopt the VCA.

3.5.3 Online Retailers Do Not Adjust Tax-Exclusive Prices; Consumers Reduce Quantity Purchased

We decompose the change in tax-exclusive online expenditure into the change in the tax-exclusive price of goods and change in consumer demand. Our specification estimating the effect on tax-exclusive prices:

$$\log(p_{cmu}) = \beta_0 + \beta_1 T_c * Post_{cm} + \gamma_m + \nu_y + \delta_u + \alpha_c + \epsilon_{smu} \tag{3.17}$$

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.

Next, we test the effect on consumer demand (quantity purchased) within UPC using the following specification:

$$\log\left(q_{cmu}\right) = \beta_0 + \beta_1 T_c * Post_{cm} + \gamma_m + \nu_y + \delta_u + \alpha_c + \epsilon_{smu} \tag{3.18}$$

where β_1 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 a couple of 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 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 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 intensive 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.

$$\log(q_{cmu}) = \beta_0 +_1 T_c * Post_{cm} * PreVCAp_{cmu} + {}_2 T_c * PreVCAp_{cmu} + \beta_3 T_c * Post_{cm} + \gamma_m + \nu_y + \delta_u + \alpha_c + \epsilon_{smu} \tag{3.19}$$

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.

3.5.3.1 Effect of VCA on Tax-Exclusive Prices.

Table 3.11 decomposes the effect on total online expenditure into the effect on prices and quantity separately. We do this analysis at the purchase level including fixed effects for each UPC, time and household/county. Columns 3-6 shows the effect on log of prices. The coefficient of interest should be interpreted as the percent change in prices due to the VCA. 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. Therefore, the reduction in expenditure is coming from consumers reducing quantity demanded of goods online.

3.5.3.2 Quantity Purchased Online - Intensive Margin

Columns 1-3 in Table 3.11 show the effect of the VCA on the intensive margin of purchases. That is, conditional on observing a purchase of a particular UPC, how does quantity purchased of that UPC change as a result of the VCA? 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, 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.

One way to test whether this happens would be to interact quantity effect with average pre-VCA price of each UPC. These results are presented in Table 3.12. We calculate the average price in 2011 for each UPC, a year in which there were no VCA adoptions, and interact the treatment effect with this price. 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. A $\$1$ increase in the average price of a UPC in 2011 translates to a 0.2 percentage point greater decrease in the quantity demanded of that UPC. This effect is robust to the inclusion of household fixed effects. For exempt goods, quantity demanded increases on average following the VCA but less so for higher price commodities. Overall, the VCA does not decrease quantity demanded of exempt goods on the intensive margin.

3.6 VCA Effect on Tax Elasticities

While the first empirical section evidenced the direct effects of the VCA on online purchasing, this second section will examine the effect of VCA adoption on fundamental parameters of the sales tax system: the elasticity of the tax base. We estimate the effect of the VCA on 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.

We also test the effect of the VCA on a subset of this base - expenditure on UPC 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.

3.6.1 VCA Effect on the Elasticity of the Tax Base with Respect to the Tax Rate

The revenue consequence of an increase in the statutory tax rate are often divided into two countervailing effects: the ”arithmetic” effect of a higher rate which increases revenue, and the ”economic effect” of reducing the base by dis-incentivizing the taxed economic activity (See, e.g. Laffer 2004 for discussion). We are concerned with the later. In our context, a higher sales tax rate increases the cost of taxed goods, and can reduce the sales tax base through multiple channels. The sales tax base can shrink in if taxpayers substitute to tax exempt products (substitution effect) or reduce consumption of all products (income effect), both of which are determined by consumers' utility functions. In addition, the base might shrink if consumers respond to a higher tax rate by putting greater effort into sales tax avoidance via cross border shopping, black market purchases, or in the context at hand, by ordering items online. Unlike the substitution and income effects, the "avoidance effect" of increasing the tax rate on the tax base is determined by other features of the tax system, such as the enforcement regime, that determine the effort/costs the taxpayer must expend/incur to avoid their jurisdiction's tax rate. (See, e.g. Slemrod 2008).

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

$$B_{ht} = \sum_{i}^{I} p_{iht}(\tau) X_{iht}(q_{iht}(p_{iht}(\tau), \tau)) \tag{3.20}$$

where I is the set of all taxable goods in the jurisdiction of household h, and 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

$$\frac{d_{ht}}{dVCAd\tau} = \frac{d_{ht}}{d\tau}|_{VCA=1} - \frac{d_{ht}}{\tau}|_{VCA=0} \tag{3.21}$$

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

We estimate this effect with the following OLS specification at the household-month level:

$$\Delta log(e_{hcst}) = \beta_0 + \beta_1 \Delta\tau_{ct} + \beta_2 treat_s post_{st} + \beta_3 \Delta\tau_{ct} treat_s post_{st} + \pi X_{ct} + \gamma_h + \gamma_t + \gamma_s * t + \epsilon_{hcst} \tag{3.22}$$

β_1 captures the relationship between the tax base and the sales tax rate in untreated states. β_2 represents the tax rate invariant effect of VCA adoption on expenditures. The coefficient of interest, β_3 , captures how the effect of VCA adoption varies with changes in the sales tax rate. 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, respectively.

In Table 3.13, 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.

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 that this change is not statistically significant.

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 focus on only positive tax rate changes. We find a very large estimated elasticity of the tax base of -3.8, which is even larger when we restrict the sample to just prior to the VCA (and to states that adopt the VCA) at -4 (column 2). The coefficient on $_3$ in column 4 is positive, as we expect, suggesting that the VCA reduced the elasticity of the effective base.

In column 5, we estimate the same specification on the subset of goods that are purchased both online and offline. Surprisingly, we do not find the same effect of the VCA on this subset of goods. Columns 6-9 restrict the analysis to only brick-and-mortar purchases. The estimated effects are largely similar to what we see in the effects on the effective tax base. This is what we would expect since brick-and-mortar purchases form 99 percent of the effective base.

Although we control for hyper local market conditions, we recognize that our estimates may still be vulnerable to omitted variable bias. Future analysis will explore potential instruments for locality I's tax rate, for example, the lagged tax rate of similar counties or proximate counties, or fixing price to some period before the treatment window (See Case, Rosen, Hines (1993); spatial correlation in tax rate paper estimated on UK data).

3.7 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. 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. This response suggests a sales tax elasticity of between -1.2 and -1.4, smaller but still in the range of elasticity estimates reported by Baker and Keung in their study of consumer response to local sales tax rate changes. Both of these findings call into question the view that sales taxes are not salient to buyers at the point of purchase. Finally, we attempt to measure the impact of VCA adoption on the sales tax elasticity. Unfortunately, only two states in our sample change their tax rates after adopting a VCA, providing insufficient variation to reliably measure this estimate. In future work, we plan to use state sales tax holidays as an alternative source of tax rate variation to measure this impact. For example, if VCA adoption meaningfully limits consumers' ability to avoid paying sales taxes throughout the year, then we would expect consumer response to sales tax holidays to increase.

3.8 Tables and Figures

Figure 3.1: Date of Implementation of Amazon VCAs

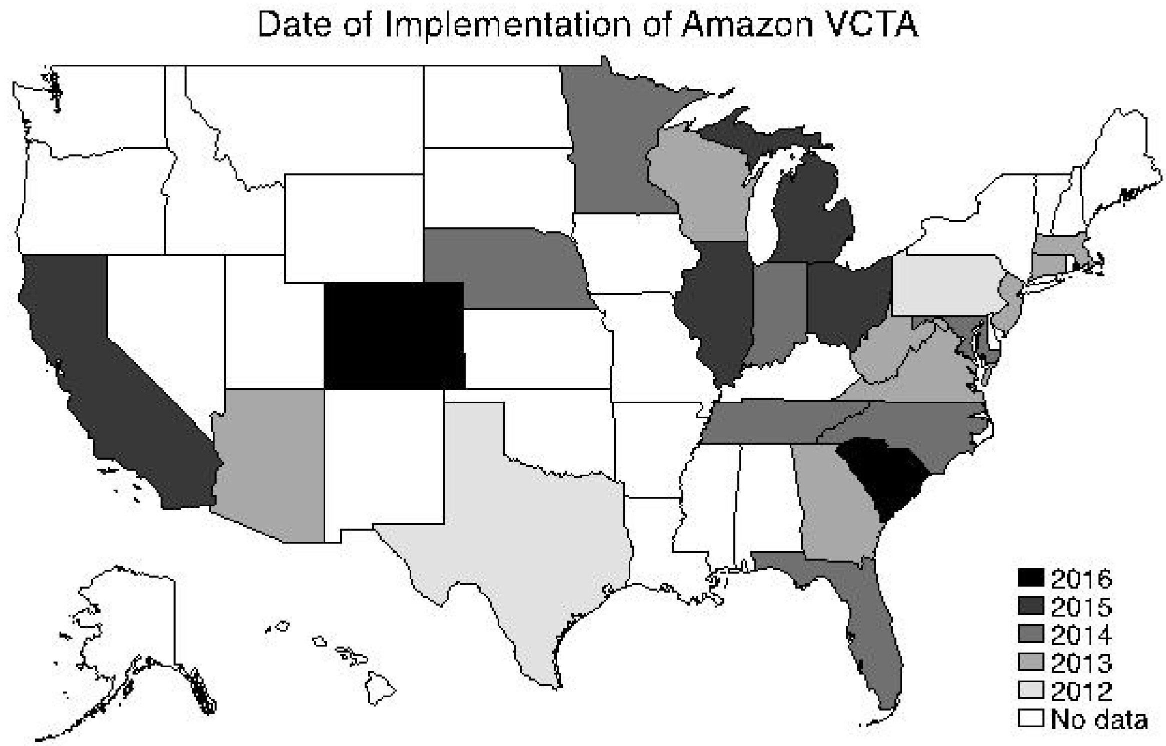


Figure 3.2: Fraction of Trips with Only Taxed Items that Paid No Sales Tax

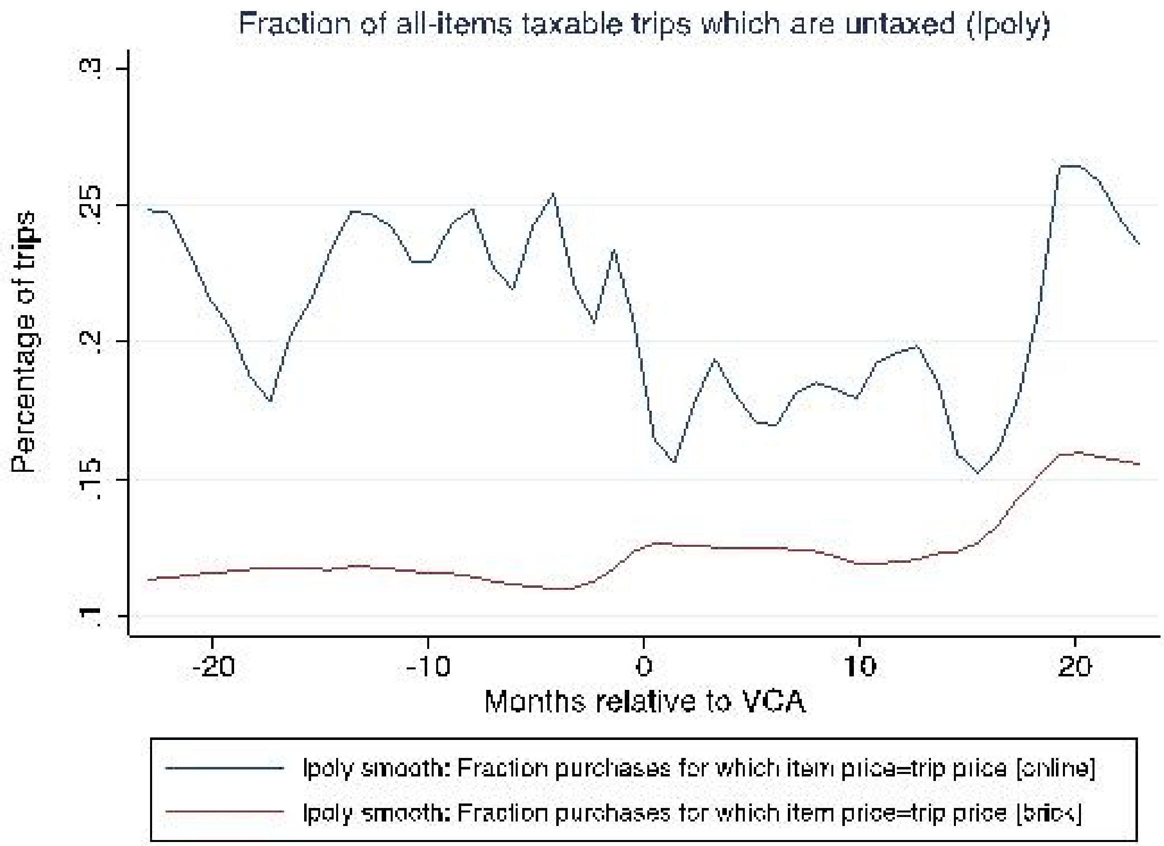


Figure 3.3: Change in Average Monthly Household Expenditure on Taxable Goods Online

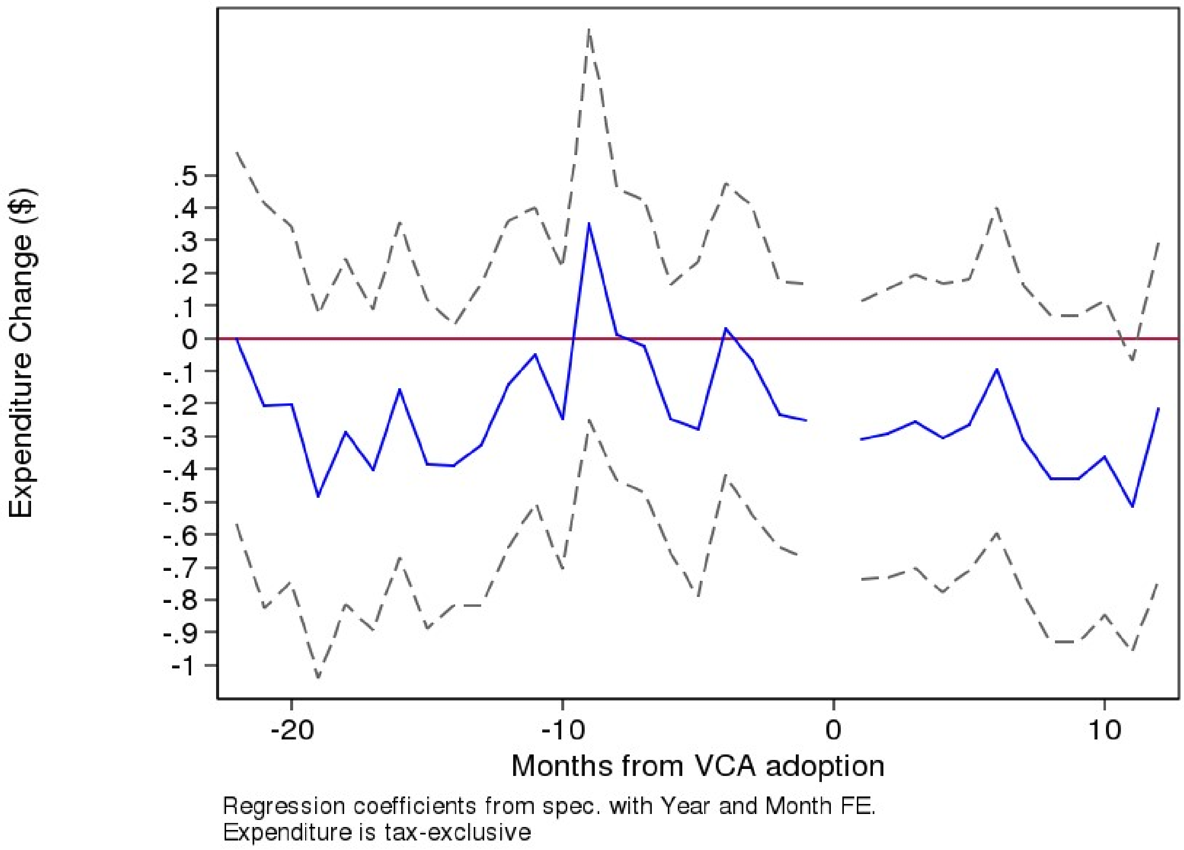


Figure 3.4: Change in Average Monthly Household Expenditure on Taxable Goods Online at Large Retailers

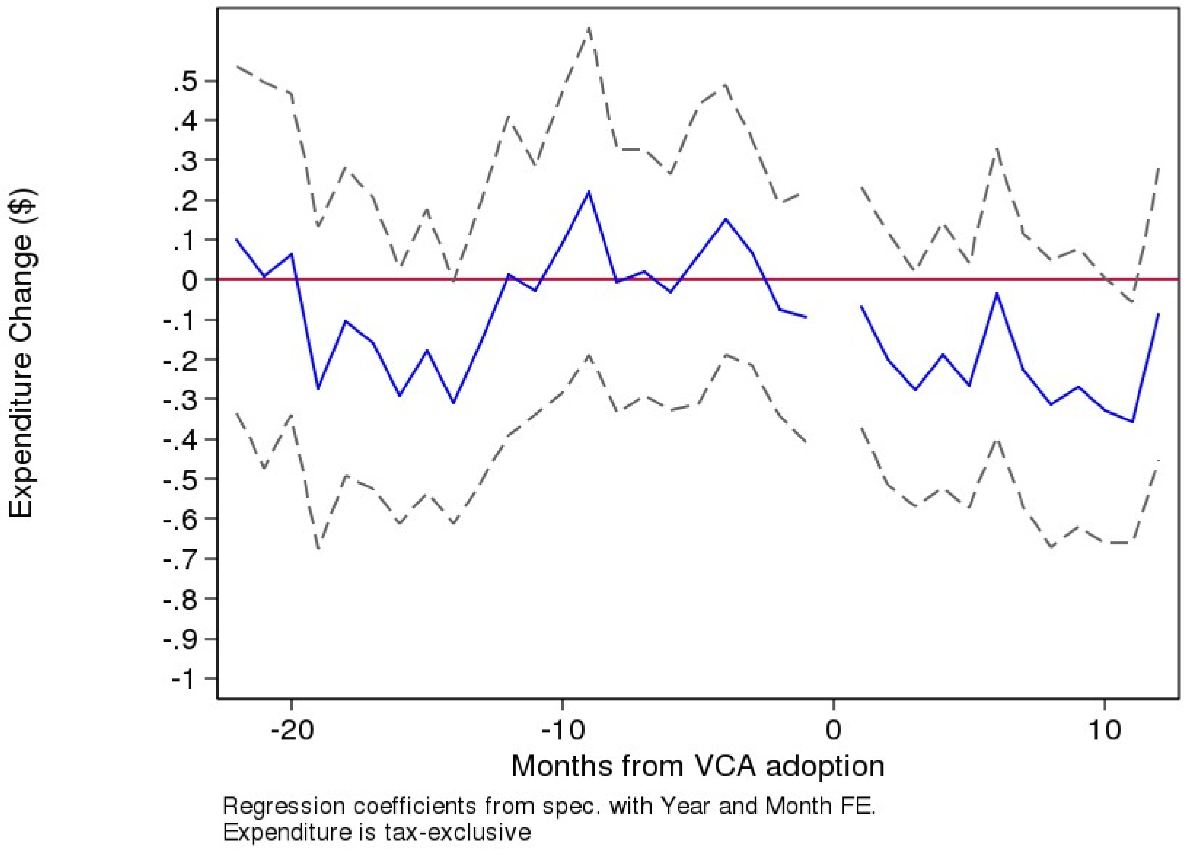
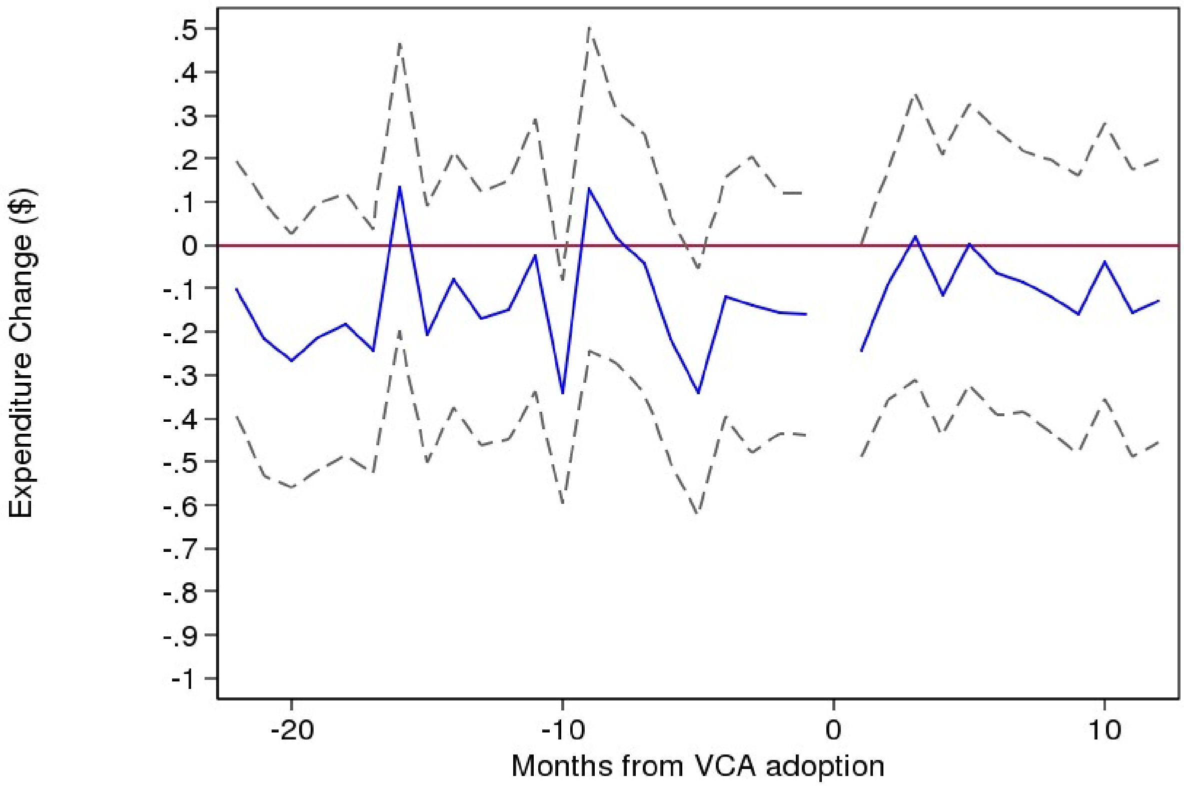


Figure 3.5: Change in Average Monthly Household Expenditure on Taxable Goods Online at Small Retailers



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

Figure 3.6: Change in Average Monthly Household Expenditure on Exempt Goods Online

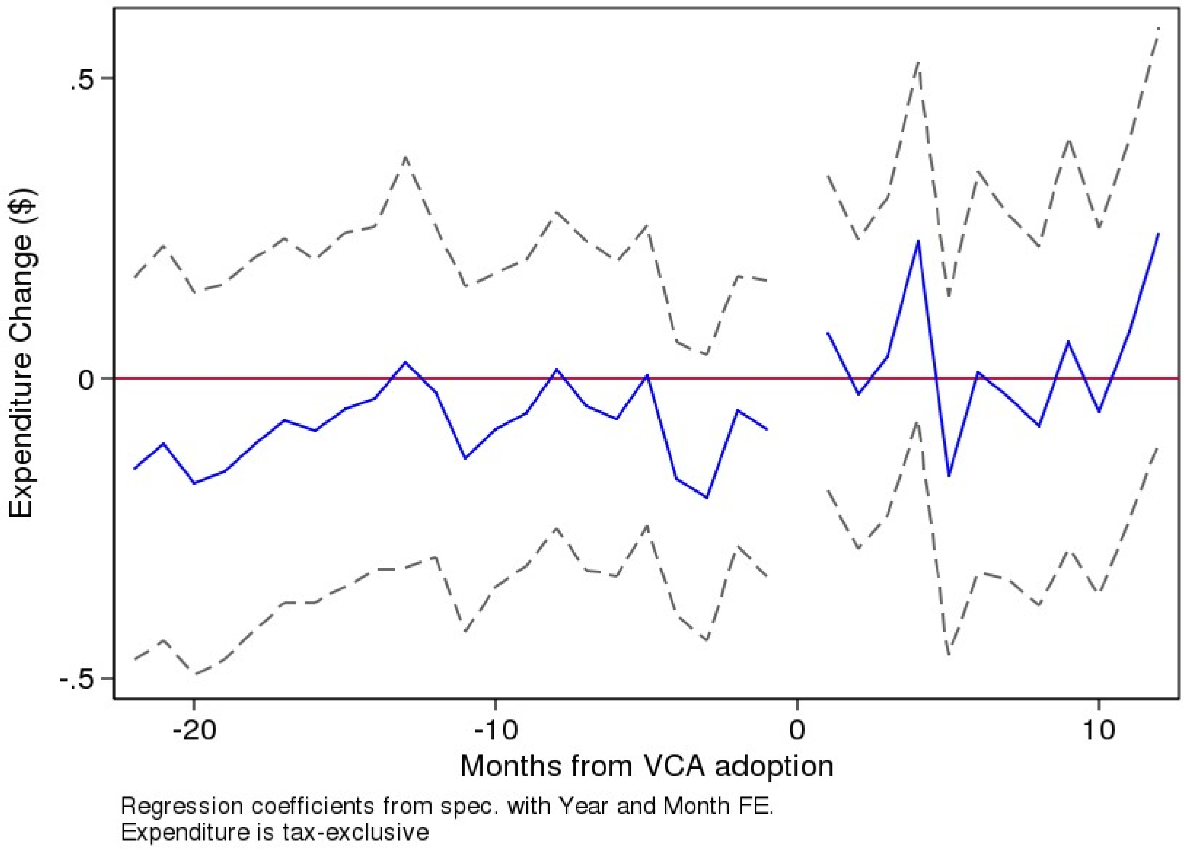
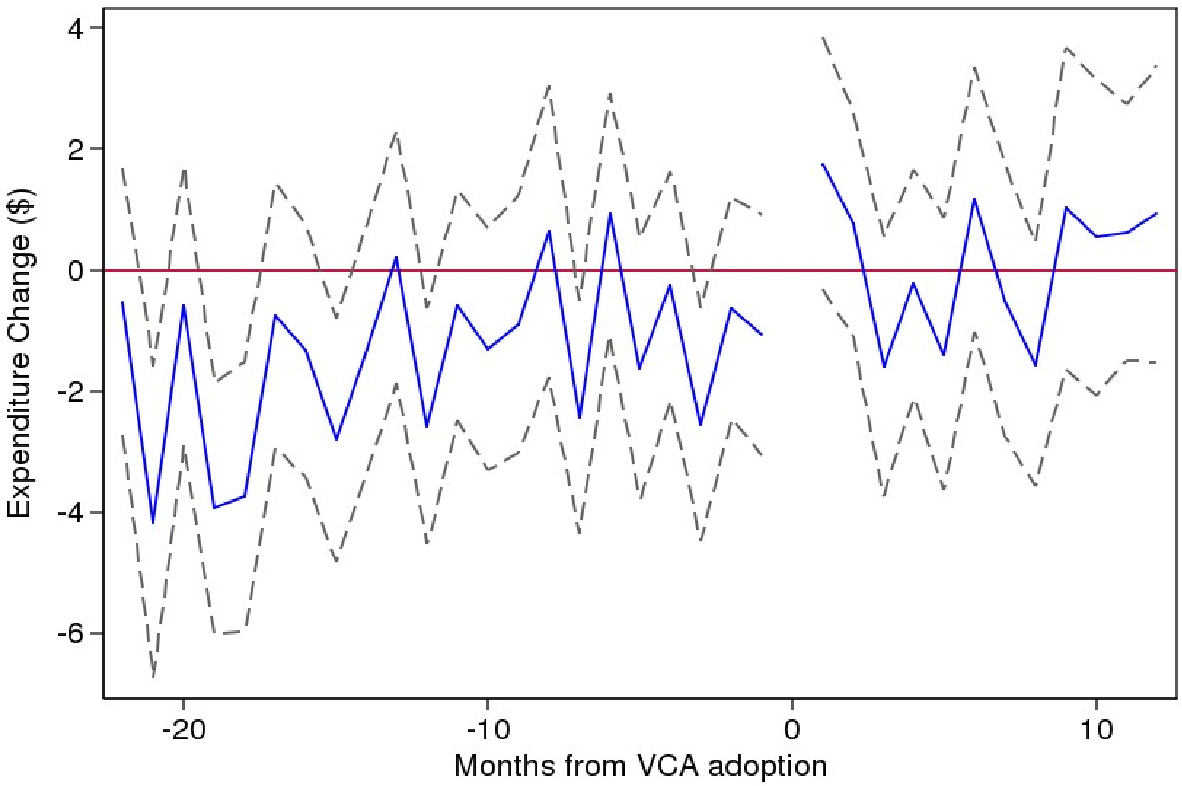


Figure 3.7: Change in Average Monthly Household Expenditure on Taxable Goods at Brick-and-Mortar Stores



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

Figure 3.8: Local Sales Tax Rate Changes

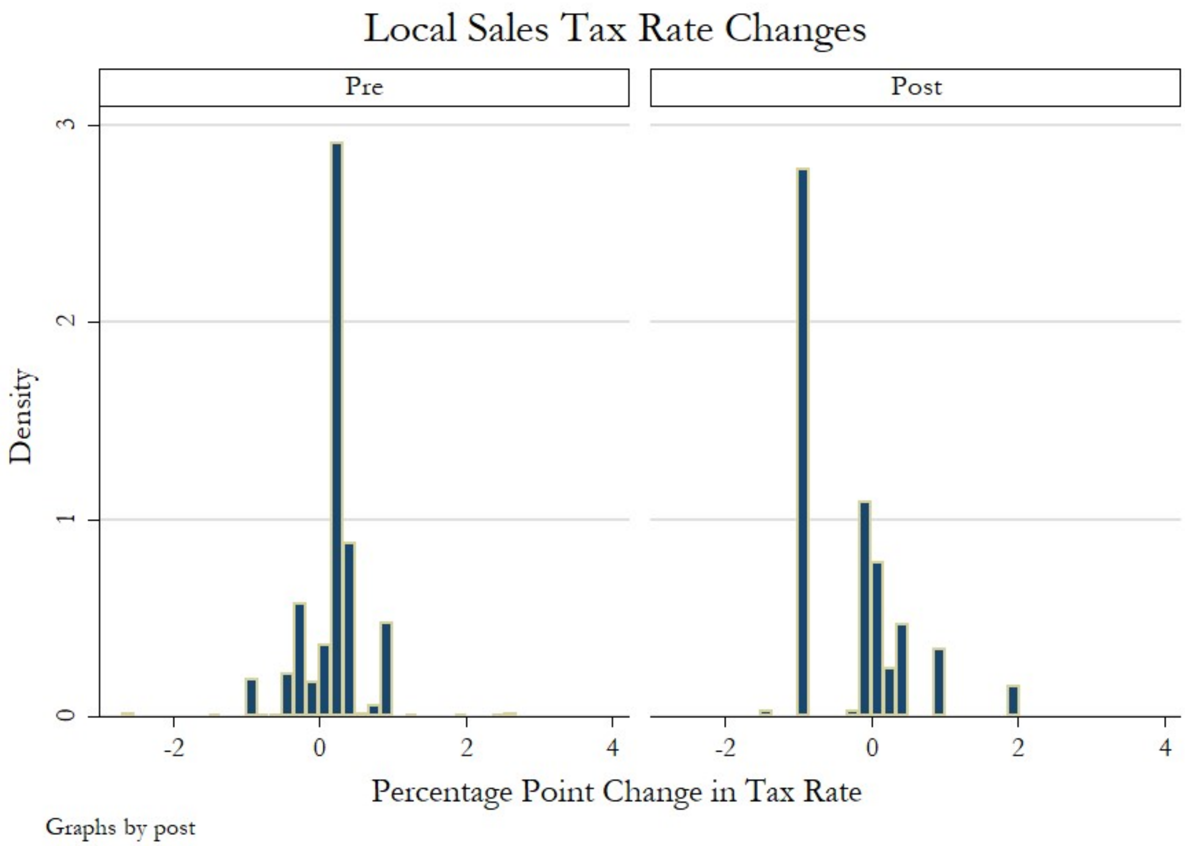


Figure 3.9: State and Local Sales Tax by Year

State and Local Sales Tax by Year	2010	2011	2012	2013	2014	Total
State Rate Changes	3	3	0	8	0	14
County Rate Changes	68	59	65	92	88	372
City Rate Changes	207	247	1109	271	255	2089
Total	278	309	1174	371	343	2475

Figure 3.10: Effect of VCA on Change in Average Monthly Household Expenditure

	Dependent Variable: Average Monthly Household Expenditure in Category					
	(1)	(2)	(3)	(4)	(5)	(6)
	Online				Brick-and-Mortar	
	Taxable			Exempt	Taxable	Exempt
	Total	Large Retail	Small Retail			
Treat X Post	-0.231*	-0.247***	0.016	0.118	0.556	0.546
	(0.119)	(0.091)	(0.103)	(0.088)	(0.677)	(1.105)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3591230	3591230	3591230	3591230	3591230	3591230

Note: Standard errors in parentheses, clustered by state. *p<0.1, **p<0.05, ***p<0.1. Dependent Variable is measured in dollars. Average online taxable expenditure per month is approximately $2.70 (of which $1.20 is at large retail), average online exempt expenditure online is approximately $1.40. Online taxable expenditure declines by 8.5 percent. Online taxable expenditure at large retailers declines by almost 20 percent.

Figure 3.11: Pass-through of VCA to Prices, and Effect of VCA on Quantity Demanded Controlling for UPC-level Fixed Effects

	Dependent Variable: Log(Quantity)			Dependent Variable: Log(Tax-Exclusive Price)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Taxable		Exempt	Taxable		Exempt
Treat X Post	-0.007	-0.007	-0.001	-0.009*	-0.001	0.002
	(0.006)	(0.008)	(0.009)	(0.005)	(0.005)	(0.007)
UPC FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs (Purchases)	884647	778420	888773	879392	773596	885008

Note: Standard errors in parentheses, clustered by state. *p<0.1, **p<0.05, ***p<0.1. Columns (2) and (5) exclude videos and CDs/ DVDs.

Figure 3.12: Variation in Effect of VCA on Quantity Demanded by Ex-Ante Price of UPC

	Dependent Variable: Log(Quantity)			
	(1)	(2)	(3)	(4)
		Taxable Products		Exempt Products
Treat X Post X 2011 Price	-0.001**	-0.002**	-0.001**	-0.009***
	(0.001)	(0.001)	(0.001)	(0.003)
Treat X 2011 Price	-0.000	-0.000	-0.001*	0.002
	(0.000)	(0.000)	(0.000)	(0.002)
Treat X Post	-0.004	-0.004	-0.007	0.007
	(0.007)	(0.009)	(0.007)	(0.011)
UPC FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes		Yes
Household FE			Yes	
Obs (Purchases)	884647	778420	769024	888773

Note: Standard errors in parentheses, clustered by state. *p<0.1, **p<0.05, ***p<0.1. 2011 price is the average price recorded for each UPC in 2011 across all purchases in the Nielsen Homescan data. Column (2) excludes video products.

Figure 3.13: Effect of VCA on Elasticity of the Tax Base.

	Δ Log(Effective Base)				Δ Log (Effective Base-select)	Δ Log(Brick-and-Mortar Base)			
	All	Pre	Pre	All	All	All	Pre	Pre	All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ Tax Rate	-3.860***	-4.611***	-3.431*	-3.191	-5.757	-3.913***	-4.547***	-3.354*	-3.110
	(1.466)	(1.539)	(1.980)	(1.986)	(8.809)	(1.470)	(1.538)	(1.980)	(1.988)
Treat X Δ Tax Rate			-2.791	-2.769	3.752			-2.822	-2.786
			(3.182)	(3.154)	(11.864)			(3.180)	(3.151)
Post X Δ Tax Rate				7.828	-10.752				6.297
				(5.390)	(20.024)				(5.539)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N (Household-Month)	3298724	2714777	2714777	3298724	542098	3296636	2714777	2714777	3296636

Note: Standard errors in parentheses. *p<0.1 **p<0.05 *** p<0.01. Sample restricted to time periods that experience either positive or no change in tax rate. Columns (1), (4), (5),(6) and (9) include all time periods. Columns (2),(3),(7) and (8) online include time periods prior to VCA and therefore also only states that implement the VCA between 2010 and 2014. The "Effective Base- select" includes only expenditure on UPC that are purchased online between 5 and 95 percent of the time. The "Effective Base" is defined as expenditure on brick-and-mortar purchases prior to the VCA (or in the absence of VCA) and expenditure on brick and mortar purchases as well as online expenditure after the VCA.

APPENDIX A

Chapter I Supporting Material

A.1 Appendix

In this section I will provide details about omitted proofs and some of the equations. Interested readers are referred to the online appendix for a more detailed analysis.

The following inequality is always true in this model:

$$0 < \underline{\beta} < \underline{y} < \omega < y_\omega < \overline{\beta} < \overline{y} < m \tag{A.1}$$

A.1.1 Agent's Problem

EI_{dif} increases with income.

$$EI_{dif} = \begin{cases} \frac{t(y-\underline{\omega})^2}{2(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \underline{\beta} \le y \le \underline{y} \\ \frac{t(-\pi^2(\overline{\varpi}-y)^2-(\overline{\varpi}-\underline{\omega})^2+2\pi(y^2+\underline{\omega}^2-\underline{\omega}\overline{\varpi}+\overline{\varpi}^2-y(\overline{\varpi}+\underline{\omega}))}{4\pi(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \underline{y} \le y \le \overline{\beta} \\ -\frac{t(\pi^2(\overline{\varpi}-y)^2-2\pi(\overline{\varpi}-\underline{\beta})(y-\underline{\omega})+(\overline{\varpi}-\underline{\omega})^2}{4\pi(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \overline{\beta} \le y \le \overline{y} \\ t\frac{\overline{\varpi}-\underline{\omega}}{2} & \text{if} \quad \overline{y} \le y < m \end{cases}$$

$$\frac{\partial EI_{dif}}{\partial y} = \begin{cases} \frac{t(y-\underline{\omega})}{(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \underline{\beta} \le y \le \underline{y} \\ \frac{t((\pi-1)\overline{\varpi}-\underline{\omega}+(2-\pi)y)}{2(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \underline{y} \le y \le \overline{\beta} \\ \frac{t((\pi+1)\overline{\varpi}-\pi y-\underline{\omega}}{2(\overline{\varpi}-\underline{\omega})} & \text{if} \quad \overline{\beta} \le y \le \overline{y} \\ 0 & \text{if} \quad \overline{y} \le y < m \end{cases}$$

Derivative in the first interval is positive since $\overline{\varpi} > y > \underline{\omega}$. For the second and third interval, both the denominator and the numerator are positive because $\overline{\varpi} > y > \underline{\omega}$ and $1 < p < 2$.

A.1.2 Demand

$y_d(c)$ is continuous in c.

$$y_d(c) = \begin{cases} y_y = \underline{\beta} + \frac{\sqrt{2}\sqrt{c(\overline{\beta}-\underline{\beta})}}{t} & \text{if} \quad 0 \leq c \leq \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \\ y_r = \frac{\underline{\beta}+\sqrt{2}\sqrt{\frac{2c(\pi-2)\pi+(\pi-1)^2 t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}-\pi\overline{\beta}}{\pi-2} & \text{if} \quad \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \leq c \leq \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \\ y_{\overline{\beta}} = \frac{(-\underline{\beta}+\sqrt{2}\pi\sqrt{\frac{(2c+t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}+\pi\overline{\beta}}{\pi} & \text{if} \quad \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \leq c \leq \frac{(\overline{\beta}-\underline{\beta})t}{2} \\ m & \text{if} \quad c > \frac{(\overline{\beta}-\underline{\beta})t}{2} \end{cases}$$

It is obvious that each cut-off function is continuous in c. Then, showing that the cut-offs do not jump at the boundaries is enough. Plugging in c at each boundary point will yield the following:

$$y_d(c) = \begin{cases} y_y = y_r = \underline{y} & \text{if} \quad c = \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \\ y_r = y_{\overline{\beta}} = \overline{\omega} & \text{if} \quad c = \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \\ y_{\overline{\beta}} = \overline{y} & \text{if} \quad c = \frac{(\overline{\beta}-\underline{\beta})t}{2} \end{cases}$$

A.1.2.1 Comparative Statics

Derivative with respect to $\underline{\beta}$:

$$\frac{\partial y_d(c)}{\partial \underline{\beta}} = \begin{cases} 1 - \frac{c}{\sqrt{2}\sqrt{ct(\overline{\beta}-\underline{\beta})}} & \underline{\beta} + \frac{2\pi^2 c}{(\pi-1)^2 t} \leq \overline{\beta} \\ -\frac{\frac{\sqrt{\frac{2}{\pi}}\left((\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)}{\sqrt{t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)}}+1}{\pi-2} & \frac{4\pi c}{t-2\pi t} + \overline{\beta} \geq \underline{\beta} \wedge \underline{\beta} + \frac{2\pi^2 c}{(\pi-1)^2 t} \geq \overline{\beta} \\ -\frac{\sqrt{\frac{2}{\pi}}(c+t(\underline{\beta}-\overline{\beta}))}{\sqrt{t(\underline{\beta}-\overline{\beta})(2c+t(\underline{\beta}-\overline{\beta}))}} - \frac{1}{\pi} & \underline{\beta} + \frac{2c}{t} \leq \overline{\beta} \wedge \frac{4\pi c}{t-2\pi t} + \overline{\beta} \leq \underline{\beta} \end{cases}$$

Derivative with respect to $\overline{\beta}$:

$$\frac{\partial y_d(c)}{\partial \overline{\beta}} = \begin{cases} \frac{c^2 t}{2\sqrt{2}(ct(\overline{\beta}-\underline{\beta}))^{3/2}} & (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \leq 0 \\ -\frac{\sqrt{2}(\pi-2)\pi^{3/2}c^2 t}{\left(t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)\right)^{3/2}} & \frac{4\pi c}{t-2\pi t} + \overline{\beta} \geq \underline{\beta} \wedge (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \geq 0 \\ -\frac{\sqrt{\frac{2}{\pi}}c^2 t}{(t(\underline{\beta}-\overline{\beta})(2c+t(\underline{\beta}-\overline{\beta})))^{3/2}} & \underline{\beta} + \frac{2c}{t} \leq \overline{\beta} \wedge \frac{4\pi c}{t-2\pi t} + \overline{\beta} \leq \underline{\beta} \end{cases}$$

Derivative with respect to c:

$$\frac{\partial y_d(c)}{\partial c} = \begin{cases} -\frac{1}{2\sqrt{2}\sqrt{-ct(\underline{\beta}-\overline{\beta})}} & (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \leq 0 \\ -\frac{\sqrt{2}(\pi-2)\pi^{3/2}ct(\underline{\beta}-\overline{\beta})}{\left(t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)\right)^{3/2}} & \frac{4\pi c}{t-2\pi t} + \overline{\beta} \geq \underline{\beta} \wedge (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \geq 0 \\ -\frac{\sqrt{\frac{2}{\pi}}ct(\underline{\beta}-\overline{\beta})}{(t(\underline{\beta}-\overline{\beta})(2c+t(\underline{\beta}-\overline{\beta})))^{3/2}} & \underline{\beta} + \frac{2c}{t} \leq \overline{\beta} \wedge \frac{4\pi c}{t-2\pi t} + \overline{\beta} \leq \underline{\beta} \end{cases}$$

Derivative with respect to t:

$$\frac{\partial y_d(c)}{\partial t} = \begin{cases} \frac{c}{2\sqrt{2}t\sqrt{-ct(\underline{\beta}-\overline{\beta})}} & (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \leq 0 \\ \frac{\sqrt{2}(\pi-2)\pi^{3/2}c^2(\underline{\beta}-\overline{\beta})}{\left(t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)\right)^{3/2}} & \frac{4\pi c}{t-2\pi t} + \overline{\beta} \geq \underline{\beta} \wedge (\pi-1)^2(\underline{\beta}-\overline{\beta}) + \frac{2\pi^2 c}{t} \geq 0 \\ \frac{\sqrt{\frac{2}{\pi}}c^2(\underline{\beta}-\overline{\beta})}{(t(\underline{\beta}-\overline{\beta})(2c+t(\underline{\beta}-\overline{\beta})))^{3/2}} & \underline{\beta} + \frac{2c}{t} \leq \overline{\beta} \wedge \frac{4\pi c}{t-2\pi t} + \overline{\beta} \leq \underline{\beta} \end{cases}$$

Derivative with respect to π:

$$\frac{\partial y_d(c)}{\partial \pi} = \begin{cases} 0 & \underline{\beta} + \frac{2\pi^2 c}{(\pi-1)^2 t} \leq \overline{\beta} \vee (\\ \frac{(\underline{\beta}-\overline{\beta})\left(2\pi^{3/2}\sqrt{t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)}+2\sqrt{2}(\pi-2)\pi^2 c+\sqrt{2}\left(-2+3\pi-2\pi^2+\pi^3\right)t(\underline{\beta}-\overline{\beta})\right)}{2(\pi-2)^2\pi^{3/2}\sqrt{t(\underline{\beta}-\overline{\beta})\left(2(\pi-2)\pi c+(\pi-1)^2 t(\underline{\beta}-\overline{\beta})\right)}} & \frac{4\pi c}{t-2\pi t} + \overline{\beta} \geq \underline{\beta} \wedge \underline{\beta} + \\ \frac{(\underline{\beta}-\overline{\beta})\left(2\pi^{3/2}\sqrt{t(\underline{\beta}-\overline{\beta})(2c+\underline{\beta}t-\overline{\beta}t)}+2\sqrt{2}\pi^2 c+\sqrt{2}\pi^2 t(\underline{\beta}-\overline{\beta})\right)}{2\pi^{7/2}\sqrt{t(\underline{\beta}-\overline{\beta})(2c+t(\underline{\beta}-\overline{\beta}))}} & \text{True} \end{cases}$$

Derivative with respect to $(\overline{\beta} - \underline{\beta})$: To do this define $\overline{\beta} = \omega + \epsilon$ and $\underline{\beta} = \omega - \epsilon$

$$\frac{\partial y_d(c)}{\partial \epsilon} = \begin{cases} \frac{c}{\sqrt{ct\epsilon}} - 1 & \frac{\pi^2 c}{(\pi-1)^2 t} \leq \epsilon \\ \frac{\pi^{3/2}\sqrt{t\epsilon((\pi-1)^2 t\epsilon-(\pi-2)\pi c)}+\sqrt{2}(\pi-2)\pi c-2\sqrt{2}(\pi-1)^2 t\epsilon}{(\pi-2)\sqrt{\pi}\sqrt{t\epsilon((\pi-1)^2 t\epsilon-(\pi-2)\pi c)}} & \frac{2\pi c}{t-2\pi t} + \epsilon \geq 0 \wedge \frac{\pi^2 c}{(\pi-1)^2 t} \geq \epsilon \\ \frac{\sqrt{\frac{2}{\pi}}(c-2t\epsilon)}{\sqrt{t\epsilon(t\epsilon-c)}} + \frac{2}{\pi} + 1 & \frac{c}{t} \leq \epsilon \wedge \frac{2\pi c}{t-2\pi t} + \epsilon \leq 0 \end{cases}$$

A.1.3 Information revelation by government as an instrument of compliance

A.1.3.1 Evasion

Proposition 1:

$$\underline{\triangle r_1} = \int_{\underline{y}}^{\bar{y}} r^* dy + \int_{\bar{y}}^{m} \overline{\beta} dy - \int_{\underline{y}}^{\omega} y dy - \int_{\omega}^{m} \omega dy$$

$$\underline{\triangle r_1} = \frac{4m\pi^2(\underline{\beta} + 3\overline{\beta}) + \underline{\beta}^2(-3\pi^2 - 4) + \underline{\beta}\overline{\beta}(8 - 6\pi^2) - \overline{\beta}^2(7\pi^2 + 4)}{8\pi^2}$$

$$\underline{\triangle r_2} = \int_{\bar{y}}^{m} (\overline{\beta} - \omega) dy > 0$$

$$\underline{\triangle r_2} = \frac{(\underline{\beta} - \overline{\beta})(-\underline{\beta} + \overline{\beta} - m\pi + \overline{\beta}\pi)}{2\pi}$$

$$\underline{\triangle r_1} - \underline{\triangle r_2} = \frac{(-4 + 4\pi - 3\pi^2)\underline{\beta}^2 - 2(-4 + 4\pi + 5\pi^2)\underline{\beta}\overline{\beta} + (-4 + 4\pi - 3\pi^2)\overline{\beta}^2 + 8\pi^2 m(\underline{\beta} + \overline{\beta})}{8\pi^2}$$

This difference is positive as long as

$$\frac{(4 - 4\pi + 3\pi^2)\underline{\beta}^2 + 2(-4 + 4\pi + 5\pi^2)\underline{\beta}\overline{\beta} + (4 - 4\pi + 3\pi^2)\overline{\beta}^2}{8\pi^2(\underline{\beta} + \overline{\beta})} < m$$

Which is satisfies by the assumption that

$$\bar{y} < m$$

Therefore minimum possible change in reported income is $\underline{\triangle r_2}$, which is positive as long $\bar{y} < m$.

The least upper bound, which is the change in reported income where only people with income higher than y_ω hire the firm can be characterized by the following equation:

$$\overline{\triangle r} = \int_{y_\omega}^{\bar{y}} r^* dy + \int_{\bar{y}}^{m} \overline{\beta} dy - \int_{y_\omega}^{m} \omega dy \tag{A.2}$$

$$\overline{\triangle r} = \frac{(\underline{\beta} - \overline{\beta})(-2m\pi + (\pi - 2)\underline{\beta} + (2 + \pi)\overline{\beta}}{4\pi} > 0 \tag{A.3}$$

Furthermore, we can calculate the change in reported income given any cut-off point (previously defined as $y_d(c)$):

$$\triangle r = \begin{cases} \int_{\underline{y}}^{\bar{y}} r^* dy + \int_{\bar{y}}^{m} \overline{\beta} dy - \int_{\underline{y}}^{\omega} y dy - \int_{\omega}^{m} \omega dy & \text{if } y_d(c) \leq \underline{y} \\ \int_{y_d(c)}^{\bar{y}} r^* dy + \int_{\bar{y}}^{m} \overline{\beta} dy - \int_{y_d(c)}^{\omega} y dy - \int_{\omega}^{m} \omega dy & \text{if } y_d(c) \in [\underline{y}, \omega] \\ \int_{y_d(c)}^{\bar{y}} r^* dy + \int_{\bar{y}}^{m} \overline{\beta} dy - \int_{y_d(c)}^{m} \omega dy & \text{if } y_d(c) \in [\omega, \bar{y}] \\ \int_{y_d(c)}^{m} (\overline{\beta} - \omega) dy & \text{if } y_d(c) \geq \bar{y} \end{cases}$$

A.1.3.2 Reported Income Comparative Statics

For further analysis of reported income, define $\overline{\omega} = \omega + \epsilon$ and $\underline{\omega} = \omega - \epsilon$ to simplify notation.

Case 1: Everyone hires the firm, i.e. $y_d(c) = y_y$

Reported income:

$$RI(y_y) = \omega m - \frac{\omega^2}{2}$$

In this case, none of the parameters have an effect on the reported income.

Case 2: Only taxpayers with income above y_r *hire the firm and* $y_r < y_\omega$*, i.e.* $y_d(c) = y_r < y_\omega$

Reported income:

$$RI(y_r|y_r < y_\omega) = \frac{4c(\pi-2)\pi^2\epsilon + 8\sqrt{2}(\pi-1)\epsilon\sqrt{\pi t\epsilon\left((\pi-1)^2 t\epsilon - c(\pi-2)\pi\right)} + \omega(\pi-2)^2\pi^2 t(2k-\omega) - 4\left(\pi^3 - 3\pi + 2\right)t\epsilon^2}{2(\pi-2)^2\pi^2 t}$$

Derivative with respect to ϵ-spread:

$$\frac{\partial RI(y_r|y_r < y_\omega)}{\partial \epsilon} = \frac{-4\sqrt{2\pi}\left(2 - 2\pi + \pi^2\right)\epsilon\sqrt{t\epsilon\left((\pi-1)^2 t\epsilon - (\pi-2)\pi c\right)}}{2(\pi-2)^2\pi^2 t} - \frac{4(\pi-2)\pi^2 c\epsilon + (\pi-2)^2\pi^2\omega t(2m-\omega) + \left(-8 + 20\pi - 16\pi^2 + 4\pi^3 + \pi^4\right)t\epsilon^2}{2(\pi-2)^2\pi^2 t}$$

Derivative with respect to π

$$\frac{\partial RI(y_r|y_r<y_\omega)}{\partial \pi} = \frac{-\sqrt{2}c\pi^6t\epsilon^2+4\sqrt{2}c\pi^5t\epsilon^2-14\sqrt{2}c\pi^4t\epsilon^2-4p^4t\epsilon^2\sqrt{pt\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}{(\pi-2)^3\pi^3t\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}$$
$$+\frac{28\sqrt{2}c\pi^3t\epsilon^2+12\pi^3t\epsilon^2\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}-4c\pi^3\epsilon\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}{(\pi-2)^3\pi^3t\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}$$
$$+\frac{-16t\epsilon^2\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}+\sqrt{2}\pi^6t^2\epsilon^3-4\sqrt{2}\pi^5t^2\epsilon^3+17\sqrt{2}\pi^4t^2\epsilon^3-36\sqrt{2}\pi^3t^2\epsilon^3}{(\pi-2)^3\pi^3t\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}$$
$$+\frac{34\sqrt{2}\pi^2t^2\epsilon^3-12\sqrt{2}\pi t^2\epsilon^3}{(\pi-2)^3\pi^3t\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}}$$

Derivative with respect to t

$$\frac{\partial RI(y_r|y_r<y_\omega)}{\partial t} = \frac{c\epsilon\left(2-\frac{\sqrt{\frac{2}{\pi}}\left(2-2\pi+\pi^2\right)t\epsilon}{\sqrt{t\epsilon((\pi-1)^2t\epsilon-(\pi-2)\pi c)}}\right)}{(\pi-2)t^2}$$

Derivative with respect to c:

$$\frac{\partial RI(y_r|y_r<y_\omega)}{\partial c} = \frac{\epsilon\left(\frac{\sqrt{\frac{2}{\pi}}\left(2-2\pi+\pi^2\right)\epsilon}{\sqrt{t\epsilon((\pi-1)^2t\epsilon-(\pi-2)\pi c)}}-\frac{2}{t}\right)}{\pi-2}$$

Case 3: Only taxpayers with income above y_r hire the firm and $y_r > y_\omega$, i.e. $y_d(c) = y_r > y_\omega$

Reported income

$$RI(y_r|y_r>y_\omega) = \frac{-4\sqrt{2}\left(\pi^2-2\pi+2\right)x\sqrt{\pi t\epsilon\left((\pi-1)^2t\epsilon-c(\pi-2)\pi\right)}-4c(\pi-2)\pi^2\epsilon}{2(\pi-2)^2\pi^2t}+$$
$$\frac{\omega(\pi-2)^2\pi^2t(2k-\omega)+\left(\pi^4+4\pi^3-16\pi^2+20\pi-8\right)t\epsilon^2}{2(\pi-2)^2\pi^2t}$$

Derivative with respect to ϵ-spread

$$\frac{\partial RI(y_r|y_r > y_\omega)}{\partial \epsilon} = -\frac{\frac{2\sqrt{2\pi}\left(2-2\pi+\pi^2\right)t\epsilon\left(2(\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}{\sqrt{t\epsilon((\pi-1)^2t\epsilon-(\pi-2)\pi c)}} + 4\sqrt{2\pi}\left(2-2\pi+\pi^2\right)\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}{2(\pi-2)^2\pi^2 t} + -\frac{4(\pi-2)\pi^2 c - 2\left(-8+20\pi-16\pi^2+4\pi^3+\pi^4\right)t\epsilon}{2(\pi-2)^2\pi^2 t}$$

Derivative with respect to π

$$\frac{\partial RI(y_r|y_r > y_\omega)}{\partial \pi} = \frac{-\sqrt{2}\pi^6 ct\epsilon^2 + 4\sqrt{2}\pi^5 ct\epsilon^2 - 14\sqrt{2}\pi^4 ct\epsilon^2 + 28\sqrt{2}\pi^3 ct\epsilon^2 - 16\sqrt{2}\pi^2 ct\epsilon^2}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$
$$+ \frac{-4\pi^{9/2}t\epsilon^2\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)} + 12\pi^{7/2}t\epsilon^2\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$
$$+ \frac{-30\pi^{5/2}t\epsilon^2\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)} + 36\pi^{3/2}t\epsilon^2\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$
$$+ \frac{-16\sqrt{\pi}t\epsilon^2\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)} + 2\pi^{9/2}c\epsilon\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$
$$+ \frac{-4\pi^{7/2}c\epsilon\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)} + \sqrt{2}\pi^6t^2\epsilon^3 - 4\sqrt{2}\pi^5t^2\epsilon^3 + 17\sqrt{2}\pi^4t^2\epsilon^3 - 36\sqrt{2}\pi^3t^2\epsilon^3}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$
$$+ \frac{34\sqrt{2}\pi^2t^2\epsilon^3 - 12\sqrt{2}\pi t^2\epsilon^3}{(\pi-2)^3\pi^{7/2}t\sqrt{t\epsilon\left((\pi-1)^2t\epsilon-(\pi-2)\pi c\right)}}$$

Derivative with respect to t

$$\frac{\partial RI(y_r|y_r > y_\omega)}{\partial t} = \frac{c\epsilon\left(2 - \frac{\sqrt{\frac{2}{\pi}}\left(2-2\pi+\pi^2\right)t\epsilon}{\sqrt{t\epsilon((\pi-1)^2t\epsilon-(\pi-2)\pi c)}}\right)}{(\pi-2)t^2}$$

Derivative with respect to c:

$$\frac{\partial RI(y_r|y_r > y_\omega)}{\partial c} = \frac{\epsilon\left(\frac{\sqrt{\frac{2}{\pi}}\left(2-2\pi+\pi^2\right)\epsilon}{\sqrt{t\epsilon((\pi-1)^2t\epsilon-(\pi-2)\pi c)}} - \frac{2}{t}\right)}{\pi-2}$$

Case 4: Only taxpayers with income above $y_{\overline{\beta}}$, i.e. $y_d(c) = y_{\overline{\beta}}$
Reported income:

$$RI(y_r|y_{\overline{\beta}}) = \frac{-4\sqrt{2}\pi^{3/2}\epsilon\sqrt{t\epsilon(t\epsilon - c)} - 4\pi c\epsilon + \pi^2\omega t(2k - \omega) + (-4 + 8\pi + \pi^2)\, t\epsilon^2}{2\pi^2 t}$$

Derivative with respect to ϵ-spread

$$\frac{\partial RI(y_r|y_{\overline{\beta}})}{\partial \epsilon} = -\frac{\frac{2\sqrt{2}\pi^{3/2}t\epsilon(2t\epsilon - c)}{\sqrt{t\epsilon(t\epsilon - c)}} + 4\sqrt{2}\pi^{3/2}\sqrt{t\epsilon(t\epsilon - c)} + 4\pi c - 2\,(-4 + 8\pi + \pi^2)\, t\epsilon}{2\pi^2 t}$$

Derivative with respect to π

$$\frac{\partial RI(y_r|y_{\overline{\beta}})}{\partial \pi} = \\ \frac{\epsilon\left(t\epsilon\left(-4\pi^{5/2}\sqrt{t\epsilon(t\epsilon - c)} + 4\pi^{3/2}\sqrt{t\epsilon(t\epsilon - c)} + \sqrt{2}\pi^3 t\epsilon\right) + c\left(2\pi^{5/2}\sqrt{t\epsilon(t\epsilon - c)} - \sqrt{2}\pi^3 t\epsilon\right)\right)}{\pi^{9/2} t\sqrt{t\epsilon(t\epsilon - c)}}$$

Derivative with respect to t

$$\frac{\partial RI(y_r|y_{\overline{\beta}})}{\partial t} = -\frac{c\epsilon\left(\sqrt{2}\pi^{3/2}\sqrt{t\epsilon(t\epsilon - c)} + 2\pi c - 2\pi t\epsilon\right)}{\pi^2 t^2 (t\epsilon - c)}$$

Derivative with respect to c:

$$\frac{\partial RI(y_r|y_{\overline{\beta}})}{\partial c} = \frac{\epsilon\left(\frac{\sqrt{2\pi}t\epsilon}{\sqrt{t\epsilon(t\epsilon - c)}} - 2\right)}{\pi t}$$

Case 4: No one hires the firm, i.e $y_d(c) = m$.
Reported income:

$$RI(m) = -\frac{\omega^2}{2} - \omega\epsilon + m(\omega + \epsilon) + \left(-\frac{2}{\pi^2} - \frac{1}{2}\right)\epsilon^2$$

Derivative with respect to ϵ-spread:

$$\frac{\partial RI(m)}{\partial \epsilon} = -\omega + k + \left(-1 - \frac{4}{\pi^2}\right)\epsilon$$

Derivative with respect to π:

$$\frac{\partial RI(m)}{\partial \pi} = \frac{4\epsilon^2}{\pi^3}$$

Other derivatives are equal to 0.

A.1.4 Effect of tax preparation firms when tax preparation costs are increasing in income

Expected income difference is as follows

$$EI_{dif} = \begin{cases} \frac{2cy(\overline{\beta}-\underline{\beta})-t(y-\underline{\beta})^2}{2(\underline{\beta}-\overline{\beta})} & \underline{\beta} \leq y \leq \frac{\underline{\beta}+(\pi-1)\overline{\beta}}{\pi} \\ \frac{-2\pi\left(2cy(\underline{\beta}-\overline{\beta})+t\left(\underline{\beta}^2-\underline{\beta}\overline{\beta}+\overline{\beta}^2+y^2-y(\underline{\beta}+\overline{\beta})\right)\right)+t(\underline{\beta}-\overline{\beta})^2+\pi^2 t(y-\overline{\beta})^2}{4\pi(\underline{\beta}-\overline{\beta})} & \frac{\underline{\beta}+(\pi-1)\overline{\beta}}{\pi} \leq y \leq \overline{\beta} \\ \frac{-2\pi(\underline{\beta}-\overline{\beta})(2cy+t(\underline{\beta}-y))+t(\underline{\beta}-\overline{\beta})^2+\pi^2 t(y-\overline{\beta})^2}{4\pi(\underline{\beta}-\overline{\beta})} & \overline{\beta} \leq y \leq \frac{-\underline{\beta}+\pi\overline{\beta}+\overline{\beta}}{\pi} \\ \frac{1}{2}(t(\overline{\beta}-\underline{\beta})-2cy) & y \geq \frac{-\underline{\beta}+\pi\overline{\beta}+\overline{\beta}}{\pi} \end{cases}$$

Due to large size of equations and conditions, the rest of the analysis is presented in the online appendix

The following depicts all possible points where the $EI_{dif} = cy$. In other words, these are cutoffs from at which either demand can be starting or ending.

If $0 < c < \frac{1}{4} \wedge \frac{1}{1-2c} < \pi < 2 \wedge \frac{2\pi c}{\pi-1} < t < 1 \wedge \underline{\beta} > 0 \wedge \frac{\underline{\beta}\left(2\pi c+(\pi-1)^2 t\right)}{(\pi-1)(2\pi c-\pi t+t)} + \overline{\beta} \geq 0$

Then the cutoff is

$$y_y = \frac{c(\overline{\beta}-\underline{\beta}) + \sqrt{c(\underline{\beta}-\overline{\beta})(\underline{\beta}c - c\overline{\beta} - 2\underline{\beta}t)} + \underline{\beta}t}{t}$$

such that

$$\underline{\beta} \leq y_y \leq \underline{y}$$

If

$$\left(0 < c < \frac{1}{4} \land \left(\left(\left(1 < \pi \leq \frac{1}{1-2c} \land \frac{4c\pi}{2\pi-1} < t < 1 \land \underline{\beta} > 0 \land \overline{\beta} \geq \frac{\underline{\beta}(1-2\pi)t}{4c\pi - 2\pi t + t}\right) \lor \right.\right.\right.$$

$$\left(\underline{\beta} > 0 \land \frac{1}{1-2c} < \pi < 2 \land \left(\left(\left(\frac{2c\pi}{\pi-1} < t < 1 \land \frac{\underline{\beta}(1-2\pi)t}{4c\pi - 2\pi t + t} \leq \overline{\beta} \leq -\frac{\underline{\beta}\left(2c\pi + (\pi-1)^2 t\right)}{(\pi-1)(2c\pi - \pi t + t)}\right) \lor \right.\right.\right.$$

$$\left(\overline{\beta} \geq \frac{\underline{\beta}(1-2\pi)t}{4c\pi - 2\pi t + t} \land \frac{4c\pi}{2\pi-1} < t \leq \frac{2c\pi}{\pi-1}\right) \lor$$

$$\left(4c = 1 \land 1 < \pi < 2 \land \frac{\pi}{2\pi-1} < t < 1 \land \underline{\beta} > 0 \land \overline{\beta} \geq \frac{\underline{\beta}(1-2)t}{-2t+\pi+t}\right) \lor$$

$$\left(\frac{1}{4} < c < \frac{3}{8} \land \frac{1}{2-4c} < \pi < 2 \land \frac{4c\pi}{2\pi-1} < t < 1 \land \underline{\beta} > 0 \land \overline{\beta} \geq \frac{\underline{\beta}(1-2)t}{4c\pi - 2\pi t + t}\right)$$

Then the cutoff is

$$y_r = \frac{-\sqrt{2\pi}\sqrt{(\overline{\beta}-\underline{\beta})\left(2\pi c^2(\overline{\beta}-\underline{\beta}) + 2\pi c t(\underline{\beta} - \pi\overline{\beta} + \overline{\beta}) + (\pi-1)^2 t^2(\overline{\beta}-\underline{\beta})\right)}}{(\pi-2)\pi t} + \frac{2\pi c(\underline{\beta}-\overline{\beta}) - \pi t(\underline{\beta}+\overline{\beta}) + \pi^2\overline{\beta} t}{(\pi-2)\pi t}$$

which satisfies

$$\underline{y} \leq y_r \leq \overline{\beta}$$

If the parameters satisfy the following conditions

$$
\begin{aligned}
&\bigg(0 < c \leq \frac{1}{4} \wedge 1 < \pi < 2 \wedge \bigg(\bigg(\frac{2c(\pi+1)}{\pi} < t < 1 \wedge \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \leq \overline{\beta} \leq \frac{\underline{\beta}(2c-\pi t)}{2c(\pi+1)-\pi t}\bigg) \vee \\
&\bigg(\overline{\beta} \geq \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \wedge c\bigg(\sqrt{\frac{1}{\pi^2}+1}+\frac{1}{\pi}+1\bigg) < t \leq \frac{2c(\pi+1)}{\pi}\bigg) \vee \\
&\bigg(4c > 1 \wedge c + \frac{1}{\sqrt{2}} \leq 1 \wedge \underline{\beta} > 0 \wedge \bigg(\bigg(\overline{\beta} \geq \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \wedge c\bigg(\sqrt{\frac{1}{\pi^2}+1}+\frac{1}{\pi}+1\bigg) < t \wedge \\
&\bigg(\bigg(\pi > 1 \wedge t < 1 \wedge \frac{1}{2c-1}+\pi+1 \leq 0\bigg) \vee \bigg(\frac{2c}{1-2c} < \pi \wedge \pi < 2 \wedge t \leq \frac{2c(\pi+1)}{\pi}\bigg)\bigg)\bigg) \vee \\
&\bigg(\frac{2c}{1-2c} < \pi < 2 \wedge \frac{2c(\pi+1)}{\pi} < t < 1 \wedge \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \leq \overline{\beta} \leq \frac{\underline{\beta}(2c-\pi t)}{2c(\pi+1)-\pi t}\bigg) \vee \\
&\bigg(\underline{\beta} > 0 \wedge c + \frac{1}{\sqrt{2}} > 1 \wedge 3c < 1 \wedge \\
&\bigg(\bigg(\frac{2c}{1-2c} < \pi < 2 \wedge \bigg(\bigg(\frac{2c(\pi+1)}{\pi} < t < 1 \wedge \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \leq \overline{\beta} \leq \frac{\underline{\beta}(2c-\pi t)}{2c(\pi+1)-\pi t}\bigg) \vee \\
&\bigg(\overline{\beta} \geq \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \wedge c\bigg(\sqrt{\frac{1}{\pi^2}+1}+\frac{1}{\pi}+1\bigg) < t \leq \frac{2c(\pi+1)}{\pi}\bigg) \vee \\
&\bigg(\overline{\beta} \geq \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2} \wedge \frac{2(c-1)c}{2c-1} < \pi \leq \frac{2c}{1-2c} \wedge c\bigg(\sqrt{\frac{1}{\pi^2}+1}+\frac{1}{\pi}+1\bigg) < t < 1\bigg) \vee \\
&\bigg(3c \geq 1 \wedge 2c + \sqrt{5} < 3 \wedge \frac{2(c-1)c}{2c-1} < \pi < 2 \wedge c\bigg(\sqrt{\frac{1}{\pi^2}+1}+\frac{1}{\pi}+1\bigg) < t < 1 \wedge \underline{\beta} > 0 \wedge \\
&\qquad \overline{\beta} \geq \frac{\underline{\beta}\left(2c^2-2ct+\pi t^2\right)}{2c^2-2c(\pi+1)t+\pi t^2}
\end{aligned}
$$

Then the cutoff point is:

$$
y_{\overline{\omega_1}} = \frac{\sqrt{2}\pi\sqrt{(\underline{\beta}-\overline{\beta})\left(2c^2(\underline{\beta}-\overline{\beta})+2ct(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})+\pi t^2(\underline{\beta}-\overline{\beta})\right)}+2\pi c(\underline{\beta}-\overline{\beta})+\pi t(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})}{\pi^2 t}
$$

However, if the following is true

$$\Bigg(0<c\leq \frac{1}{4}\land 1<p<2\land \Bigg(\Bigg(\frac{4cp}{2p-1}<t<1\land \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\leq \overline{\beta}\leq \frac{\underline{\beta}(1-2p)t}{4cp-2pt+t}\Bigg)\lor$$

$$\Bigg(\overline{\beta}\geq \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\land c\left(\sqrt{\frac{1}{p^2}+1}+\frac{1}{p}+1\right)<t\leq \frac{4cp}{2p-1}\Bigg)\lor$$

$$\Bigg(4c>1\land c+\frac{1}{\sqrt{2}}\leq 1\land \Bigg(\Bigg(\overline{\beta}\geq \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\land c\left(\sqrt{\frac{1}{p^2}+1}+\frac{1}{p}+1\right)<t\land$$

$$\Bigg(\Bigg(p>1\land t<1\land p\leq \frac{1}{2-4c}\Bigg)\lor \Bigg(\frac{1}{2-4c}<p\land p<2\land t\leq \frac{4cp}{2p-1}\Bigg)\Bigg)\Bigg)\lor$$

$$\Bigg(\frac{1}{2-4c}<p<2\land \frac{4cp}{2p-1}<t<1\land \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\leq \overline{\beta}\leq \frac{\underline{\beta}(1-2p)t}{4cp-2pt+t}\Bigg)\lor$$

$$\Bigg(c+\frac{1}{\sqrt{2}}>1\land 8c<3$$

$$\land\Bigg(\Bigg(\frac{1}{2-4c}<p<2\land \Bigg(\Bigg(\frac{4cp}{2p-1}<t<1\land \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\leq \overline{\beta}\leq \frac{\underline{\beta}(1-2p)t}{4cp-2pt+t}\Bigg)\lor$$

$$\Bigg(\overline{\beta}\geq \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\land c\left(\sqrt{\frac{1}{p^2}+1}+\frac{1}{p}+1\right)<t\leq \frac{4cp}{2p-1}\Bigg)\lor$$

$$\Bigg(\overline{\beta}\geq \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}\land \frac{2(c-1)c}{2c-1}<p\leq \frac{1}{2-4c}\land c\left(\sqrt{\frac{1}{p^2}+1}+\frac{1}{p}+1\right)<t<1\Bigg)\lor$$

$$\Bigg(8c\geq 3\land 2c+\sqrt{5}<3\land \frac{2(c-1)c}{2c-1}<p<2\land c\left(\sqrt{\frac{1}{p^2}+1}+\frac{1}{p}+1\right)<t<1\land$$

$$\overline{\beta}\geq \frac{\underline{\beta}\left(2c^2-2ct+pt^2\right)}{2c^2-2c(p+1)t+pt^2}$$

$$y_d(c(y))=\begin{cases}\frac{c(\overline{\beta}-\underline{\beta})+\sqrt{c(\underline{\beta}-\overline{\beta})(\underline{\beta}c-c\overline{\beta}-2\underline{\beta}t)}+\underline{\beta}t}{t} & \underline{\beta}\leq y\leq \frac{\underline{\beta}+(\pi-1)\overline{\beta}}{\pi}\\ \frac{-\sqrt{2\pi}\sqrt{(\overline{\beta}-\underline{\beta})\left(2\pi c^2(\overline{\beta}-\underline{\beta})+2\pi ct(\underline{\beta}-\pi\overline{\beta}+\overline{\beta})+(\pi-1)^2t^2(\overline{\beta}-\underline{\beta})\right)}+2\pi c(\underline{\beta}-\overline{\beta})-\pi t(\underline{\beta}+\overline{\beta})+\pi^2\overline{\beta}t}{(\pi-2)\pi t} & \frac{\underline{\beta}+(\pi-1)\overline{\beta}}{\pi}\leq y\leq \overline{\beta}\\ \frac{\sqrt{2}\pi\sqrt{(\underline{\beta}-\overline{\beta})\left(2c^2(\underline{\beta}-\overline{\beta})+2ct(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})+\pi t^2(\underline{\beta}-\overline{\beta})\right)}+2\pi c(\underline{\beta}-\overline{\beta})+\pi t(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})}{\pi^2 t}, & \\ \frac{-\sqrt{2}\pi\sqrt{(\underline{\beta}-\overline{\beta})\left(2c^2(\underline{\beta}-\overline{\beta})+2ct(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})+\pi t^2(\underline{\beta}-\overline{\beta})\right)}+2\pi c(\underline{\beta}-\overline{\beta})+\pi t(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})}{\pi^2 t} & \overline{\beta}\leq y\leq \frac{-\underline{\beta}+\pi\overline{\beta}+\overline{\beta}}{\pi}\\ \frac{t(\overline{\beta}-\underline{\beta})}{2c} & y\geq \frac{-\underline{\beta}+\pi\overline{\beta}+\overline{\beta}}{\pi}\end{cases}$$

The following are all possible forms the demand function can take when the cost function is defined to be cy

- There is a single cutoff

- There are two cutoffs:

- Demand is the interval $[y_y, y_m]$
- Demand is the interval $[y_r, y_m]$
- Demand is the interval $[y_{\overline{\beta}}, y_m]$
- Demand is the interval $[y_{\overline{\beta}_1}, y_{\overline{\beta}_2}]$

Proposition 3: Proof: As mentioned

A.1.5 Effect of tax preparation firms when firms have imperfect information

In this section, the following inequality is always true:

$$0 < \underline{\beta} < \underline{y} < \underline{y_f} < \underline{\omega_f} < \omega < \overline{\omega_f} < \overline{\beta} < \overline{y_f} < \overline{y} < m \tag{A.4}$$

If firms have more informative knowledge than agents believe them to have, the following inequality should be true:

$$0 < \underline{\beta} < \underline{y} < \underline{y_f} < \mathbb{E}[\underline{\omega_f}] < \underline{\omega_f} < \omega < \overline{\omega_f} < \mathbb{E}[\overline{\omega_f}] < \overline{\beta} < \overline{y_f} < \overline{y} < m \tag{A.5}$$

Demand cutoff schedule

$$y_d(c) = \begin{cases} \frac{\sqrt{2}(\overline{\beta}-\underline{\beta})\sqrt{t\left((\pi-2)^2t-\frac{32\pi c}{\underline{\beta}-\overline{\beta}}\right)}+2\pi t(\underline{\beta}+\overline{\beta})}{4\pi t} & 0 < c \leq \frac{\left(4-12\pi+\pi^2\right)t(\overline{\beta}-\underline{\beta})}{64\pi} \\ \frac{\sqrt{\pi}(\underline{\beta}-\overline{\beta})\sqrt{t\left(\frac{4c}{\underline{\beta}-\overline{\beta}}+t\right)}+t(-\underline{\beta}+\pi\overline{\beta}+\overline{\beta})}{\pi t} & \frac{1}{4}t(\overline{\beta}-\underline{\beta}) > c \geq \frac{\left(4-12\pi+\pi^2\right)t(\overline{\beta}-\underline{\beta})}{64\pi} \\ m & c > \frac{1}{4}t(\overline{\beta}-\underline{\beta}) \end{cases}$$

To make the analysis easier, rewrite the previous schedule with the notation $\underline{\beta} = \omega - \epsilon$ and $\overline{\beta} = \omega + \epsilon$

$$y_d(c) = \begin{cases} \frac{\sqrt{2}\epsilon\sqrt{t\left(\frac{16\pi c}{\epsilon}+(\pi-2)^2t\right)}+2\pi t\omega}{2\pi t} & c > 0 \wedge 32\pi c \leq (4-12\pi+\pi^2)\, t\epsilon \\ -\frac{2\epsilon\sqrt{t\left(t-\frac{2c}{\epsilon}\right)}}{\sqrt{\pi}t} + \omega + \frac{2\epsilon}{\pi} + \epsilon & 2c < t\epsilon \wedge 32\pi c \geq (4-12\pi+\pi^2)\, t\epsilon \\ m & 2c > t\epsilon \end{cases}$$

Proposition 4:

Proof:

$$\int_{y_d}^{\underline{y_f}} (y - r_f^*)dy + \int_{\underline{y_f}}^{\overline{y_f}} (r_f^* - r_s^*)dy + \int_{\overline{y_f}}^{\overline{y}} (\overline{\omega_f} - r_s^*)dy + \int_{\overline{y}}^{m} (\overline{\omega_f} - \overline{\omega})$$

The lowest possible demand cutoff is when $c = 0$ which is $\frac{\sqrt{2}(\overline{\beta}-\underline{\beta})\sqrt{(p-2)^2t^2+2pt(\underline{\beta}+\overline{\beta})}}{4pt}$. Substituting this cutoff for y_d yields the following equation:

$$\frac{1}{32}\left(16m(\underline{\beta}-\overline{\beta}+2x)\right.$$
$$+\frac{(\overline{\beta}-\underline{\beta})\left(\overline{\beta}\left(\left(9-2\sqrt{2}\right)\pi^2+4\left(3+2\sqrt{2}\right)\pi-8\sqrt{2}+4\right)+\underline{\beta}(\pi-2)\left(\left(7+2\sqrt{2}\right)\pi-4\sqrt{2}+2\right)\right)}{\pi^2}-$$
$$\left.\frac{16\left(\pi^2+4\right)x^2}{\pi^2}-16x(\underline{\beta}+\overline{\beta})\right) \quad \text{(A.6)}$$

Because we are considering Case 1, the following inequality must be true:

$$0<\underline{\beta}<\underline{y}<\underline{y_f}<\underline{\omega_f}<\omega<\overline{\omega_f}<\overline{\beta}<\overline{y_f}<\overline{y}<m \quad \text{(A.7)}$$

Under these conditions, equation A.6 is always negative, which implies reported income always decreases, hence, evasion increases with the availability of firms.

A.1.6 Extensions

A.1.6.1 Monopoly

Suppose now that there is only one firm. In this case, the firm will choose the fee (f) that maximizes its profit function rather than setting it equal to the marginal cost. The agent‘s problem is unchanged, therefore the demand cutoff schedule from section 1.2.1 is exactly the same:

$$y_d(f)=\begin{cases} y_y=\underline{\beta}+\sqrt{2}+\sqrt{\frac{f(\overline{\beta}-\underline{\beta})}{t}} & \text{if} \quad 0\leq f\leq\frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2} \\ y_r=\frac{\underline{\beta}+\sqrt{2}\sqrt{\frac{2f(\pi-2)\pi+(\pi-1)^2t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}-\pi\overline{\beta}}{\pi-2} & \text{if} \quad \frac{(\pi-1)^2(\overline{\beta}-\underline{\beta})t}{2\pi^2}\leq f\leq\frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi} \\ y_{\overline{\beta}}=\frac{(-\underline{\beta}+\sqrt{2}\pi\sqrt{\frac{(2f+t(\underline{\beta}-\overline{\beta}))(\underline{\beta}-\overline{\beta})}{\pi t}}+\overline{\beta}+\pi\overline{\beta}}{\pi} & \text{if} \quad \frac{(2\pi-1)(\overline{\beta}-\underline{\beta})t}{4\pi}\leq f\leq\frac{(\overline{\beta}-\underline{\beta})t}{2} \\ m & \text{if} \quad f>\frac{(\overline{\beta}-\underline{\beta})t}{2} \end{cases}$$

Given a demand cutoff $y_d(f)$, firms maximize the following profit function:

$$(m-y_d(f))(f-c) \quad \text{(A.8)}$$

Solving the firm's maximization problem gives us the following optimal fee schedule which is presented in the online appendix. For some intuition, suppose the marginal cost is equal to 0. This will provide us the case where a monopoly chooses highest demand. Even in this case, a monopoly will never serve agents with income below y_y. When the penalty is small enough ($\pi < 1.5$), demand is large enough that a monopoly will only serve people with income larger than $\overline{\beta}$. If the penalty rate is greater than 1.5, then the group of people monopoly serves depends on the top income level. If the top income level is high enough monopoly will serve people with income higher than $\overline{\beta}$. The firm will tap into the lower income levels $y > y_y$ if the top income is not high enough. Looking at the smallest possible cut-off demand a monopoly will choose (largest demand possible), one can see that it is always greater than y_ω which is the threshold above which all self-preparing agents are reporting more than the audit threshold. From prior evasion analysis, we have that if $y_d > y_\omega$ decreasing demand increases compliance. Therefore, one can conclude that in the monopoly case the government always wants to decrease demand.

Unlike the perfect competition setting, it is not always the case that noncompliance levels are higher in a monopoly setting.

A.1.6.2 Effect of tax preparation firms when firms have imperfect information

When firms do not have perfect information about the audit rule, the benefit of the firm to taxpayers decreases. However, this benefit will still be increasing in income and hence, with the constant marginal cost assumption, demand for tax preparation services will be characterized by a single cutoff. This demand cutoff is likely to be higher than the demand cutoff derived in the perfect information case, given a fixed marginal cost, because the net benefit of hiring a firm decreases for all taxpayers. Furthermore, as this demand cutoff increases, the mass of taxpayers who hire the firm, will include a smaller proportion of the taxpayers increase their reported income. This effect will increase evasion in the economy. On the contrary, evasion on individual level will decrease because firms' information about the audit rule is not perfect anymore. Therefore, it is not straightforward to see if the level of evasion in this case is higher than the level of evasion in the perfect information case. Still, firms will increase evasion compared to the case where they are not present.

A.1.6.3 Risk-averse agents

Changing the risk-preference of agents changes self-preparation expected income more than it affects anything else in the model. In cases where an agent chooses to underreport her income, imposing risk-averse behavior will decrease the level of expected income under self-preparation more than firm-preparation. This is because agents are exposed to the risk of being audited in the former case, whereas there is no risk of audit in the latter. This implies that given a fixed marginal cost, demand for tax preparation services will be higher in the model with risk-averse agents. However, it is not obvious whether this change in assumptions will always lead to a higher evasion level.

APPENDIX B

Chapter III Supporting Material

B.1 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.

B.1.1 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[1]; not all items purchased by the panelist are tracked by

[1]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."

Nielsen (only ”fast moving” goods tracked)[2]; the scanner malfunctioned; and item price is censored (capped) at $999.99 for non-magnet items.

B.1.2 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 B.1 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 B.2).

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 3.2). 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.

[2]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.).”

Figure B.1: Histogram of Number of Items Purchased per Trip

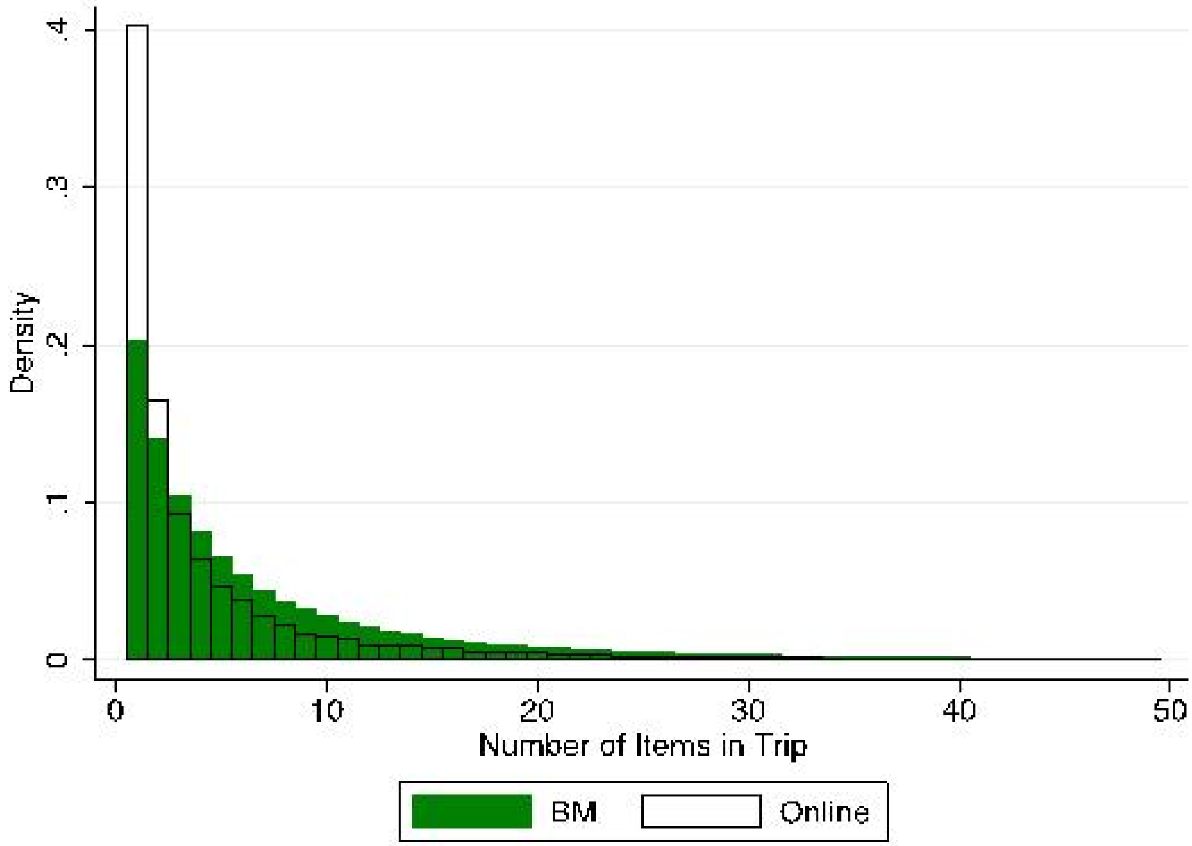
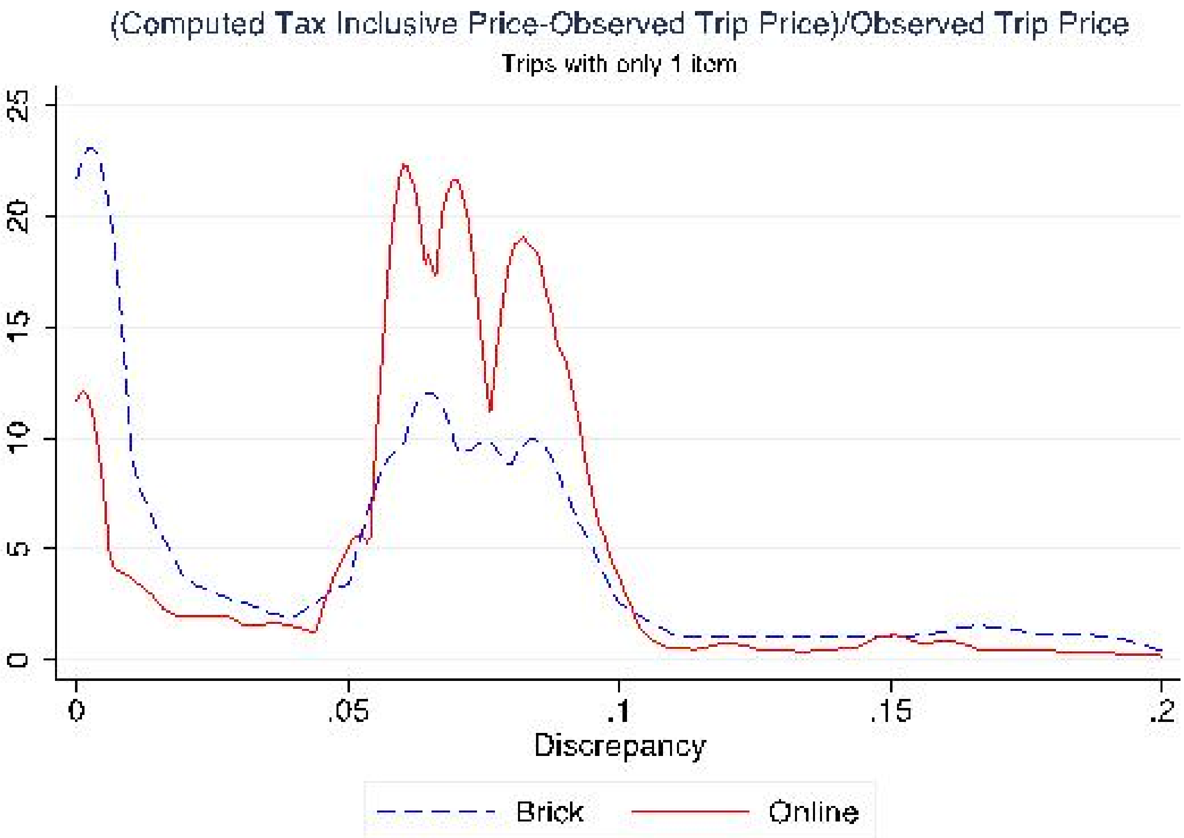
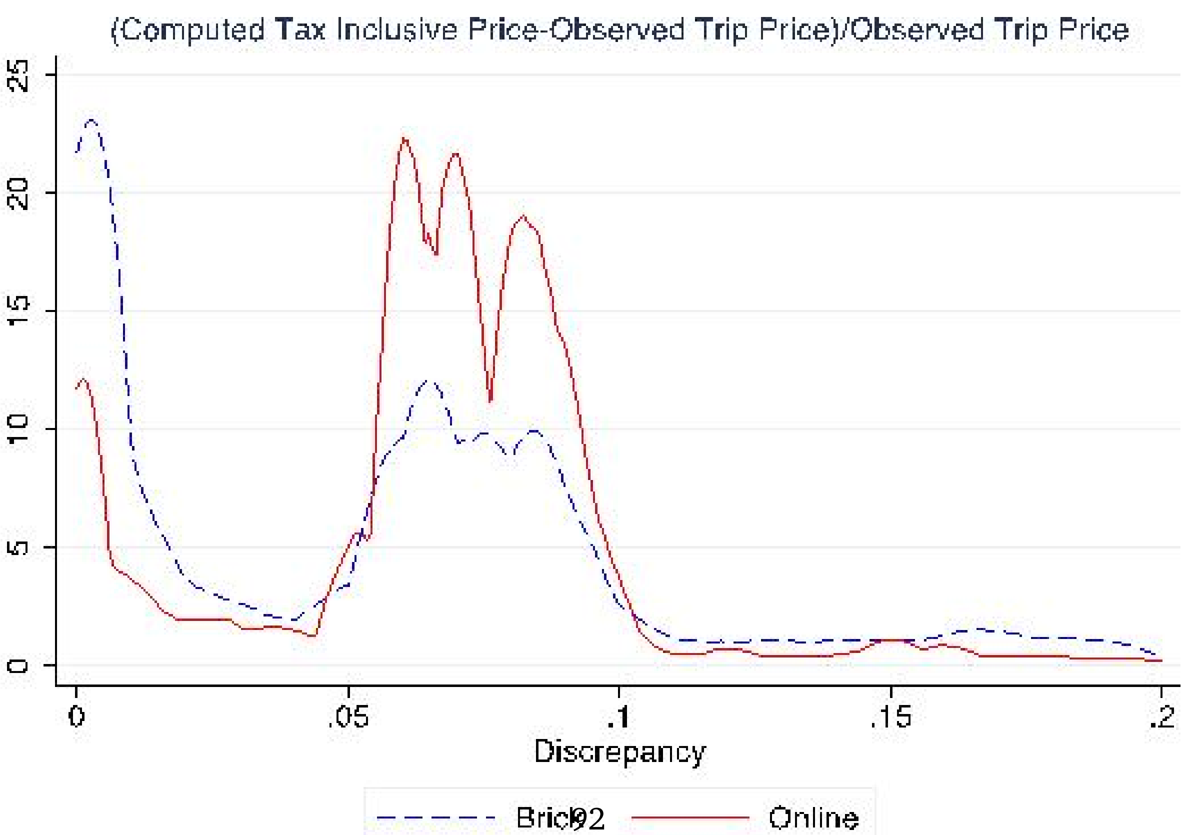


Figure B.2: Discrepancy between Computed and Observed Tax-inclusive Prices





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