Determinants of Tax Avoidance

Charles McClure[1]

Stanford University

January 2018

Abstract

I model the determinants of corporate tax avoidance. Prior research hypothesizes that firms forgo profitable tax-saving strategies due to non-tax costs, financial reporting incentives, and tax authority scrutiny. Because many of these frictions are not directly observable, I quantify their effects using a dynamic structural model in which the firm chooses a set of tax-saving projects in each period in order to maximize share price. I find that average non-tax costs decrease pre-tax earnings by 14.7%. Existing tax risk disclosures decrease tax avoidance by 6.9% but only capture 63% of the expected repayment amount under the audit assumptions specified in the disclosure. The cross-sectional dispersion in effective tax rates primarily arises from differences in the ability to avoid taxes rather than differences in non-tax costs. Finally, I also consider the impact of hypothetical reporting requirements on firms' decisions to avoid taxes.

[1] I am grateful for the support of my dissertation committee, David Larcker (chair), Lisa De Simone, Wesley Hartmann, and Peter Reiss. I thank Anne Beyer, Elizabeth Blankespoor, Rebecca Lester, and participants of the 2017 CMU Mini Conference and Stanford Accounting Workshop for helpful suggestions. I have also benefited greatly from Lil Mills, Bridget Stomberg, and several tax directors for providing institutional insight. Finally, I thank my fellow PhD students for their encouragement and support. All errors are my own.

1 Introduction

This paper estimates a dynamic model to quantify the determinants of tax avoidance and tax risk. Tax avoidance decreases a firm's explicit tax rate relative to the statutory rate, and tax risk is the expected amount of tax savings that can reverse in a future tax audit. I use this model to examine three questions. First, I estimate the hidden costs of tax avoidance. Second, I identify the sources for the different levels of tax avoidance across firms. Third, I assess the accuracy of existing tax risk disclosures in capturing the underlying riskiness. To address these topics, I model a firm that considers tax savings together with the operational frictions imposed by tax avoidance, financial reporting benefits, and tax authority scrutiny. I then estimate the model parameters with data.

Prior literature has proposed several factors believed to affect firms' tax avoidance strategies. A number of studies acknowledge the "undersheltering" puzzle: firms appear to underutilize strategies that can reduce the income tax expense (e.g., Weisbach, 2001; Hanlon and Heitzman, 2010). Prior literature suggests that this undersheltering arises because firms trade-off taxes with other operational cost-savings (Scholes et al., 2015), poor internal information environments make coordinating tax avoidance more difficult (Gallemore and Labro, 2015), and firms consider reputation concerns from being perceived as overly aggressive (Graham et al., 2013). Collectively, I describe these operational concerns that contribute to undersheltering as non-tax costs.

Beyond these non-tax costs, undersheltering can arise from the financial reporting considerations of tax avoidance. A large literature has investigated the book-tax trade-off where firms must balance the incentive to minimize taxes (by lowering taxable income) and to maximize book income (i.e., the income reported on the income statement). For example, managers appear reluctant to utilize tax planning if there are no immediate financial reporting benefits, even if there are cash savings (e.g., Armstrong et al., 2012; Graham et al., 2013). Engaging in significant tax avoidance can also increase tax authority scrutiny through more frequent audits or greater penalties (Mills et al., 2010; Bozanic et al., 2017).

My model estimates the extent to which non-tax costs, financial reporting incentives, and tax authority scrutiny influence the level of tax avoidance. These frictions are assumed to be major determinants in tax avoidance, but quantifying them with existing research methods is difficult because many components are unobservable (Shackelford and Shevlin, 2001). In addition, the true level of tax avoidance is unobservable because the tax payment related to current period activities is not reported outside the firm. As a result, researchers rely on a number of proxies to triangulate the level of tax avoidance and associated risk, with only limited success (Guenther et al., 2016). Publicly available proxies like income tax expense or current income taxes can over- or under-state the actual tax liability for the current period (Hanlon, 2003), while private tax return data only pertain to particular jurisdictions or entities within a corporation (Hanlon and Heitzman, 2010). To address the limitations in observable proxies for tax avoidance, risk, non-tax costs, and financial reporting incentives, I model the dynamic nature of tax avoidance and estimate each effect with publicly available data.

I model a firm that chooses a set of tax-saving projects in order to maximize share price, defined as the discounted stream of future net income. The firm is endowed with a technology that determines the riskiness of these projects. This technology parameter represents information such as the manager's inherent ability to recognize effective tax strategies and the extent to which the firm can sustainably avoid tax authority scrutiny. The firm considers four effects on share price when it chooses these projects. First, when the firm uses these tax-saving projects, it incurs non-tax costs which reduce pre-tax income. Second, there are diminishing returns to tax avoidance. Each project the firm chooses has a unique probability of surviving a tax audit and the more projects the firm uses, the riskier the marginal project becomes. Third, as I discuss in more detail below, risk also affects the financial reporting benefits of tax avoidance because riskier projects confer smaller financial benefits based on existing reporting standards. Finally, tax authority scrutiny, defined as the number of projects the tax authority inspects, is a function of the disclosed tax risk and the variance of the firm's strategies over time. Thus, if the firm has a large amount of disclosed tax risk or variance in strategies, the firm will have a greater fraction of its positions inspected by the tax authority. This may induce a larger repayment of avoided taxes.[1]

Because the model does not have a closed-form solution, I estimate model parameters governing firm behavior with simulated method of moments. I identify many parameters, including the unobservable tax payment for current period activities, with the uncertain tax benefits ("UTBs"). UTBs are an estimate of tax benefits (i.e., tax savings) that may be disallowed upon

[1] Throughout the paper, I use tax-saving positions and projects interchangeably.

future tax audit and are determined by ASC 740-10, *Accounting for Uncertainty in Income Taxes* ("FIN 48"). This rule stipulates how firms reserve for tax-saving positions that may be overturned during a future tax audit, and these reserves are publicly disclosed in the firm's annual report. The reserve delays the recognition of some tax benefits and must remain a liability until the audit period has lapsed, the position is inspected, or the firm gains new information that results in the reversal of the reserve.

I use UTBs as my primary source of identification instead of other measures of tax avoidance and risk (e.g., cash ETRs) for two reasons.[2] First, firms must separately disclose reserves for current period activities. Other avoidance measures like cash or GAAP ETRs contain payments related to prior period deficiencies so researchers are unable to isolate the liability for the current period. Second, FIN 48 clearly defines the relation between tax avoidance, tax risk, and UTB reserves. While prior literature observes that UTBs do not completely capture the underlying tax risk (e.g., Robinson et al., 2015), the clear relation between these three tax amounts minimizes researcher discretion, and makes these reserves particularly conducive to structural estimation. In particular, once I estimate the parameters that define the relation between UTB reserves and tax avoidance, I can invert the relation to recover the firm's (unobservable) effective tax rate for the current period and measure the corresponding non-tax costs.

Based on this estimation, I find that for the average effective tax rate in my sample, non-tax costs reduce pre-tax profit by 15% or $88 million per firm-year. This estimate of non-tax costs is roughly equivalent to the R&D expense in my sample. Tax avoidance increases net income by approximately 1% compared to the scenario where the firm did not engage in any tax avoidance. These findings suggest non-tax costs are non-trivial and an important consideration in determining a firm's tax strategy, even though they are difficult to observe. I also examine how tax avoidance influences tax authority scrutiny. I find that a large amount of disclosed tax risk only has a modest effect on tax authority scrutiny, while the primary factor appears to be the variance in tax strategies over time. This result highlights how dynamics affect tax avoidance and can explain why Dyreng et al. (2008) observes firms often display persistent ETRs over time as they try and mitigate tax authority scrutiny.

[2] Throughout the paper, I refer to the firm's unobserved "true" effective tax rate as the "effective tax rate". Observable proxies like GAAP or cash effective tax rates, I specify with the abbreviation "ETR".

While my main specification assumes all firms are subject to the same rate of non-tax costs and ability to avoid taxes, I relax this assumption by examining different subsamples of firms. In particular, I examine why firms have such disperse ETRs by separately estimating the model for firms with high long-run cash ETRs and those with low long-run cash ETRs. I find that low ETR firms have similar non-tax costs relative to high ETR firms, but only incur approximately 40% of the risk for a given level of tax avoidance. This finding suggests that the primary reason for divergent ETRs is firms' differing tax-avoiding abilities, not different non-tax costs.

I also explore the effect of this rule on the firm's decision to avoid taxes. Prior research observes that FIN 48 reserves may not accurately reflect the underlying tax risk because only a fraction of positions require a reserve (e.g., Mills et al., 2010; Robinson et al., 2015) and because firms must assume 100% audit and inspection rates, even though not all positions are inspected. I find that on average, FIN 48 only captures 63% of the expected repayment amount, assuming 100% audit and inspection rates. This implies that firms have an average of $58 million in undisclosed tax risk under the existing financial reporting rules. However, once I incorporate audit and inspection rates into the expected repayment amount, firms over-reserve by about 3.8 times, or approximately $59 million per firm-year. These findings suggest existing disclosures may be insufficient to accurately reflect tax risk and can explain why prior literature finds little association with reserves and future tax payments (e.g., Robinson et al., 2015; Guenther et al., 2016).

The incomplete nature of FIN 48 reserves may also influence firms' tax strategies. To address this issue, I consider how hypothetical changes to the rules surrounding FIN 48 would alter firm behavior. Structural modeling permits me to estimate how firms would change their behavior under different reporting environments, even though we never observe these counterfactuals. By knowing the structural parameters governing firm behavior, I can adjust the model to reflect hypothetical scenarios and estimate the firm's expected response. There are two benefits with this analysis relative to other methodologies, such as studying stock market reactions surrounding changes. First, I can consider hypothetical changes not observed in the data. Second, counterfactuals are not subject to investor's expectations that can result in over- or under-reaction to changes.

The first counterfactual analysis considers how firms would respond if UTBs were set to accurately reflect the expected repayment assuming 100% inspection and audit rates, instead of the 63% that is currently reflected in the reserve. I estimate effective tax rates would increase by 1.21 percentage points because firms would recognize a smaller fraction of the benefit by requiring a larger reserve. Engaging in less tax avoidance reduces non-tax costs, so that pre-tax income increases by 1.8%. The net effect of this change is that shareholder value would increase by 0.7%. This counterfactual demonstrates a complex relation between tax avoidance, non-tax costs, and shareholder value. The second counterfactual considers tax avoidance when there are no disclosure requirements, such as the reporting environment prior to the implementation of FIN 48. I find that, in the absence of reporting requirements, firms would set effective tax rates 0.79 percentage points lower, increasing share price by 1.0%. Through analyses like these, I can quantify the effects of financial reporting requirements on a firm decision (Graham et al., 2005), in this case the magnitude and riskiness of the firm's tax planning.

I also consider how tax authority scrutiny affects a firm's propensity to avoid taxes. The third counterfactual considers how firms behave if the tax authority is not strategic in its scrutiny of firms and inspects a fixed fraction of positions, regardless of a firm's tax avoiding behavior. I estimate tax rates would increase by 0.61 percentage points. Finally, to isolate the effect of non-tax costs, I estimate firm behavior if non-tax costs are the only cost facing the firm and eliminate tax authority scrutiny and corresponding reserves. I find that on average, tax rates decrease by 1.84 percentage points; however, tax rates would still be approximately 21% which demonstrates the significance of non-tax costs in forming a firm's strategy.

My paper makes several contributions to the literature on financial reporting and taxes. First, I quantify non-tax costs. I show that these hidden costs and competing incentives are non-trivial and have a significant effect on a firm's tax strategy and profitability, which can explain why firms appear to disregard positive NPV tax projects. Second, I show that the primary dispersion in effective tax rates stems from differences in tax avoiding ability instead of differences in non-tax costs. Third, I use structural estimation and counterfactual analysis to document the effect of a financial reporting standard on a real firm activity. By recovering the unobservable parameters affecting a firm's decision, I can consider hypothetical scenarios not observed in the data. Similar techniques could be used to model other relations between accounting rules and firm decisions. This type of analysis can provide financial standard setters and researchers an estimate of the impact of standards when they are not yet implemented or when it is difficult to observe the costs and benefits for the firm. Finally, I combine several hypothesized factors affecting a firm's tax decision into a cohesive model in which a firm optimally sets its level of tax avoidance and risk, subject to its ability to avoid taxes. In doing so, I answer the call in Hanlon and Heitzman (2010) to distill important determinants of tax avoidance into a structural model.

The rest of the paper is organized as follows. Section 2 discusses related literature and background on FIN 48. Section 3 presents the model. Section 4 describes the sample while Section 5 discusses how I estimate the model. Section 6 presents results and Section 7 concludes.

2 Background and Related Literature

2.1 Research on Tax Avoidance and Risk

Prior research suggests firms appear to under-utilize profitable tax saving strategies. For example, Mills et al. (1998) finds that for every $1 dollar spent on tax-savings, the tax liability is reduced by an average of $4. The large returns from tax avoidance suggest that undersheltering is a significant feature in the firm's tax avoidance decision. Prior research has hypothesized three broad categories which contribute to undersheltering. First, non-tax costs arise when tax avoidance has a detrimental effect on the firm's operations. Second, many types of tax avoidance include some risk that a tax authority will overturn the position during an audit. If particular positions incur enough risk – either from being overturned in a tax audit or from increasing tax authority scrutiny – firms may be hesitant to use them. Finally, firms appear to focus on the financial reporting effect from tax avoidance rather than the actual cash savings. Thus, if a particular strategy is profitable on a cash basis but confers no financial reporting benefit, firms appear reluctant to use it.[3]

A large literature has looked at the non-tax costs that prevent firms from achieving an "optimal" level of tax avoidance. I define non-tax costs as those costs that arise from tax planning and reduce pre-tax profits. Prior research has found these frictions can take a variety of forms. Graham et al. (2013) surveys managers to find that reputation concerns from being perceived as overly aggressive is the highest stated determinant in the firm's tax decision. Firms may also be

[3]For a comprehensive review on the determinants of tax avoidance, Shackelford and Shevlin (2001), Hanlon and Heitzman (2010), and Wilde and Wilson (2017) provide excellent summaries of the relevant literature.

unable to take advantage of particular strategies because certain firm structures are better-suited to tax avoidance (Gupta and Newberry, 1997; Rego, 2003). Agency costs related to tax avoidance also create non-tax costs (e.g., Desai and Dharmapala, 2006; Gaertner, 2014; Armstrong et al., 2015). Finally, taxes are just one of many costs facing a firm, so it must balance minimizing taxes with other operational costs. As a result, manager's compensation is often determined by a mix of pre- and post-tax metrics that can dis-incentivize managers from engaging in tax minimization (e.g., Newman, 1989; Rego and Wilson, 2012).

In addition to non-tax costs, tax authority scrutiny influences a firm's tax decision. When a firm is audited and its tax-saving positions are inspected, some of the benefits will be overturned by the taxing authority, which will decrease future net income as the firm must repay any deficiencies. Given this concern, prior literature finds a positive relation between cash ETRs and audit rates (Hoopes et al., 2012) as well as IRS scrutiny (Bozanic et al., 2017). These findings suggest a link between the level of tax avoidance and the risk of repayment.[4] Firms also exhibit smooth cash ETRs over time (Dyreng et al., 2008) which can signal that the firm's tax strategy is less risky (e.g., Mills et al., 2010; Bozanic et al., 2017). Thus, tax authority scrutiny appears to be determined by both the level and the variance of tax rates over time.

A large body of research examines the book-tax tradeoff where firms balance lower taxable income with higher book income. Generally, financial reporting benefits of tax avoidance appear to be more important than cash savings. Armstrong et al. (2012) find that tax directors are primarily compensated on GAAP ETRs instead of cash ETRs. This result supports survey evidence in Graham et al. (2013) that managers value the financial reporting benefits of tax avoidance more than the cash savings. Thus, when firms choose tax avoidance, it appears they are focused on the effect on net income instead of cash flow. The reserve for uncertain tax benefits (UTB) delays the recognition of some of the risky cash savings and is one reason why cash savings do not directly map into financial reporting benefits.

Non-tax costs and tax audit risk appear to affect firms differently as Dyreng et al. (2008) document that the cross-section of firms have disperse long-run cash ETRs. For example, when Dyreng et al. (2008) compute the long-run cash ETR over a 10 year horizon, they find some firms

[4] Studies that directly relate risk and avoidance have found mixed evidence of a relation between the level of avoidance and risk (e.g., Guenther et al., 2016; Dyreng et al., 2016; Hanlon et al., 2017). Guenther et al. (2016) posits this occurs because observable measures of tax risk and avoidance are poor proxies for the underlying constructs.

with rates close to 0% while others firms are closer to 50%. The long horizon in this measure mitigates the concern that the dispersion is a result of short-term fluctuations in either the tax payment (e.g., arising from repayments or penalties) or abnormally low pre-tax profit. Prior research has proposed several hypotheses for this cross-sectional variance. Guenther et al. (2016) claim these differences arise because differential non-tax costs as they find no association between low ETRs and future ETR volatility. However, Blouin (2014) posits the low correlation between ETRs and tax risk occurs because some firms have access to lower-risk projects, such as those with significant intellectual property. However, without a structural model that recovers the underlying constructs of non-tax costs and tax risk, it is difficult to disentangle which hypothesis is the primary factor in differential tax rates across firms.

Given the findings in prior research and the difficulty in separating the different constructs which influence tax avoidance, I utilize a structural model for several reasons. First, the firm's total tax liability for the current period's activity is unobservable as publicly available proxies and confidential tax return data give an incomplete picture (Hanlon and Heitzman, 2010). Second, as Shackelford and Shevlin (2001) observe, quantifying non-tax costs are particularly difficult. While papers have attempted to indirectly measure some of these costs in quasi-experimental or isolated settings (e.g., Berger, 1993; Dhaliwal et al., 1994; Engel et al., 1999; Gallemore et al., 2014), they often only capture a fraction of the total non-tax costs facing a firm. Finally, tax avoidance and risk are jointly determined. Without a structural model, it is difficult to disentangle non-tax costs, the financial reporting incentives, and the underlying risk associated with a particular strategy.

2.2 Background on FIN 48

I discuss the financial reporting requirements related to FIN 48 in further detail as I use the FIN 48 reserve as a primary source of identification. Effective for fiscal years ending after December 15, 2006, FIN 48 standardized the recognition and disclosure related to uncertain tax benefits (UTBs). Uncertainty in tax avoidance arises because, when a firm enters into a position that reduces its income taxes paid, it is unclear how much of this benefit will survive audit by the taxing authority. Prior to its implementation, the rules governing income tax expense recognition, FAS 109, made no mention of how to properly account for uncertainty related to income tax assets and liabilities. Most firms relied upon guidance from FAS 5, which required firms to disclose contingencies if it was probable the position would not be sustained and the liability could be reasonably estimated. As a result, firms often created unallocated pools of reserves as a "cushion" that was subject to significant managerial discretion. Given the lack of guidance, "a diverse set of accounting practices... developed resulting in inconsistency in the criteria used to recognize, derecognize, and measure benefits related to income taxes" (Financial Accounting Standards Board, 2006). FIN 48 attempts to standardize the recognition and measurement of the uncertain portion of tax assets and liabilities and provide additional information to investors. FIN 48 determines the reserve amount for tax positions based on *median* amounts the firm expects to retain upon audit. Using the nomenclature from Mills et al. (2010), depending on the likelihood of surviving an audit for a particular position, FIN 48 may require firms to not recognize any of the benefit ("weak positions"), only a fraction of the position ("medium positions"), or the entire tax benefit ("strong positions").

In particular, FIN 48 stipulates a two-step process for determining the reserve. The first step is recognition and determines whether a position satisfies the more-likely-than-not ("MLTN") threshold. Specifically, if the firm believes that a position has less than a 50% chance of passing audit (i.e., the median retained benefit is $0), it cannot recognize any tax savings and must fully reserve the amount of these weak positions. This results in the firm recognizing increased income tax expense and a deferred tax liability. Thus, while weak positions reduce cash taxes paid, fully reserving confers no financial reporting benefit from these positions. The second step is measurement. If a position satisfies the MLTN threshold (i.e., the median benefit is greater than $0), a firm can only recognize the amount it believes will have a 50% chance of passing an audit. Medium positions satisfy the MLTN threshold but still require a reserve. Strong positions do not require a reserve because they satisfy the MLTN threshold and the firm believes there is a greater than 50% chance it will survive audit, so the median amount is equal to the full benefit. Even though these strong positions do not require a reserve, they can still possess underlying risk because the expected (i.e., mean) post-audit benefit may be less than the full amount if there is some possibility the firm will not retain the full benefit. Appendix A provides a numerical example for weak, medium, and strong positions.

When a firm determines the reserve for a particular position, it must assume that the taxing authority has all relevant information to determine the merits of the position and that there is a 100% audit and inspection probability. Once a firm reserves for a particular position, it must keep the reserve as a deferred tax liability until the position has been audited, the taxing authority's ability to audit has lapsed, or new information is acquired regarding the likelihood of surviving an audit. In the FIN 48 disclosure, firms must reconcile the difference between the beginning and ending UTB balance by separately disclosing the impact from these three effects as well as the current period activity.

While FIN 48 clearly describes the rules for reserving for tax uncertainty, these reserves are not a direct measure of tax risk. Prior literature (e.g., Mills et al., 2010; Robinson et al., 2015) suggests that the underlying distribution of audit outcomes for tax-saving positions are not symmetric. This finding is problematic because FIN 48 reserves are based on the median repayment amount which will not equal to the expected repayment if the underlying distribution is asymmetric.[5] In particular, most positions appear to be negatively skewed, such that the median savings are greater than the expected savings.[6] As a result, in aggregate, firms will under-reserve relative to the expected repayment because certain positions require little to no reserve even though in expectation there is some risk of repayment. Conversely, the reserve will be overstated for any particular position because firms must assume a 100% audit and inspection rate even though it is unlikely every tax position within a firm will be inspected. For example, Robinson et al. (2015) find that for every dollar of reserve, on average, $0.24 is actually paid to the taxing authorities, and the remaining $0.76 reverses through other means. Given these shortcomings of FIN 48, it is unclear how well FIN 48 reserves reflect the underlying tax risk and expected repayments. However, I correct for these unique features of FIN 48 to recover unobservable structural parameters.

I use the reserve from FIN 48 to help identify my model for two reasons. First, the current portion of the reserve is only related to the current period's activity. Other publicly available measures of tax avoidance such as the income tax expense or cash taxes paid can include deficiencies

[5]Throughout the paper, I define the expected repayment assuming 100% audit and inspection rates as specified in FIN 48. Instances where I incorporate audit and inspection rates from the tax authority, I explicitly state that I condition on these rates.

[6]As shown in Appendix A, both the Medium and Strong position exhibit negative skewness so the reserve is less than the expected repayment. Only the Weak position has positive skewness. In my discussions with practitioners, firms rarely, if ever, utilize weak positions because these require the entire benefit to be reserved and confer no immediate financial reporting benefit. Therefore, it is likely that a majority of tax saving positions are negatively skewed such that the reserve under-reports the underlying risk.

from prior periods. Meanwhile, confidential tax return data only provide a partial view of the firm's tax avoidance by providing tax liabilities for certain jurisdictions and certain entities within the firm (Hanlon and Heitzman, 2010). As Mills and Plesko (2003) observe, it is often impossible to reconcile existing tax return data to the income statement. Second, FIN 48 clearly defines how firms should set a reserve based on a level of tax avoidance and expected repayment amount. In particular, when setting a reserve, a firm must assume that the tax authority has the same information as the firm. This implies the reserve should reflect the firm's belief of the incurred tax risk, subject to the reporting rules. With structural estimation, I can invert the relation between reserves and risk to recover an estimate of the unobserved expected repayment and tax rate. Even with confidential tax return data, it is difficult to link tax avoidance with tax risk because repayments are often not associated with particular positions.

As I discuss in Section 3, I assume the firm truthfully reports its UTB. There is support that manipulation is minimal, or at least a second order concern with the FIN 48 reserve. Chester Spatt, Chief Economist of the SEC during the implementation of FIN 48, wrote that "[FIN 48] appears to reduce the firm's and indeed, the auditor's discretion".[7] Furthermore, research on UTBs and manipulation do not provide clear evidence that manipulation is a concern. Gupta et al. (2015) finds evidence that the increased disclosures from FIN 48 curtailed earnings management through the tax reserve and Ciconte et al. (2016) shows that UTBs appear to be an unbiased estimate of future tax cash flows.[8]

3 Model

I model an infinitely-lived firm that chooses a set of tax-saving projects in each discrete period. Specifically, it chooses these projects in order to set its effective tax rate, τ_t, and maximize share price which is the stream of discounted future income. In addition to the savings from paying lower taxes, the choice of projects affect price three ways. First, these projects reduce pre-tax profit by creating operational frictions. Second, the firm must truthfully set a UTB based on the median repayment amount that arises from the tax risk incurred from these projects. The

[7] https://www.sec.gov/news/speech/2007/spch030807css.htm

[8] In untabulated analysis, I consider how misreporting affects my inferences. In particular, I re-estimate my model assuming every firm underreports its reserve by a fixed amount relative to the reserve specified in FIN 48. I consider missreporting of 5% and 10% relative to the true reserve and find my results are qualitatively unchanged.

portion of the benefit that requires a reserve is not recognized in the current period and can only be recognized in the future if the position is not audited and the statute of limitations to audit has lapsed. Finally, these projects also affect future tax repayments as the inspection rate increases when the firm deviates from the prior period's tax strategy or if it discloses a large UTB reserve.

Figure 1 depicts the timeline for a set of tax saving projects. The firm is endowed with a beginning FIN 48 reserve, R_t, and the prior period's UTB reserve, $r\left(\tau_{t-1}\right)$. I assume "core earnings" before any non-tax costs are constant so the variance in pre-tax profit only arises from the choice of tax-saving projects.[9] The firm selects the set of tax-saving projects to determine its effective tax rate, τ_t. After choosing the projects, the firm incurs non-tax costs, sets its UTB reserve to reflect the associated tax risk, and realizes net income. The firm also sends its tax return to the tax authority and period t ends. At the start of period $t+1$, the tax authority randomly decides whether or not to audit the firm. If the firm is audited, the tax authority decides how many projects to inspect and this inspection rate is determined by the UTB reserve balance and the variance of tax strategies over time. The inspected projects no longer require a reserve and the firm repays the expected deficiency but incurs no incremental penalties. Also, in each period, a fraction, θ, of unaudited beginning reserves lapse and decrease the income tax expense. After inspections and lapses occur, states are updated.

3.1 Tax-Avoiding Projects

3.1.1 Mean and median benefits for tax-saving projects

The firm has access to a continuum of tax-saving projects of infinitesimal size and chooses a set of these projects that determine its effective tax rate. Each project has a unique risk profile which describes how much of the savings is expected to survive a tax audit. I assume these profiles arise from the family of beta distributions for several reasons. First, random variables parameterized with a beta distribution have positive support over the interval $[0, 1]$, so the likelihood a project survives an audit is constrained between 0 and 1. Second, their shape is determined by two parameters, a and b, and depending on their values, these distributions can assume a variety of shapes such as the negative skewness Mills et al. (2010) suggests is typical in tax projects.

[9] I define pre-tax profit as pre-tax income less special items. I use "profit" instead of "income" in my definition to clearly differentiate this amount from pre-tax income which includes special items.

Figure 2 plots three examples of the risk profiles for the projects. For these examples, I will assume each project yields \$1 of tax savings. These profiles are the pdfs for beta distributions corresponding to each project. The solid line represents the distribution for project A, a low-risk project with shape parameters $\{a = 1.111,\ b = 0.123\}$. The expectation for a beta distribution with these parameter values is 0.9 (see row 1 of the table accompanying Figure 2).[10] Therefore, if this position is inspected, the firm expects to retain \$0.90 and repay \$0.10 (= \$1 − 0.90). The median retained benefit for this project is \$0.996.[11] Because FIN 48 requires firms to set reserves based on the median repayment amount, it will only have to reserve \$0.004 $(= 1 - 0.996)$, even though in expectation the firm will repay \$0.1 if it is audited. Therefore, the firm will be under-reserved for project A. The dashed line in Figure 2 plots the distribution for project B, a riskier project that has a symmetric distribution with parameters $a = b = \frac{1}{2}$. This corresponds to a mean and median of 0.50, so the firm's reserve of \$0.50 equals its expected repayment. Finally, the dotted line shows the PDF for project C, a risky project with parameters $\{a = 3,\ b = 0.222\}$. In this scenario, the firm will over-reserve by \$0.01 because in expectation it will \$0.71 for an expected repayment of \$0.70.

While each of the three projects in Figure 2 produces an immediate \$1 of tax-savings, the financial reporting benefits are quite different. Column 4 in the adjoining table for Figure 2 reports the median retained benefit, which is the amount of tax savings the firm can recognize in the current period based on FIN 48 rules. Clearly, the firm prefers A over B because project A is less risky and the firm can recognize nearly all (i.e., 99.6%) of A's benefit but only recognize 50% of the benefit from B. Similarly, the firm would prefer project B over C. Thus, if the firm wanted to save \$2 in taxes, and only had these three projects available, it would select projects A and B because they are the least risky and confer the greatest financial reporting benefit for the current period.

Firms can apply a similar ordering to the entire continuum of available projects. Because each project has a unique distribution, the firm can order projects by first selecting the less risky projects. However, as the firm diverges further from paying the statutory rate, $\bar{\tau}$ (i.e., 35%), it must utilize increasingly risky projects that require a larger reserve. I describe this deterioration

[10] As I show in Equation 2 below, the expectation of a random variable with a beta distribution and shape parameters a and b is $\frac{a}{a+b}$.

[11] I numerically compute the median because there is no general closed-form solution for the median of a beta distribution.

in the quality of the projects through the function $\mu(\tau_t;\alpha)$. Specifically, for a given tax rate, τ_t, the firm expects to retain $\mu(\cdot)$ of tax savings for the *marginal* project if it is audited. For example, if the firm chose project B as the marginal project, then $\mu(\cdot) = 0.5$. The parameter α in $\mu(\tau_t;\alpha)$ is the tax-avoiding technology parameter which describes how easily the firm can avoid taxes by specifying the increasing rate of riskiness for the marginal project as the firm engages in more tax avoidance (i.e., as τ_t declines).[12] I parameterize $\mu(\cdot)$ with the following:

$$\mu(\tau_t;\alpha) = \left(\frac{\tau_t}{\bar{\tau}}\right)^{\alpha} \tag{1}$$

This function has a number of desirable properties. First, the marginal project when the firm pays the statutory rate (i.e., $\tau = \bar{\tau}$) is risk-free so that $\mu(\bar{\tau};\alpha) = 1$. When the firm pays no taxes (i.e., $\tau_t = 0$), $\mu(0;\alpha) = 0$ so the firm expects to repay the entire benefit for the marginal project. The technology parameter α describes how quickly the expectation of the retained benefit deteriorates to zero.[13] Because $\mu(\cdot)$ describes the retained benefit for each project, $1-\mu(\cdot)$ is the expected repayment amount if the project is inspected. In Figure 3, Panel A, $\mu(\cdot)$ is depicted as the dashed line for all values of $\tau_t \in [0, 0.35]$ and assumed technology parameter $\alpha = 0.5$. With Equation 1, I can also determine when the project becomes the marginal project by inverting $\mu(\tau_t;\alpha)$ and solving for τ_t. In the example projects in Figure 2, with an assumed tax avoiding technology parameter $\alpha = 0.5$, these projects would become the marginal projects when τ_t is 28.4%, 8.75%, and 3.15%, for projects A, B, and C, respectively.

While $\mu(\tau_t;\alpha)$ describes the mean amounts the firm expects to keep after an audit, I need to also determine median amounts through the assumed beta distribution. This linking is important because the reported reserves from FIN 48 are based on medians. In order to link means with medians, I restrict project distributions two ways. First, I assume each project has negative skew which is consistent with Mills et al. (2010) and my discussions with tax practitioners. Second, I

[12]A smaller value of α implies a greater tax avoidance ability. I elected to estimate α instead of $1/\alpha$, where a smaller value of α implies less ability, because the objective function I estimate with respect to α is highly non-linear. Estimating the parameter $1/\alpha$ could be affected by numerical precision.

[13]This parameterization of $\mu(\tau_t;\alpha)$ assumes all positions except the one first used by the firm have some expected repayment amount. This ignores certain risk-free positions like investing in municipal bonds. Interviews with tax directors, suggest few positions are truly risk-free. If firms do utilize a significant amount of risk-free strategies, my parameterization will overstate τ_t. Conversely, I assume all projects used to achieve an effective tax rate greater than zero has some chance of surviving audit. Firms likely will exhaust strategies with non-zero likelihoods of surviving audit before $\tau_t = 0$. However, the fact that I find an average τ_t of 0.234 suggests low-outcome positions do not play an important role in a firm's tax avoidance decision.

compress the two parameters defining a beta distribution, a and b, to a single tax avoiding technology parameter (i.e., α). To do this and still preserve the negative skew, I assume that the first shape parameter of the beta distribution, a, is equal to $\frac{1}{\mu(\tau_t;\alpha)}$. To determine the second parameter, b, as a function of $\mu(\cdot)$, I use the expression for the expectation of a beta distribution and set it equal to $\mu(\tau_t;\alpha)$ (the expected retained benefit after audit):

$$\mathbb{E}(t) = \frac{a}{a+b} = \frac{\frac{1}{\mu}}{\frac{1}{\mu}+b} = \mu \tag{2}$$

This equation can be rearranged to show that $b = \frac{1-\mu}{\mu^2}$. With the two shape parameters $\{\frac{1}{\mu}, \frac{1-\mu}{\mu^2}\}$, I can then determine the median for any project. To specifically recover the median, for the marginal project used at tax rate τ_t, I implicitly define the median amount the firm expects to retain, $\rho(\tau_t;\alpha)$, as the function which satisfies the following equation:

$$F_B\left(\rho(\tau_t;\alpha); \frac{1}{\mu(\tau_t;\alpha)}, \frac{1-\mu(\tau_t;\alpha)}{\mu(\tau_t;\alpha)^2}\right) = \frac{1}{2} \tag{3}$$

In this equation, $F_B(\cdot)$ is the cdf of the beta distribution. The solution to Equation 3 for all possible marginal projects is depicted as the solid line in Figure 3, Panel A.

While this approach to link means and medians may seem arbitrary, it well approximates the actual relation between the mean and median of tax positions for several reasons. First, for large values of $\mu(\cdot)$ (i.e., marginal projects where the firm expects to retain most of the benefit), the median is close to 1. This property preserves the negative skew and ensures that some inherently risky projects require little to no reserve which is defined as $1-\rho(\cdot)$. Second, the solution to Equation 3 is strictly increasing in τ_t. This implies that for small values of τ_t where the firm has utilized many projects, the median and expected retained benefit is smaller for the marginal projects. This ensures there are diminishing returns to tax avoidance.

3.1.2 Recovering tax risk from UTB reserve

In this section, I compute the expected repayment and current period reserve from the formulas for the mean and median retained benefits for each project (i.e., $\mu(\tau_t;\alpha)$ and $\rho(\tau_t;\alpha)$). When the firm chooses an effective tax rate, τ_t, it uses every marginal project for tax rate s for

$s \geq \tau_t$. The corresponding expected repayment for each project is $1 - \mu(s;\alpha)$. Thus, the expected repayment for a given τ_t, is the sum of every project's repayment amount that is used by the firm. I define the total expected repayment as $\sigma(\tau_t)$, which is one minus the integral of $\mu(s;\alpha)$ for $s \in [\tau_t, \bar{\tau}]$:

$$\sigma(\tau_t) = x \int_{\tau_t}^{\bar{\tau}} 1 - \mu(s;\alpha)\, ds = x \left[\frac{\alpha\bar{\tau} + \tau_t \left(\left(\frac{\tau_t}{\bar{\tau}}\right)^{\alpha} - 1 - \alpha \right)}{1+\alpha} \right] \tag{4}$$

Because $\mu \in [0,1]$ and τ_t is a rate, the integral in this expression is bounded between 0 and $\bar{\tau}$. In order to convert this amount into dollars, I include the scale parameter x. Figure 3, Panel B, graphs this equation as the light shaded region with an assumed scale parameter $x = 1$.

To recover the current period reserve, $r(\tau_t)$, I perform a similar procedure with the median repayment amount and Equation 3. In particular, I subtract one minus the sum of the median retained benefit for each project used by the firm (i.e., $1 - \rho(s;\alpha)$ for $s \in [\tau_t, \bar{\tau}]$). Thus, for a chosen tax rate τ_t, the current period reserve is:

$$r(\tau_t) = x \int_{\tau_t}^{\bar{\tau}} 1 - \rho(s;\alpha)\, ds \tag{5}$$

Figure 3, Panel C, depicts the reserve as the dark shaded region above the solid line (i.e., above $\rho(\tau_t;\alpha)$). Comparing the expected repayment amount, $\sigma(\tau_t)$, and the reported reserve, $r(\tau_t)$, shows that they are not equal to one another. Thus, a portion of the expected repayment does not have a corresponding reserve. This occurs because of negative skew and is consistent with Mills et al. (2010) and my discussions with tax professionals. I will label this unreserved repayment as $m(\tau_t)$:

$$m(\tau_t) = \sigma(\tau_t) - r(\tau_t) \tag{6}$$

In Figure 3, Panel C, $m(\tau_t)$ is the light shaded region between the solid and dashed lines. Because I assume the set of available projects is fixed and there is a strict ordering of projects based on their risk, the selection of tax projects is equivalent to the firm choosing a tax rate. Therefore, for the remainder of the model, I will focus on the firm's choice in τ_t instead of the choice of projects.

3.2 State Variables and Laws of Motion

Now that I have described the relation between UTB reserves and the expected repayment, I can describe the firm's optimization by first detailing the state variables. Unlike structural parameters (e.g., α) which are fixed, state variables can evolve over time but also affect the firm's choice. The state space, $\mathbf{s}$, exists in $\mathbb{R}^2_{++}$ and contains two elements, $r(\tau_{t-1})$ and R_t. The first element, $r(\tau_{t-1})$, is the previous period's current UTB reserve (i.e., the reserve associated with the projects chosen in period $t-1$). The evolution of this first state evolves mechanically as the next period's lagged current UTB reserve is $r(\tau_t)$ (i.e., in $t+1$, $r(\tau_t)$ is the prior period's reserve). The second dimension of s, R_t, is the beginning UTB reserve at the time the firm chooses τ_t and represents the UTB for all auditable positions that were taken in prior years. This amount increases by the current period reserve, $r(\tau_t)$, and decreases when reserves lapse or when the firm is audited and positions are inspected. In the next section, I discuss in further detail the mechanics of inspections and audits.

Conditional on whether the firm is audited, the evolution of R_t is deterministic:

$$R_{t+1} = \begin{cases} r(\tau_t) + (1-\theta) R_t & \text{If not audited} \\ (1-\eta(\cdot)) \left[r(\tau_t) + (1-\theta) R_t \right] & \text{If audited} \end{cases} \tag{7}$$

The first row describes the law of motion when the firm is not audited. If this occurs, a fraction θ of R_t lapse because these projects occurred well in the past and the tax authority can no longer inspect these projects. The firm is no longer required to reserve for these lapsed positions, so only the fraction $1-\theta$ of R_t carries over until the next period.[14] Because the firm was not audited, the entire amount of $r(\tau_t)$ must remain on the books in $t+1$. Thus, if the firm is not audited, $R_{t+1} = r(\tau_t) + (1-\theta) R_t$.

As I describe in the next section, if the firm is audited, a fraction $\eta(\cdot)$ of projects are inspected. Because the firm has already claimed the deductions for the tax savings associated with $r(\tau_t)$ at the time of inspection (which occurs in $t+1$), both $r(\tau_t)$ and R_t are subject to inspection. Once a project is inspected, the uncertainty around the benefit is resolved, so the firm

[14] In reality, the oldest positions lapse, but Blouin et al. (2007) find the average firm has 5.7 years of positions open to audit which makes estimation infeasible.

does not need an associated reserve. Thus $\eta(\cdot)(R_t + r(\tau_t))$ will reverse from inspections. Similar to the unaudited case, a fraction θ of unaudited projects associated with R_t reverse because the ability for tax authority inspection has lapsed (i.e., $(1-\eta(\cdot))\theta R_t$). Therefore, only the fraction $(1-\eta(\cdot))(1-\theta)$ of R_t carries over to the next period and the law of motion for R_t when the firm is audited is defined as the second row of Equation 7.[15]

3.3 Audits and Inspection Rates

While I do not explicitly model the tax authority, I assume it randomly audits companies with probability p. This randomness can arise from the limited resources of the tax authority that prevent it from examining every company in a given year.[16] Once a firm is selected for audit, the tax authority determines how much it will inspect based on the variance of tax strategies over time and the total reserve balance, $r(\tau_t) + R_t$. These two effects result in the firm's optimization becoming a dynamic problem as it trades off current period taxes with future tax authority scrutiny. Also, because I assume the set of projects available to the firm is fixed and the relation between risk, avoidance, and reserves is time-invariant through the parameter α, maintaining a consistent strategy is equivalent to smooth tax rates or reserves.

I incorporate both the variance of strategies and the balance of reserves into the inspection function, $\eta(\cdot)$, based on evidence in prior research and my conversations with tax professionals. For example, prior research finds that smooth tax rates can signal lower overall tax risk (Mills et al., 2010; Bozanic et al., 2017) and Dyreng et al. (2008) finds firms exhibit persistent ETRs over time, which can occur if the firm maintains smooth tax rates to minimize tax authority scrutiny. These findings are consistent with the statements from the tax directors I interviewed who believe that high variance over time can increase tax authority scrutiny. Many of these tax professionals thought that tax authorities focus on both the level and year-over-year change in tax strategies to determine the intensity of their audit.[17]

[15]FIN 48 stipulates that any penalties and interest should accrue to the reserve for delaying payment. However, based on my conversations with practitioners, these penalties are benign and are often negotiated down to a nominal amount. Therefore, I will ignore the impact of penalties from the model.

[16]Through 2015, many of the largest firms were part of the Coordinated Industry Case program (CIC). Firms in this program were under near-continual audit by the IRS. However, prior research finds audit rates for a broader cross-section of public firms to be closer to 50% (e.g., De Simone et al., 2015) while published aggregate audit rates for firms with assets greater than $250 million averages 26% per year over my sample window of 2007 - 2016.

[17]One tax director stated his/her belief that the variance in tax risk is an important component in tax authority

I also include the total UTB reserve amount in the inspection rate because of the "road map" hypothesis. When FIN 48 was first proposed, firms widely criticized the standard because these reserves reflect the firm's opinion of its tax risk and could be used by the tax authority as a "roadmap" to identify firms that engage in risky tax avoidance (Blouin et al., 2007). Thus, I parameterize the inspection rate, $\eta\left(r\left(\tau_t\right), r\left(\tau_{t-1}\right), R_t\right)$, as the following:

$$\eta\left(r\left(\tau_t\right), r\left(\tau_{t-1}\right), R_t\right)=\frac{\eta_1\left(r\left(\tau_t\right)+R_t\right)+\eta_2\left(r\left(\tau_t\right)-r\left(\tau_{t-1}\right)\right)^2}{1+\eta_1\left(r\left(\tau_t\right)+R_t\right)+\eta_2\left(r\left(\tau_t\right)-r\left(\tau_{t-1}\right)\right)^2} \tag{8}$$

Assuming η_1, $\eta_2 > 0$, this specification ensures the inspection rate is bounded between 0 and 1. The first term, $\eta_1\left(r\left(\tau_t\right)+R_t\right)$, represents the increased scrutiny from a large UTB balance. The second term, $\eta_2\left(r\left(\tau_t\right)-r\left(\tau_{t-1}\right)\right)^2$, represents increased the scrutiny from having a large variance in tax strategies.

3.4 Cost of Tax Authority Scrutiny

When a firm is audited and the tax authority inspects projects, there are two effects on net income. First, the associated UTB reserves reverse as the uncertainty has been resolved. This decrease in UTBs flows through the income statement by decreasing the tax expense (and hence, increasing net income). The second effect is the firm must also repay the expected deficiency as I assume the firm incurs no incremental penalties. Prior research (e.g., Mills et al., 1998; Mills and Sansing, 2000) and my discussions with tax directors indicate that penalties beyond the deficiency are rarely proposed or enforced. In order to simplify estimation, I also assume the repayment amount is deterministic and equals the expected repayment.[18] To provide context for these two effects on net income, suppose all the projects from period t are inspected. The firm would repay $\sigma\left(\tau_t\right)$ (Equation 4) which decreases net income, but also receive the windfall of $r\left(\tau_t\right)$ reversing. Thus, the net effect would be a "penalty" equal to the repayment of the unreserved portion of the expected repayment amount, $m\left(\tau_t\right)$ (i.e., Equation 6).

In reality, the tax authority can inspect positions across multiple years. However, because

scrutiny because if the firm was recently audited, the tax authority has some assurance from its prior audit that the firm is not being overly aggressive.

[18]In reality, there is uncertainty regarding the actual repayment amount. However, incorporating uncertainty into payoffs does not significantly influence the firm's decision but does complicate estimation as the firm must form expectations over this uncertainty.

of lapses and prior inspections, it is difficult to observe the relation between the UTB reserve, R_t, and the expected repayment amount for all projects. I estimate the total expected repayment amount by "grossing-up" the total UTB reserve by the expected repayment in the current period, $\sigma(\tau_t)$ to the corresponding reserve, $r(\tau_t)$. This approach implies the expected repayment amount for all positions which can be audited is approximated by $(R_t + r(\tau_t))\frac{\sigma(\tau_t)}{r(\tau_t)}$.[19] Thus, the combined effect on net income from inspected reserves reversing and the firm repaying any deficiencies is expressed as Equation 9:

$$\kappa(\tau_t, r(\tau_{t-1}), R_t) = \eta(\cdot)(R_t + r(\tau_t))\left(\frac{\sigma(\tau_t)}{r(\tau_t)} - 1\right) \tag{9}$$

I include $\eta(\cdot)$ in this Equation because the fraction of inspected positions are defined by Equation 8. $R_t + r(\tau_t)$ is the total amount of UTBs reported by the firm. I gross-up these UTBs by $\frac{\sigma(\cdot)}{r(\cdot)}$ to approximate the expected repayment. However, similar to $m(\tau_t)$ in the one-period example, the net effect of UTBs reserving and repaying the expected repayment is equal to the unreserved risk of inspected projects which is why $R_t + r(\tau_t)$ is multiplied by $\left(\frac{\sigma(\cdot)}{r(\cdot)} - 1\right)$.

3.5 Net Income and the Firm's Problem

As mentioned previously, a risk-neutral firm seeks to maximize its stream of discounted future net income. Net income for period t, π_t, is defined below:

$$\pi(\tau_t; r(\tau_{t-1}), R_t) = x(1 + \phi\tau_t)(1 - \tau_t) - r(\tau_t) \tag{10}$$

The first term in Equation 10, $x(1 + \phi\tau_t)$, is the pre-tax profit. In this expression, ϕ represents the non-tax costs that arise when a firm chooses a tax rate below the statutory rate.[20,21] To see how this

[19] In order for this to be a valid proxy for the actual repayment amount, the firm is assumed to be in a steady state. In particular, I assume the fraction of expected repayment, $\sigma(\tau_t)$, that is captured by $r(\tau_t)$ should approximate the ratio of total repayment amount (i.e., sum of all $\sigma(\tau_t)$ still subject to audit) to the reported UTB balance (i.e., $R_t + r(\tau_t)$). By utilizing an infinite-period model, I have already assumed the firm is in steady-state with respect to their tax avoidance decision.

[20] As discussed in Section 2.2, prior literature has proposed several factors that contribute to non-tax costs. Because it is infeasible to explicitly incorporate all of these possibilities, I have abstracted away from the source of the non-tax costs.

[21] An alternative specification is to parameterize pre-tax profit as $x(1 - \phi(\bar{\tau}_t - \tau_t))$. In untabulated analysis, I re-estimate the model under this alternative specification, and find non-tax costs are roughly equivalent. However, the UTB reserve captures a smaller fraction of the expected repayment. This occurs because under the main specification, the scale parameter, x, can also be interpreted as the pre-tax profit when the firm pays no taxes. Under the alternative

represents non-tax costs, if the firm chose to pay the statutory tax rate of 35%, then pre-tax profit would be $x(1+0.35\phi)$. However, if the firm chose $\tau_t < 0.35$, then $x(1+\phi\tau_t) < x(1+0.35\phi)$. The parameter ϕ represents non-tax costs because as ϕ increases, pre-tax profit for an effective tax rate τ_t shrinks relative to pre-tax profit at the statutory rate. The second term in Equation 10 is $x(1+\phi\tau_t)\tau_t$ and represents the tax payment for the current period's activity. This expression also shows that the level of non-tax costs determines the firm's tax base.[22] The next term in Equation 10 is the UTB reserve for the current period's activity ($r(\tau_t)$). This amount is a component of income tax expense and decreases net income.

It is important to note that during period t, other tax factors influence the *reported* net income which is different from Equation 10. In particular, lapsed reserves, decreases in reserves from audits and inspections, and any repayments for tax deficiencies all influence reported net income in period t. However, all of these outside influences enter linearly into reported net income and are irrelevant to the firm's decision in τ_t because I can set R_t to be net of these effects. However, in period $t+1$, the amount of lapsed reserves and inspection amounts are (partially) determined by the value of τ_t and need to be incorporated into the firm's problem.

Now that I have defined net income and the impact on firm value from lapses and inspections, I can define the firm's problem. The firm sets τ_t in order to maximize the stream of discounted income which I denote as V. The firm's per-period discount rate is δ, so the firm's problem is defined as:

$$V(\boldsymbol{s}_t) = \max_{\tau_t} \pi(\tau_t; r(\tau_{t-1}), R_t) + \delta\left[(1-p\eta(\cdot))\theta R_t - p\kappa(\tau_t, r(\tau_{t-1}), R_t) + \mathbb{E}(V(\boldsymbol{s}_{t+1}))\right] \tag{11}$$

The first term in this equation, $\pi(\cdot)$, is the firm's net income in period t. All remaining amounts in this equation are discounted by the rate δ because they occur in period $t+1$. The expression $(1-p\eta(\cdot))\theta R_t$ is the expected benefit from lapses after accounting for audit and inspection rates. The next term, $p\kappa(\cdot)$, is the expected repayment from inspections, net of reserves reversing. Fi-

specification, x is defined as pre-tax profit when the firm pays the statutory rate. This change results in x becoming larger. The parameter x is also used in $r(\tau_t)$ to covert the reserve into dollars. Thus, if x is larger, the shape parameter, α, is smaller which exacerbates the effect of skew. Thus, a smaller fraction of expected repayment is captured by the reserve. Therefore, I elected to define pre-tax profit as $x(1+\phi\tau_t)$ to produce a lower bound for the unreserved expected repayment.

[22] To simplify the model, I assume the tax savings result in permanent book-tax-differences ("BTDs"). I do not model temporary BTDs as many of them are low-risk which make it unlikely they are represented in UTBs. Furthermore, temporary BTDs only benefit firms through the time value of money.

nally, the expectation of the continuation payoff, $V(\boldsymbol{s}_{t+1})$, over the uncertainty of whether the firm is audited in $t+1$. The goal of my estimation is to use data to recover the parameters that describe this problem.

4 Data

Table 1 describes my sample selection of Compustat firms from 2007-2016. My sample period starts in 2007 to ensure every observation is covered by the FIN 48 regulation. In my estimation, I scale all amounts by lagged total assets, so I require this amount to be non-missing. Consistent with prior research on tax avoidance (e.g., Dyreng et al., 2010), I define pre-tax profit as pre-tax income less special items, and I require this amount to be non-negative in my sample. To ensure observations have well-defined states, I further require non-missing ending UTB reserve balances and UTB reserves associated with the prior period's activity. I also require the current portion of the UTB reserve for year t to be non-missing because I use this amount to identify the firm's tax effective tax rate, τ_t. Finally, because the firm's choice in tax avoidance in year t determines its inspection rate, penalties, and lapse amount in year $t+1$, I ensure the firm is in Compustat in year $t+1$. Given these screens, my final sample consists of 9,038 firm-year observations and 2,118 unique firms.

Table 2, Panel A, reports summary statistics. All unbounded amounts are winsorized at 5% and 95%. Columns 2-4 report the mean, median, and standard deviation for level amounts and Columns 5-6 report the percentile of each summary statistic relative to all Compustat firms for each fiscal year. The average market capitalization is $\$7,827$ million, which corresponds to the 78th percentile of Compustat firms and indicates that the sample is comprised of large companies. Conversely, the sample has an average book-to-market ratio of 0.64 which is the 43rd Compustat percentile. Low book-to-market ratios suggest these firms have greater intangible assets or larger growth opportunities (e.g., Morck et al., 1988). Finally, I define ROA as pre-tax income less special items scaled by lagged total assets. Average ROA is 0.11, or the 74th percentile of all Compustat firms. Finally, these firms report a GAAP ETR (tax expense scaled by pre-tax income less special items) of 0.28 which suggests these firms pay less than the statutory rate of 35%. Collectively, Panel A shows that relative to the broader Compustat universe, my sample is comprised of larger, more profitable firms with greater growth opportunities.

Panel B reports the amounts used in the estimation. All unbounded amounts are reported as a percent of lagged total assets.[23] The current period reserve has an average of 0.18 (row 1), while pre-tax profit has an average of 10.7 (row 2). I define R_t as the ending UTB balance less the current period reserve which has an average of 1.08 (row 3). I set missing UTB amounts related to lapses and settlements in $t+1$ equal to zero. *Audit Indicator* is a binary variable for whether the firm reported a non-zero UTB settlement amount in $t+1$; I assume this indicator well approximates whether the firm was audited during the year, and implies 50% of my sample was audited. *Lapse Ratio* is calculated as the amount of UTB which lapse in $t+1$ scaled by R_t. This row suggests the fraction of lapsed positions is 8%. The last line, *Settle Ratio*, the ratio of settled reserves in year $t+1$ to the ending UTB balance in year t (i.e., $R_t + r(\tau_t)$) and has a mean of 6%.

5 Identification and Estimation

I use pre-tax profit and the information contained in the FIN 48 disclosure to identify the parameters specified in my model. As I mention in Section 1, I do not use the income tax expense, current income tax expense, or cash taxes paid in my estimation because these accounts contain amounts unrelated to current activities. I use FIN 48 reserves because it separately discloses the reserve associated with the current activity from other periods. Because Equation 11 has no closed-form solution, I solve the model and estimate parameters using simulated method method of moments (SMM).[24] For additional details on how I implement SMM, see Appendix B. Briefly, SMM minimizes the weighted-squared distance between a set of empirical moments with a set of simulated moments by selecting a choice of parameters defined by the vector Θ:

$$\min_{\Theta} \sum_{i=1}^{N} g(w_i, \Theta) W g(w_i, \Theta)' \tag{12}$$

The seven parameters which comprise Θ are: α, x, ϕ, θ, p, η_1, η_2. I assume a discount rate, δ, of 0.90 which is consistent with prior research (e.g., Taylor, 2013; Zakolyukina, 2017). The func-

[23]I report every data as a percent of lagged total assets in order to mitigate numerical concerns that arise when using small valued data in a numerical optimization.

[24]Cameron and Trivedi (2005) provides an excellent overview of simulation-based methods while Strebulaev and Whited (2012) provides examples how SMM has been used in corporate finance settings.

tion $g(w_i, \Theta)$ is a row vector that differences the empirical moments using data w_i and simulated moments computed with Θ. W is a weight matrix, which I set as the identity matrix.

To identify the seven parameters, I utilize eight moments. The first moment is the average current UTB reserve. This helps me identify x and α as the current UTB reserve is parameterized with Equation 5. The second moment is the average pre-tax income which helps identify ϕ and x. In order to isolate the effect of α and ϕ from x, the next two moments are the variance of the current UTB reserve and pre-tax income in natural logarithms. To identify p, I assume that if a firm is audited, it repays any deficiencies in the period it is audited. I further assume the actual repayment amount equals the expected repayment amount (some of which has a reserve), so I infer whether a firm is audited if it reports a non-zero UTB settle amount (i.e., the variable *Audit Indicator*). Thus, the fifth moment is the fraction of firms that report a non-zero settle amount.

The remaining three moments use subsamples of the data depending on whether the firm reported a non-zero settle amount. I refer to these groups as the no-audit (zero reported settlement) and the audit group (non-zero settlement). In order to identify the fraction of positions which lapse, θ, the next moment is the ratio of lapsed UTBs to R_t. However, this moment only uses the no-audit subsample because the amount of reserve that has lapsed in audited firms is affected by the fraction of positions inspected by the tax authority (i.e., $1 - \eta(\cdot)\,\theta R_t$). Therefore, using audited firms in a moment condition to isolate the parameter θ would be contaminated by the audit and inspection parameters p, η_1, and η_2. The remaining two moments use the audit group and allow me to identify η_1 and η_2 which are the parameters that define inspections. In order to separate effect of the UTB balance (i.e., η_1) from the variance of tax strategies (i.e., η_2) in tax authority scrutiny, the last two moments multiply the distance between the settle rate observed in the data and the inspection rate produced by the model (i.e., $\textit{Settle Ratio} - \eta(\cdot)$) by the two state variables, R_t and $r(\tau_{t-1})$. These moments separately identify η_1 and η_2 because the two state variables directly enter the inspection function and separately affect the inspection rate through either η_1 or η_2.[25]

[25] These last two moments are similar to estimating the inspection function, $\eta(\cdot)$, by generalized method of moments with two instruments, R_t and $r(\tau_{t-1})$.

6 Results

6.1 Parameter Estimates

Table 3, Panel A, reports coefficient estimates for the seven structural parameters and Panel B uses these parameters to report summary statistics implied from these estimates. Even though the firm's true effective tax rate is unobservable, I can recover τ_t by observing the current UTB reserve, the tax avoiding technology parameter, α, and scale parameter, x. In particular, conditional on estimates of α and x, Equation 5 specifies a one-to-one mapping between the reported current period reserve, $r(\tau_t)$, and the effective tax rate τ_t. Therefore, knowing α and x, I can impute τ_t by inverting $r(\tau_t)$. Column 1 of Panel A reports a technology parameter of 4.86 and Column 2 reports a scale parameter of 7.42 which implies the average (median) unobserved tax rate is 0.234 (0.282) (row 1 of Panel B). Both the mean and median effective tax rate is well below the statutory rate of 35% which implies these firms engage in tax avoidance.

Knowing τ_t and the non-tax cost parameter ϕ, I can measure non-tax costs. I measure non-tax costs as the percent change in pre-tax income for the average (or median) effective tax rate relative to pre-tax income if the firm paid the statutory rate of 35%. Thus, I define non-tax costs as:

$$Non - Tax\ Costs = 1 - \frac{1 + \phi\tau_t}{1 + \phi \times 0.35} \tag{13}$$

Using this equation and a value of $\phi = 2.26$ (Column 3, Panel A), row 2 of Panel B reports that non-tax costs reduce pre-tax profit by an average (median) 14.7% (8.6%). These findings equate to an average (median) decrease in pre-tax income from tax avoidance of $88 million ($3.2 million). This estimate of non-tax costs is roughly equivalent to the R&D expense.[26] This suggests non-tax considerations are an important factor in determining tax avoidance, even though they are difficult to observe. Despite this decline in pre-tax profit, firms are still better off by engaging in tax avoidance as row 3 of Panel B shows that profit, net of tax, is approximately 1% greater than if the firm paid the statutory rate.

With parameter estimates, I can also measure the informativeness of FIN 48 reserves. Recall in Section 2 that the UTBs reported in the firm's financials may simultaneously underrepresent

[26] In my sample, the average (median) R&D expense is $103 million ($5.1 million).

the expected repayment amount because reserves are based on medians and over-reserve because the firm must assume 100% audit and inspection rates. Because I recover the effective tax rate, τ_t, and the two parameters, α and x, I can measure the expected repayment amount, $\sigma(\tau_t)$ (Equation 4), and compute the amount of repayment captured by the current reserve (i.e., $\frac{r(\tau_t)}{\sigma(\tau_t)}$). Using the average (median) tax rate, Row 4 of Panel B shows the current UTB reserve only captures 63% (55%) of the expected repayment. On average, this implies $58 million of the expected repayment is not disclosed to investors. If I instead assume average audit and inspection rates implied by the model which arises in the model from the parameter p and Equation 8, Row 5 of Panel B shows the reserve over-states the repayment by about 3.83 times. This amount is similar to the 24% of reserves reversing from repayments to the tax authority in Robinson et al. (2015) and equates to an overstatement of $59 million on average.

Column 4 and 5 of Panel A reports the lapse rate for uninspected positions (θ) and audit rate (p) of 0.03 and 0.32. Columns 6 and 7 report parameters related to the inspection rates that arise from UTB reserves (η_1) and the variance of tax strategies over time (η_2). For average values of $r(\tau_{t-1})$, R_t, and $r(\tau_t)$, if a firm is audited, the tax authority inspects 52% of positions. Row 6, Panel B, also show that the equivalent median rate is 9%.

To measure the relative effect of the variance in strategies in tax authority scrutiny, I compute the following ratio:

$$Scrutiny\ from\ Variance = \frac{\eta_2\left(\bar{r}(\tau_t) - \bar{r}(\tau_{t-1})\right)^2}{\bar{\eta}(\cdot)} \tag{14}$$

In this expression, the bars over $r(\tau_t)$ and $r(\tau_{t-1})$ imply either the mean or median amount. The denominator is the mean or median inspection rate that is computed according to Equation 8 (i.e., 52% for means and 9% for medians). Based on Equation 14, Row 7 of Panel B reports the relative mean (median) effect from smooth tax strategies on tax authority scrutiny is 96% (74%). Because tax authority scrutiny appears to be largely determined by the variance of tax strategies over time, this demonstrates how dynamics affect tax avoidance and provides one explanation why Dyreng et al. (2008) find tax rates are persistent over time.

In Table 4, I examine model fit. Because I use 8 moments to identify 7 parameters, the bottom row of Table 4 reports the chi-squared statistics for Hansen's J-test. With a p-value of 0.23, the statistic is insignificantly different from zero which suggests that collectively, all 8 simulated moments used in my estimation are not significantly different from their corresponding empirical moments. To further investigate model fit, I examine five empirical means to those simulated with model parameters. Following Taylor (2010), I employ a Monte Carlo approach where I create 10,000 sets of simulated means and report the average from these sets. Column 3 shows that all simulated means are significantly different from their empirical counterparts, which likely is a result of the only stochastic component arising from whether the firm is audited. Row 1 and 2 of Table 4 shows that the simulated current reserve and pre-tax income are larger than the empirical averages. Row 3 shows that the simulated audit rate of 32% is less than the empirical 50%. Row 4 (5) show that simulated lapse rates (average inspection rates) are smaller (larger) than the empirical rates.

Overall, this estimation finds non-tax costs are a significant consideration in tax planning. I also find that tax authority scrutiny is primarily driven by the variance in tax strategies over time. Finally, when I continue to assume 100% audit and inspection rates, I show that UTBs capture less than two thirds of the expected repayment amount which suggests these disclosures may be insufficient to adequately measure a firm's tax risk.

6.2 Subset Analysis

In this section, I study why there is a large dispersion of ETRs across firms. To confirm that the dispersion exists in my sample, Figure 4 plots a histogram of the three-year cash ETR as calculated in Dyreng et al. (2008). Consistent with prior research (e.g., Dyreng et al., 2008), my sample has long-run cash ETRs ranging from less than 10% to approximately 50%. Given these long-run cash ETRs are computed with three years of data, it is unlikely that idiosyncratic variations in cash taxes paid (the numerator) or pre-tax profit (the denominator) are the primary reason for the dispersion. Therefore, it is likely there are fundamental differences in tax planning across these firms.

I consider whether this dispersion arises because of differences in non-tax costs (i.e., ϕ) or tax avoiding technology (i.e., α). Tax avoidance might create a smaller impact on the operations of some firms which is represented with a smaller ϕ parameter. Conversely, some companies might be better able to sustainably avoid taxes so the cost from tax audit and tax authority scrutiny is lower. This effect would be represented with a smaller α value. To investigate this question, I split the sample into two groups – firms with 3-year average cash ETRs above the sample median ("high ETR firms") and firms below the median ("low ETR firms").[27] I use this measure of tax avoidance because it can approximate a firm's average true effective tax rate (Dyreng et al., 2008) and has been widely used in prior research.

However, without employing a structural model that recovers the underlying parameters governing the firm's decision, it is difficult to determine whether this dispersion is a result of low ETR firms having lower non-tax costs or better tax avoiding technology. To demonstrate this difficulty with observable proxies, Table 5 compares summary statistics related to tax avoidance and risk across the two subsamples. This discussion focuses on whether low ETR firms have greater tax avoiding ability instead of lower non-tax costs because non-tax costs are difficult to directly observe. As expected, Row 1 shows the low ETR firms have lower long-run cash ETRs than the high ETR group. The low ETR group also is more likely to be a multinational (row 2) and have greater R&D activities (row 3) which prior literature suggests is evidence that these firms have better opportunities to reduce taxes (e.g., Dyreng et al., 2010, 2017). Row 4 reports the 5-year forward volatility in cash ETRs which Guenther et al. (2016) uses as a measure of tax risk. Guenther et al. (2016) posits that firms with low volatility in future cash ETRs are less likely to have paid penalties. Despite the significant reduction in observations that a five year measure imposes, this finding also suggests that low ETR firms have greater tax avoiding skill.

While rows 2–4 provide evidence that low ETR firms have better tax avoidance abilities, other tax risk measures offer a different story. Row 5 shows that low ETR firms have larger ending UTB balances which suggests they have incurred greater risk (and hence, require a greater reserve). However, the larger reserve may be a result of these firms engaging in greater avoidance. To address this concern, Rego and Wilson (2012) creates a Predicted UTB measure which attempts to correct for inherent differences in tax avoiding abilities. This measure is reported in the last row shows the low ETR firms have higher predicted UTB measures. This implies these firms do not have better tax avoiding ability and could suggest they have low ETRs because of smaller non-

[27] I split observations based at the firm level instead of at the observation level because I assume that a firm's tax technology and non-tax costs cannot significantly change year-over-year.

tax costs which are not directly observable. Overall, the findings in Table 5 demonstrate that it is difficult to isolate whether the dispersion in ETRs is driven by differences tax avoiding ability or non-tax costs.

To separate the two constructs (i.e., non-tax costs and tax avoiding ability), I separately estimate the model for low ETR and high ETR firms. Table 5, Panel A, reports the results for low ETR (row 1 and 2) and high ETR firms (rows 3 and 4).[28] Column 1 reports the tax avoiding technology parameter for low ETR firms is 0.86 while high ETR firms have $\alpha = 3.37$.[29] Recall in Figure 3 that a smaller value of α implies the firm expects to repay less of the savings if it is audited. Thus, low ETR firms appear to have better tax avoiding ability. In order to quantify the skill (or opportunities) of low ETR firms relative to high ETR firms, I compute the expected repayment ($\sigma(\tau_t)$) at the mean effective tax rate for high ETR firms (i.e., 0.229) and compute the ratio of the expected repayment for low ETR firms to high ETR firms. Based on $\alpha = 0.86$ (low ETR firms) and $\alpha = 3.37$ (high ETR firms), I find that low ETR firms only incur 39% of the risk that high ETR firms incur. This finding suggests there are substantial differences in tax avoiding ability across the two groups.

Column 3 of Panel A reports the non-tax cost parameter, ϕ, for both groups. I find low ETR firms have greater non-tax costs than high ETR firms (i.e., $\phi = 2.35$ versus $\phi = 1.64$). Panel B, row 2, reports the non-tax cost as a percent of pre-tax income as calculated in Equation 13. For the mean (median) effective tax rate in each group, I find non-tax costs are 15.8% (15.6%) for low-ETR firms and 12.5% (7.5%) for high ETR firms. While the mean effective tax rates across the two groups are roughly equivalent, the median effective tax rates are different. This difference in medians affects the level of non-tax costs. If I set the low ETR firms' effective tax rate to equal the high ETR rate (i.e., 0.230 for means and 0.278 for medians), the difference in non-tax costs shrink. If low ETR firms paid the higher rate, they would incur non-tax costs of 15.8% on average but 10.9% at the median. This suggests that the non-tax costs are roughly similar across the two groups. Collectively, Table 6 suggests that the primary reason firms have persistent differences in

[28]While it is intuitive that estimates reported in Table 3 should be a weighted average of the estimates in Table 6, Panel A, by estimating all parameters separately, the stochastic nature of these estimates can result in the point estimates for some parameters to be above (or below) the pooled results.

[29]In order to test whether parameter values are significantly different across the two samples, I would need to bootstrap the estimates by randomly assigning firms into subsamples and compare the observed difference between low and high ETR firms to the empirical distribution of differences in the bootstrapped samples. However, this approach is infeasible given the computation time to solve Equation 12.

ETRs is their differential ability to sustainably avoid taxes instead of differences in non-tax costs.

Panel A and B of Table 7 presents model fit for the low and high ETR firms. The bottom rows of each panel show that Hansen's J-test is not rejected in either subsample which suggests the simulated moments used in the estimation are not significantly different from the empirical moments. Like the pooled analysis, all of the simulated averages for both subsamples reported in Table 7 are significantly different than their empirical counterparts. However, with exception of the inspection rates for both subsamples and current UTB reserve for the high ETR subsample, the two sets of averages are economically similar.

6.3 Counterfactual Analysis

A major benefit of structural estimation is counterfactual analysis which enables me to analyze how firms would alter their behavior under different scenarios, even though these outcomes are never observed in data. I do this by adjusting the model and calculating the firm's expected response after I have parameter estimates. This approach permits me to isolate different factors affecting tax avoidance. I specifically examine four counterfactuals to understand how different components influence a firm's tax avoidance decision. The first two counterfactuals examine the role of FIN 48 on tax avoidance. These two counterfactuals quantify the real effect of financial reporting because I can measure the firm's expected tax strategy and non-tax costs under different reporting regimes. The third counterfactual investigates how tax authority scrutiny affects a firm's tax avoidance. The final counterfactual quantifies the effect of non-tax costs on a firm's tax strategy by considering firm behavior if non-tax costs were the only consideration in tax avoidance.

Row 1 of Table 8 presents the expected change in effective tax rates (Columns 1 and 2), non-tax costs (Columns 3 and 4), and price (Columns 5 and 6) if the financial reporting standard for UTBs were based on the expected repayment. Instead of requiring firms to reserve on median amounts as is currently the standard, this row considers how firms would respond to the requirement that they must set a reserve equal to the expected repayment, but continue to assume a 100% audit and inspection rate (i.e., $r(\tau_t) = \sigma(\tau_t)$). All amounts in this table are relative to the pooled sample (i.e., Table 3). Column 1 (2) shows that the average (median) effective tax rate would increase by 1.21 percentage points (2.13 percentage points). This increase in effective tax rates occurs because the reserve specified in FIN 48, $r(\tau_t)$, is smaller than the expected repayment, $\sigma(\tau_t)$, which is the reserve proposed in this counterfactual. By requiring a reserve based on the expected repayment, it delays the recognition of a larger fraction of the savings. This change lowers the marginal benefit of tax avoidance because the firm discounts future payoffs. As a result, the firm will use fewer tax-saving strategies. However, because the firm would utilize fewer tax avoiding strategies, it will also incur fewer non-tax costs which will cause pre-tax profit to rise by approximately 1.78% − 2.94% (Columns 3 and 4). The combined effect from paying higher taxes but incurring lower non-tax costs results in firm prices *increasing* relative to the status quo. Columns 5 and 6 show the mean and median price increases by 69bps and 79bps. This counterfactual demonstrates a complex relation between tax avoidance, the recognition of tax savings, non-tax costs, and firm value.

The next row in Table 8 considers how firms would choose effective tax rates if there were no reporting requirements. This counterfactual assumes firms do not have to set a UTB (which reduces net income) and is most similar to firm decisions prior to the implementation of FIN 48 when it was unclear how (or if) firms created reserves for uncertain tax benefits. Put differently, by comparing this counterfactual to the main results in Table 3, I can estimate the impact of FIN 48 on a firm's tax avoidance, even though we do not have sufficient data pre-FIN 48 to measure its effect.[30] Row 2 reports that in the absence of reserve requirements, tax rates would decrease by an average 0.79 percentage points which equates to a 6.9% change in tax avoidance.[31] The increased level of tax avoidance would decrease pre-tax profit by 1.1%; however, the net effect on firm value is positive with the average increase in value of 1.1%.[32]

The third counterfactual assumes the tax authority inspects a fixed fraction of tax positions instead of basing its scrutiny on the level of UTBs and variance of tax strategies (i.e., the function $\eta(\cdot)$). By setting a fixed inspection rate, I consider how the strategic aspect of tax authority behavior influences a firm's tax strategy. There are two possible effects that fixed inspection

[30] To operationalize this counterfactual, I remove $r(\tau_t)$ from net income and eliminate the benefit of reserve reversals which occur from lapses and inspected positions.

[31] The 6.9% is calculated as the ratio of the change in tax avoidance (i.e., 0.79%) to the existing average level of tax avoidance (i.e., 11.6% = 35% − 23.4%).

[32] This finding is in contrast to Frischmann et al. (2008) who finds little market response at the announcement of FIN 48. One possibility why I find a significant effect while Frischmann et al. (2008) do not is their market tests span multiple years which may have resulted in weaker tests.

rates can have on firm behavior. First, firms may increase their avoidance because doing so does not increase tax authority scrutiny. Conversely, because a greater variance of tax strategies increases scrutiny, it is possible that aggressive firms (i.e., those which incur significant tax risk) will no longer have the incentive to maintain aggressive strategies because keeping a constant strategy no longer reduces tax authority scrutiny.[33] Because dynamics arise through tax authority scrutiny, this counterfactual also demonstrates how dynamics affects the firm's tax avoidance. Row 3 reports that the mean (median) effective tax rate increases by 0.61 (1.24) percentage points which reduces tax avoidance by 5.2% (18.3%). As a result, pre-tax profit and firm value both increase by an average of approximately 0.9%. Thus, these findings suggest that the first-order effect from eliminating the strategic aspect of tax authority scrutiny is that firms no longer have the incentive to maintain low effective tax rates.

The final counterfactual isolates the effect of non-tax costs from the costs of tax authority scrutiny. In reality, both factors influence the firm's decision, so to separate the two effects, I consider the hypothetical scenario where a firm is never audited, so the only cost is the non-tax cost. To create this scenario, I assume the firm is never audited, projects are never inspected, and the firm is not required to set a UTB as there no longer is audit uncertainty. Table 8 Row 4 presents results under this counterfactual. Columns 1 and 2 report mean and median effective tax rates decrease by 1.84 and 2.33 percentage points. Recall that the average (median) effective tax rate in Table 3 is 23.4% (28.2%), so this implies tax rates are still greater than 20%. Because I estimate that firms maintain effective tax rates greater than 20% when they only consider non-tax costs, this finding suggests that non-tax costs play a larger role than either financial reporting considerations and tax authority scrutiny.

Broadly, these counterfactual analyses demonstrate how different components effect tax avoidance. I show that the peculiar way firms are required to set UTBs relative to the expected repayment has a meaningful effect on tax avoidance and firm value. I also quantify the effect of FIN 48 on a firm's tax strategy relative to not requiring a reserve. I show that a strategic tax authority actually decreases tax rates because firms no longer have the incentive to commit to an aggressive strategy. Finally, even though non-tax costs are difficult to observe, they appear to be

[33] In this counterfactual, I set the fixed inspection rate equal to the mean (median) inspection rate when reporting mean (median) effects. This approach ensures that any changes in firm behavior are not a result of varying levels of scrutiny.

the largest factor in determining a firm's tax avoidance.

7 Conclusion

Prior research documents that firms appear to forgo profitable tax saving strategies, yet there are many unobservable factors that prevent firms from fully utilizing them. To identify the effect of these unobservable components, I structurally estimate a model in which a firm balances tax savings with non-tax costs, financial reporting incentives, and audit risk. I estimate that non-tax costs are 14.7% of pre-tax income, which is roughly equivalent to firms' R&D expense. This finding suggests that non-tax costs have a large impact on a firm's tax avoidance, and can help to explain the "undersheltering puzzle".

I also investigate why tax rates vary across firms. Prior literature hypothesizes this dispersion occurs because firms either have different non-tax costs or different tax-avoiding abilities. Structural estimation enables me to separate these two constructs to find that the primary reason is firms have different abilities to sustainably avoid taxes, not different non-tax costs. I also examine how well the existing tax risk disclosure (FIN 48) captures the underlying tax avoidance activity. I find that it only reflects 63% of the expected repayment amount when I assume 100% audit and inspection rates, as specified in the disclosure.

Finally, I use counterfactuals to analyze how different components of tax avoidance affect firm behavior. I find that the FIN 48 disclosure and the unique rules specifying how firms measure UTBs significantly influences the incentive to avoid taxes. Similar approaches could be used to study the real effect of other accounting rules. This methodology, as it is used in this paper to identify the determinants of tax avoidance, can be applied broadly to other research questions, and should be of interest to researchers and policymakers alike.

References

Armstrong, Christopher, Jennifer Blouin, Alan Jagolinzer, and David Larcker (2015) "Corporate governance, incentives, and tax avoidance," *Journal of Accounting and Economics*, Vol. 60, pp. 1–17.

Armstrong, Christopher, Jennifer Blouin, and David Larcker (2012) "The incentives for tax planning," *Journal of Accounting and Economics*, Vol. 53, pp. 391–411.

Berger, Philip (1993) "Explicit and implicit tax effects of the R & D tax credit," *Journal of Accounting Research*, pp. 131–171.

Blouin, Jennifer (2014) "Defining and measuring tax planning aggressiveness," *National Tax Journal*, Vol. 67, p. 875.

Blouin, Jennifer, Cristi Gleason, Lillian Mills, and Stephanie Sikes (2007) "What can we learn about uncertain tax benefits from FIN 48?" *National Tax Journal*, Vol. 60, pp. 521–535.

Bozanic, Zahn, Jeffrey Hoopes, Jacob Thornock, and Braden Williams (2017) "IRS attention," *Journal of Accounting Research*, Vol. 55, pp. 79–114.

Cameron, Colin and Pravin Trivedi (2005) *Microeconometrics: Methods and Applications*: Cambridge University Press.

Ciconte, Will, Michael Donohoe, Petro Lisowsky, and Michael Mayberry (2016) "Predictable uncertainty: The relation between unrecognized tax benefits and future income tax cash outflows," *Workng Paper*.

De Simone, Lisa, Lilian Mills, and Bridget Stomberg (2015) "Examining IRS Audit Outcomes of Income Mobile Firms," *Working Paper*.

Desai, Mihir and Dhammika Dharmapala (2006) "Corporate tax avoidance and high-powered incentives," *Journal of Financial Economics*, Vol. 79, pp. 145–179.

Dhaliwal, Dan, Micah Frankel, and Robert Trezevant (1994) "The taxable and book income motivations for a LIFO layer liquidation," *Journal of Accounting Research*, pp. 278–289.

Dyreng, Scott, Michelle Hanlon, and Edward Maydew (2008) "Long-run corporate tax avoidance," *The Accounting Review*, Vol. 83, pp. 61–82.

——— (2010) "The effects of executives on corporate tax avoidance," *The Accounting Review*, Vol. 85, pp. 1163–1189.

——— (2016) "When Does Tax Avoidance Result in Tax Uncertainty?" *Working Paper*.

Dyreng, Scott, Michelle Hanlon, Edward Maydew, and Jacob Thornock (2017) "Changes in corporate effective tax rates over the past 25 years," *Journal of Financial Economics*, Vol. 124, pp. 441–463.

Engel, Ellen, Merle Erickson, and Edward Maydew (1999) "Debt-equity hybrid securities," *Journal of Accounting Research*, Vol. 37, pp. 249–274.

Financial Accounting Standards Board (2006) "Accounting for Uncertainty in Income Taxes: An interpretation of FASB statement no. 109."

Frischmann, Peter, Terry Shevlin, and Ryan Wilson (2008) "Economic consequences of increasing the conformity in accounting for uncertain tax benefits," *Journal of Accounting and Economics*, Vol. 46, pp. 261–278.

Gaertner, Fabio (2014) "CEO After-Tax Compensation Incentives and Corporate Tax Avoidance," *Contemporary Accounting Research*, Vol. 31, pp. 1077–1102.

Gallemore, John and Eva Labro (2015) "The importance of the internal information environment for tax avoidance," *Journal of Accounting and Economics*, Vol. 60, pp. 149–167.

Gallemore, John, Edward Maydew, and Jacob Thornock (2014) "The reputational costs of tax avoidance," *Contemporary Accounting Research*, Vol. 31, pp. 1103–1133.

Graham, John, Michelle Hanlon, Terry Shevlin, and Nemit Shroff (2013) "Incentives for tax planning and avoidance: Evidence from the field," *The Accounting Review*, Vol. 89, pp. 991–1023.

Graham, John, Campbell Harvey, and Shiva Rajgopal (2005) "The economic implications of corporate financial reporting," *Journal of Accounting and Economics*, Vol. 40, pp. 3–73.

Guenther, David, Steven Matsunaga, and Brian Williams (2016) "Is tax avoidance related to firm risk?" *The Accounting Review*, Vol. 1, pp. 115–136.

Gupta, Sanjay, Rick Laux, and Daniel Lynch (2015) "Do Firms Use Tax Reserves to Meet Analysts Forecasts? Evidence from the Pre-and Post-FIN 48 Periods," *Contemporary Accounting Research*, Vol. 33, pp. 1044–1074.

Gupta, Sanjay and Kaye Newberry (1997) "Determinants of the variability in corporate effective tax rates: Evidence from longitudinal data," *Journal of Accounting and Public Policy*, Vol. 16, pp. 1–34.

Hanlon, Michelle (2003) "What can we infer about a firm's taxable income from its financial statements?" *National Tax Journal*, pp. 831–863.

Hanlon, Michelle and Shane Heitzman (2010) "A review of tax research," *Journal of Accounting and Economics*, Vol. 50, pp. 127–178.

Hanlon, Michelle, Edward Maydew, and Daniel Saavedra (2017) "The Taxman Cometh: Does Tax Uncertainty Affect Corporate Cash Holdings?" *Review of Accounting Studies*, Vol. Forthcoming.

Hoopes, Jeffrey, Devan Mescall, and Jeffrey Pittman (2012) "Do IRS audits deter corporate tax avoidance?" *The Accounting Review*, Vol. 87, pp. 1603–1639.

Judd, Kenneth (1998) *Numerical Methods in Economics*: MIT press.

Mills, Lillian, Merle Erickson, and Edward Maydew (1998) "Investments in tax planning," *The Journal of the American Taxation Association*, Vol. 20, pp. 1–20.

Mills, Lillian and George Plesko (2003) "Bridging the reporting gap: a proposal for more informative reconciling of book and tax income," *National Tax Journal*, pp. 865–893.

Mills, Lillian, Leslie Robinson, and Richard Sansing (2010) "FIN 48 and tax compliance," *The Accounting Review*, Vol. 85, pp. 1721–1742.

Mills, Lillian and Richard Sansing (2000) "Strategic tax and financial reporting decisions: Theory and evidence," *Contemporary Accounting Research*, Vol. 17, pp. 85–106.

Morck, Randall, Andrei Shleifer, and Robert Vishny (1988) "Management ownership and market valuation: An empirical analysis," *Journal of Financial Economics*, Vol. 20, pp. 293–315.

Newman, Harry (1989) "Selection of short-term accounting-based bonus plans," *The Accounting Review*, pp. 758–772.

Rego, Sonja Olhoft (2003) "Tax-avoidance activities of US multinational corporations," *Contemporary Accounting Research*, Vol. 20, pp. 805–833.

Rego, Sonja Olhoft and Ryan Wilson (2012) "Equity risk incentives and corporate tax aggressiveness," *Journal of Accounting Research*, Vol. 50, pp. 775–810.

Robinson, Leslie, Bridget Stomberg, and Erin Towery (2015) "One size does not fit all: How the uniform rules of FIN 48 affect the relevance of income tax accounting," *The Accounting Review*, Vol. 91, pp. 1195–1217.

Scholes, Myron, Mark Wolfson, Merle Erickson, Michelle Hanlon, Edward Maydew, and Terrence Shevlin (2015) *Taxes and Business Strategy*: Prentice Hall.

Shackelford, Douglas and Terry Shevlin (2001) "Empirical tax research in accounting," *Journal of Accounting and Economics*, Vol. 31, pp. 321–387.

Strebulaev, Ilya and Toni Whited (2012) "Dynamic models and structural estimation in corporate finance," *Foundations and Trends in Finance*, Vol. 6, pp. 1–163.

Taylor, Lucian (2010) "Why are CEOs rarely fired? Evidence from structural estimation," *Journal of Finance*, Vol. 65, pp. 2051–2087.

——— (2013) "CEO wage dynamics: Estimates from a learning model," *Journal of Financial Economics*, Vol. 108, pp. 79–98.

Weisbach, David (2001) "Ten truths about tax shelters," *Tax L. Rev.*, Vol. 55, p. 215.

Wilde, Jaron and Ryan Wilson (2017) "Perspectives on Corporate Tax Avoidance: Observations from the Past Decade," *Working Paper*.

Zakolyukina, Anastasia (2017) "How common are intential GAAP violations? Estimates from a dynamic model," *Journal of Accounting Research*, Vol. Forthcoming.

Appendix A: Measurement of Uncertain Tax Benefits

In this Appendix, I provide an example on how FIN 48 specifies the measurement of tax reserves for a hypothetical $100 tax-saving project. Panels A, B, and C report the probabilities, expected repayments, and reserves, assuming this project is designated as a weak, medium, or strong position, respectively. In each scenario, the firm believes that if it were audited, there are three possible amounts it could keep – $100, $60, or $0. Panel A reports the probabilities for a weak position. Because the median retained benefit is $0, this project does not pass the MLTN threshold. Therefore, the firm must set a reserve for the entire $100 even though the expected repayment is only $74. Panel B presents the outcomes and probabilities for a medium position. This example satisfies the MLTN threshold because the median is greater than $0 as the cumulative probability at $60 is greater than 50%. However, because the firm believes there is less than a 50% probability it will keep all $100, the firm must reserve for this position. Since the 50% threshold occurs at $60, the firm must reserve $40 but the expected repayment is $47. Panel C reports the probabilities and outcomes for a strong position. Since the firm is more than 50% confident it will keep all $100, this position does not require a reserve even though the expected expected repayment is $30.

Panel A: Weak Position

Outcome	Prob. of Occurring	Cumulative Probability	Expected Repayment	Reserve
100	20	20		
60	10	30	74	100
0	70	100		

Panel B: Medium Position

Outcome	Prob. of Occurring	Cumulative Probability	Expected Repayment	Reserve
100	35	35		
60	30	65	47	40
0	35	100		

Panel C: Strong Position

Outcome	Prob. of Occurring	Cumulative Probability	Expected Repayment	Reserve
100	55	55		
60	25	80	30	0
0	20	100		

Appendix B: Details on Estimation

B.1 Solving the Firm's Objective Function

To solve the objective function (i.e., Equation 12), I need to solve the firm's problem (i.e., Equation 11) for each possible set of parameter values. For a given set of parameters, I solve the firm's problem using two-step policy iteration and create an 9×25 grid over the two dimensions of the state space. At each of these 225 nodes, I solve the firm's problem and compute the optimal value (i.e., price) and policy (i.e., τ_t) functions which depend on the two state variables. The first state variable is the lagged current UTB reserve (i.e., $r(\tau_{t-1})$) and the second is the beginning reserve (i.e., R_t). Because there is significant skew in the data, the grid is not uniformly distributed over the support of each dimension. Rather, I set the first element of each state to be 10% of the observed minimum value in the data while the last grid point is 110% of the observed maximum.[34] This permits states in $t+1$ evolve outside of the observed data; however, if the states evolve outside of these expanded bounds, the states are forced to remain in the grid (i.e., either the minimum or maximum of the grid). Meanwhile, the remaining grid points are distributed across the quantiles of the data. For example, the 7 interior grid points that comprise the nodes for $r(\tau_{t-1})$ are set at the minimum, the 20th quantile, 40th quantile, continuing until the maximum observed $r(\tau_{t-1})$. The value and policy functions for observations which do not lie on these grid points are interpolated.

B.2 Computing a Reserve for a Given Effective Tax Rate

Because there is no closed-form solution for Equation 5 that maps the effective tax rate, τ_t, with the current period reserve, $r(\tau_t)$, I numerically integrate a solution. In particular, I partition values of τ_t from 0.349 to 0.03 into 500 distinct values. For each of these values, I compute the marginal median risk (i.e., Equation 3) and integrate these amounts from 0.349 to τ_t via Simpson's rule to compute a reserve. However, numerical precision is a concern for small values of α and values of τ_t close to the statutory rate of 35%. When $\tau_t \to 0.35$ or $\alpha \to 0$, the shape parameter b in the beta distribution used to compute the tax audit risk for the marginal project approaches 0 (see

[34] I set the first grid point in each dimension to only be 10% of the minimum because the observed minima for $r(\tau_{t-1})$ and R_t are close to zero.

Equation 2). If $b \to 0$, the beta distribution becomes ill-behaved with a mass at 1 and is difficult to estimate. Thus, I constrain the firm's choice in τ_t to lie between 0.34 and 0.03 and constrain $\alpha \geq 0.5$.

B.3 Finding Optimal Parameters

I find optimal parameters which minimize Equation 12 through simulated annealing. Unlike other approaches like the Nelder-Meade method, simulated annealing is less prone to finding local minima because there is some probability the next iteration will use parameter values with a higher objective value. The probability that the optimization routine will accept parameters with a higher objective function declines over time according to an annealing schedule. As this "cooling" occurs, the algorithm converges to a minimum. For an overview of simulated annealing, see Judd (1998).

While I search for the global minimum over a sufficiently large parameter space, I place some bounds on parameter values. First, I require $\phi \in [0.5,\ 3.33]$. For small values of ϕ, the firm will choose a tax rate close to zero, so setting $\phi \geq 0.5$ ensures reasonable values of τ_t. The upper bound on τ_t ensures there exists a $\tau_t < 0.35$ such that pre-tax profit less the tax payment is greater than the equivalent metric had the firm paid the statutory rate:

$$\exists \tau_t < 0.35 :\ x\left(1+\phi\tau_t\right)\left(1-\tau_t\right) \geq x\left(1+0.35\phi\right)\left(1-0.35\right)$$

This expression can be rearranged to show that

$$\phi \leq \frac{0.35-\tau_t}{\left(1-0.35\right)0.35-\left(1-\tau_t\right)\tau_t}$$

The expression on the right hand side is strictly increasing in τ_t. Thus, the limit as $\tau_t \to 0.35$ finds that ϕ is bounded above by 3.33. This upper bound on ϕ ensures there exists some level of tax avoidance that is not detrimental to firm value and is consistent with the revealed preference of these firms engaging in tax avoidance as evidenced by their UTB reserves.

I also require $\alpha \in [0.5,\ 5]$. As discussed above, the lower bound of α prevents numerical concerns when calculating $r\left(\tau_t\right)$. In calibration testing, I found that values of $\alpha > 5$ produced large reserves for modest levels of tax aggressiveness. Similarly, I require x to be bounded between 1 and 12. I also require η_1 and η_2 to be non-negative which ensures the Equation 8 is positive. The upper bound for η_1 is 3 because for typical values of $r(\tau_t) + R_t$, $\eta_1 \geq 3$ implies inspection rates close to 100%. Similarly, I constrain $\eta_2 < 100$ because this will imply inspection rates close to 100% for reasonable levels of variance. Finally, I constrain the lapse rate, θ, and the audit probability, p, to lie between 0 and 1.

B.4 Computing Standard Errors

To compute standard errors, I first compute the asymptotic variance for the vector of parameters, Θ, with an arbitrary weight matrix (Cameron and Trivedi, 2005):

$$V(\Theta) = \left(G'WG\right)^{-1} G'W\Omega WG \left(G'WG\right)^{-1}$$

In this expression, Ω is the covariance matrix for the moment conditions approximated with the sample analog (i.e., $\Omega = \frac{1}{N}\sum_{i=1}^{N} g(w_i,\Theta)\, g(w_i,\Theta)'$). The term G is the sample analog for expectation of the gradient, i.e., $G = \frac{1}{N}\sum_{i=1}^{N} \bigtriangledown g(w_i,\Theta)$. There is no closed-form expression for $\bigtriangledown g(\cdot)$ so I compute a numerical gradient with a step size of 1×10^{-5}. Because I set $W = I$, the expression for the asymptotic variance can be simplified to:

$$V(\Theta) = \left(G'G\right)^{-1} G'\Omega G \left(G'G\right)^{-1}$$

Because I use subsamples of the data to compute certain moments, I compute the Ω by blocks. For example, for the moments that use all observations (i.e., the first through fifth moments), the block matrix $\Omega_{1:5,1:5}$ (i.e., the first 5 rows and columns of Ω) is computed as:

$$\Omega_{1:5,1:5} = \frac{1}{N}\sum_{i=1}^{N} g_{1:5}(w_i,\Theta)\, g_{1:5}(w_i,\Theta)'$$

For the remaining 3 moments that use subsets of data, I construct the elements of Ω, including the covariance terms, using only those observations within the subset. For example, to calculate the covariance terms related to the sixth moment, the lapse rate for no-audit firms, I only use the firms in the no-audit subsample. Specifically, I first calculate the 6×6 matrix ω for the no-audit subsample:

$$\omega = \frac{1}{N^{NA}} \sum_{i=1}^{N^{NA}} g^{NA}(w_i, \Theta) \, g^{NA}(w_i, \Theta)'$$

In this expression, the superscript NA denotes the no-audit sample. After the matrix ω is calculated, I set the sixth row and column of Ω (i.e., $\Omega_{6,6}$) as the sixth row and column of ω. For covariance terms that relate to moments captured by different subsets (e.g., the covariance of the sixth and seventh moment which use the subsets of no-audit and audit, respectively), I set to 0.

Once I have computed the variance of Θ, the standard error can be computed:

$$S.E.(\Theta) = \frac{1}{\sqrt{N}} diag\left(\sqrt{V(\Theta)}\right)$$

In this expression, $diag(\cdot)$ represents the diagonal of the matrix inside the parentheses.

FIGURE 1: Timeline of Model

This figure depicts the model's timeline for a set of tax saving projects. At the start of each period, the firm is endowed with a total UTB reserve, R_t, and the prior period's current UTB reserve, $r(\tau_{t-1})$. Based on these amounts, the firm chooses a set of tax-saving projects which determines the effective tax rate, τ_t. After choosing the projects, the firm incurs non-tax costs so that pre-tax profit is realized, sets a UTB reserve associated with the current period, and net income is realized. The firm also sends the tax return to the tax authority and period t ends. At the start of period $t+1$, the tax authority randomly decides to audit the firm. If the firm is audited, a fraction of positions are inspected which is based on the disclosed UTB reserve and variance of strategies over time. If the firm is audited, it repays the expected deficiency and the reserve associated with the inspected positions lapse. A fraction θ of uninspected positions lapse regardless of whether the firm was audited. After this occurs, states are updated.

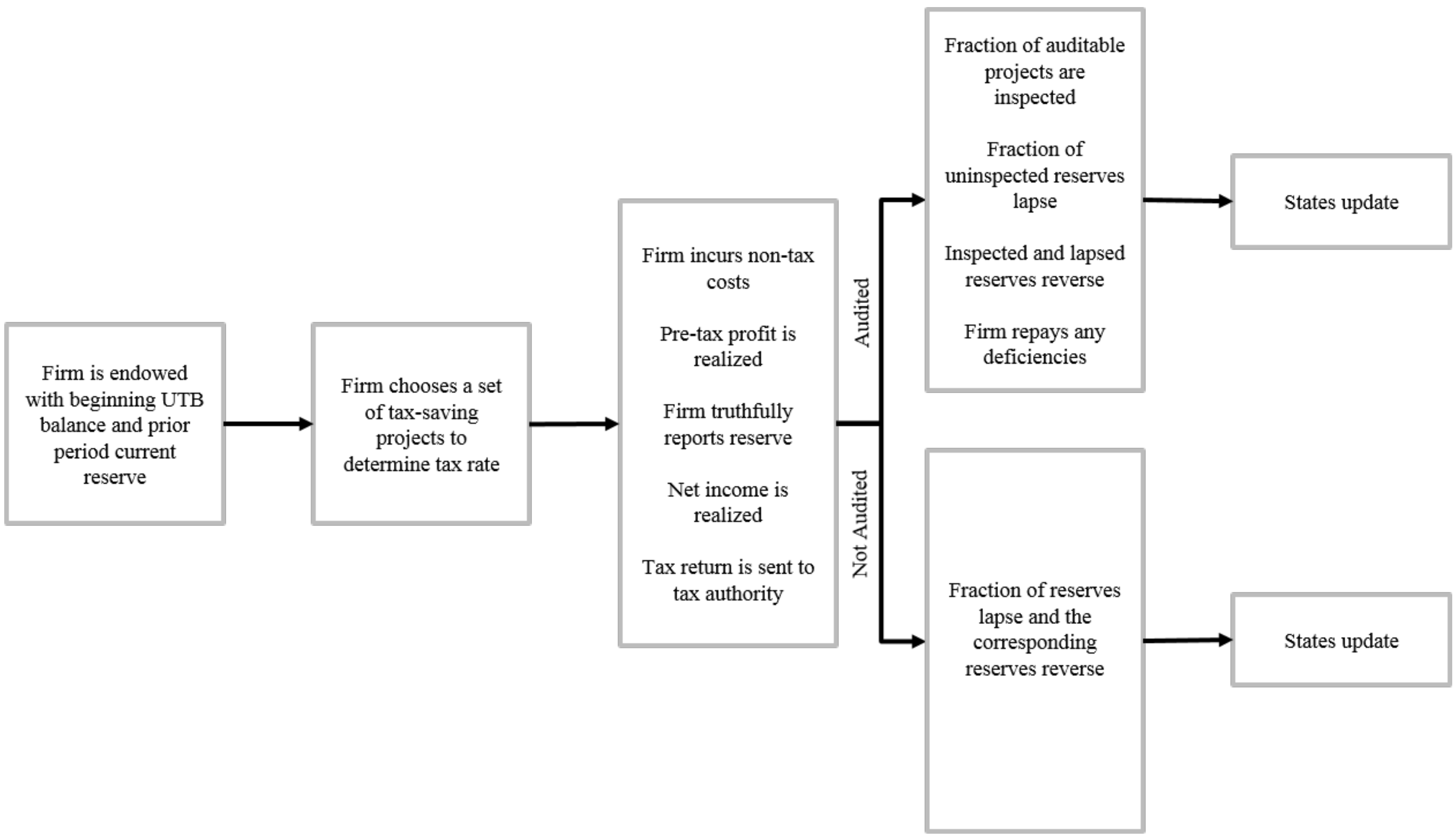


FIGURE 2: Examples of tax-saving projects

This figure presents three hypothetical projects that each save $1 in taxes. All three projects have a survival probability based on a beta distribution with unique shape parameters *a* and *b*. The accompanying table includes the shape parameters for each of these parameters (Columns 1 and 2). Column 3 (4) reports the mean (median) amount the firm will retain if it is audited. Column 5 reports the associated UTB reserve.

	a	b	Mean - Expected Benefit	Median - Retained Benefit	UTB
	(1)	(2)	(3)	(4)	(5)
A	1.111	0.123	0.9	0.996	0.004
B	2	2	0.5	0.5	0.5
C	3	0.222	0.3	0.287	0.713

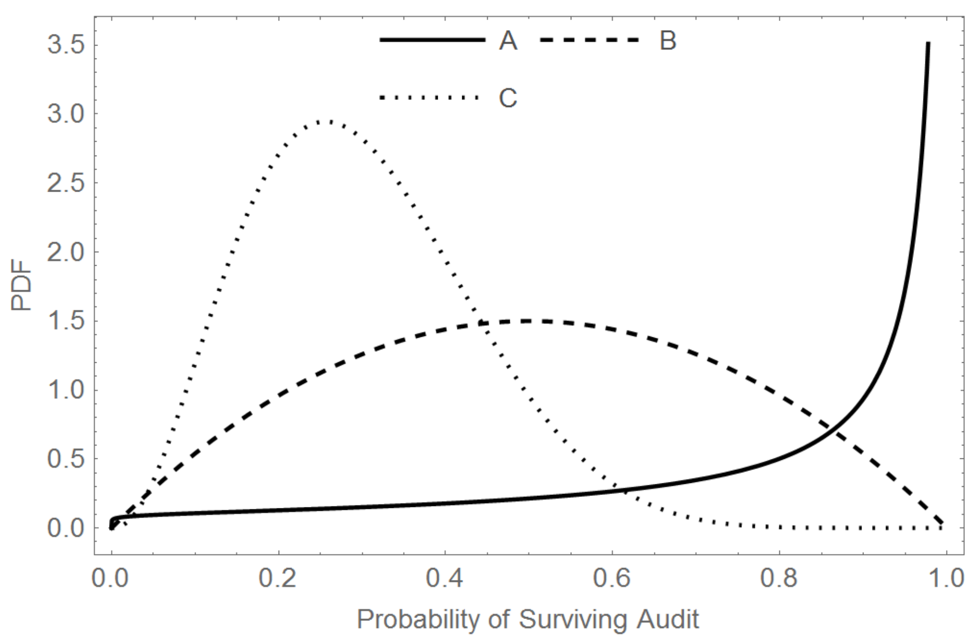
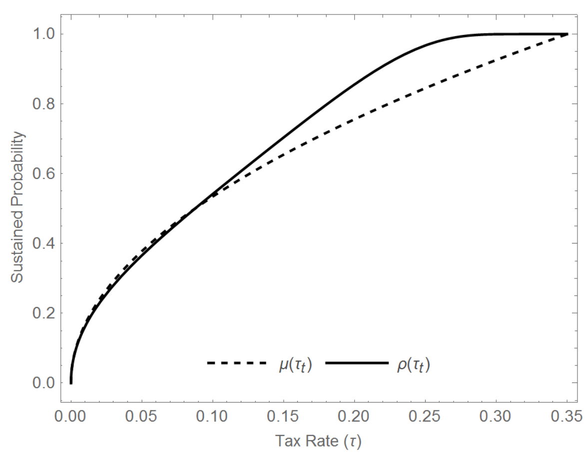


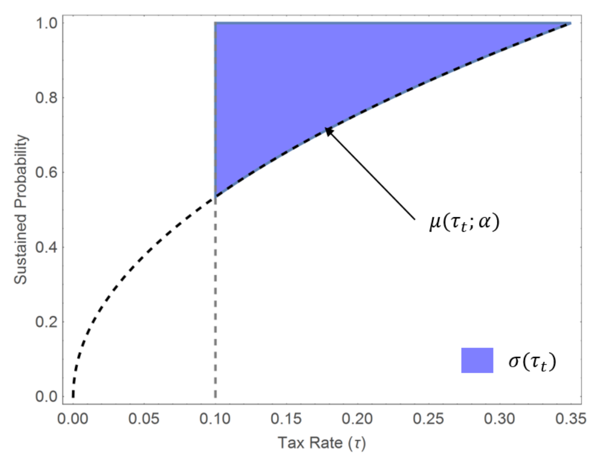
FIGURE 3: Relation between tax payment, tax risk, and UTB reserve

This figure graphically represents the relation between the expected repayment and the reserve for the tax-saving projects available to the firm. These plots assume a technology parameter of $\alpha = 0.5$ and scale parameter of $x = 1$. Panel A plots the mean and median amount the firm expects to keep for the marginal project at tax rates $\tau_t \in [0, 0.35]$. The dashed line represents $\mu(\tau_t; \alpha)$, which is the mean retained benefit. The solid line is the median retained benefit (i.e., $\rho(\tau_t; \alpha)$). Panel B reports the expected repayment (i.e., $\sigma(\tau_t)$) assuming the firm sets a tax rate of $\tau_t = 10\%$ which is represented as the shaded region. Panel C reports the expected repayment from Panel B but also plots the reported reserve based on the median amount (i.e., $r(\tau_t)$) which is the dark shaded region.

(a) Mean and median amounts for marginal projects



(b) Expected repayment



(c) Expected repayment and reserve

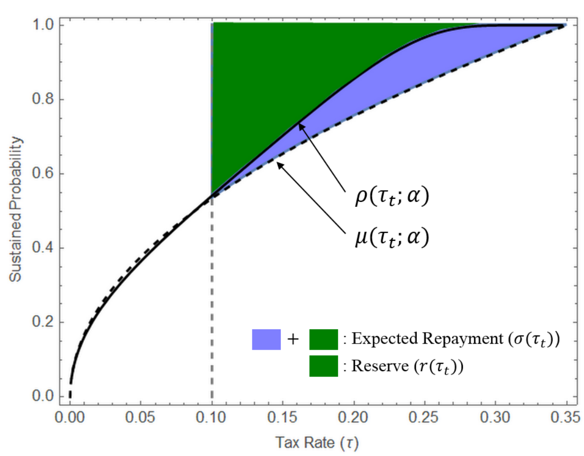


FIGURE 4: Cross-sectional Dispersion of Long-run ETRs

This figure is a histogram of the 3-year cash ETR for the observations which satisfy the sample selection specified in Table 1. Three-year average cash ETR is sum of the cash taxes paid for the previous three years divided by the sum of pre-tax income less special items for the previous three years.

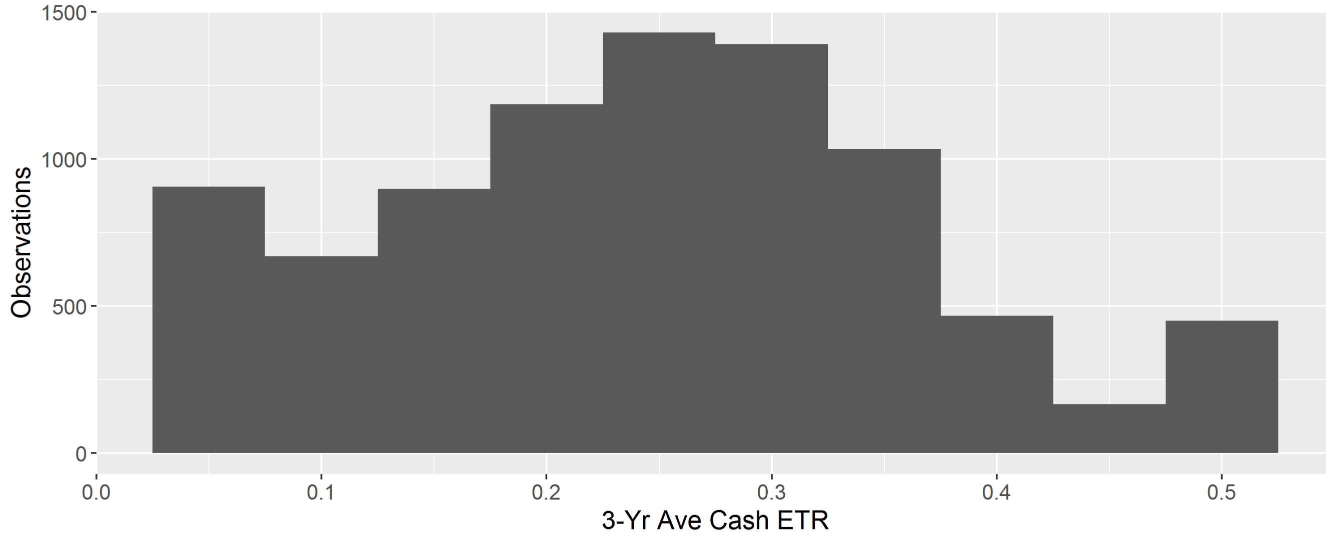


TABLE 1: Sample Selection

This table presents details on my sample selection. Because all data used in the estimation is a percent of lagged total assets, I require non-missing lagged total assets. I also require positive pre-tax income less special items to measure non-tax costs. To ensure each observation is well-defined in the state space, I require non-missing ending UTB reserves and prior period current reserve balances. In order to impute the firm's effective tax rate, observations must have a non-missing UTB reserve associated with year t. Finally, I require observations to be present in Compustat in $t+1$ as I use that period to measure audit, inspection, and lapse rates.

Sample Selection	
Compustat Observations from 2007 to 2016	91,461
Missing lagged total assets	(24,879)
Negative or missing pre-tax income less special items	(24,138)
Missing ending UTB reserve	(25,101)
Missing prior period current UTB Reserve	(5,802)
Missing current period UTB Reserve	(998)
Firm not in Compustat in year $t+1$	(1,505)
Final Sample	**9,038**

Table 2: Summary Statistics

This table presents summary statistics of my sample. Column 1 reports the number of non-missing observations for each variable. Column 2 through 4 report summary statistics in levels. Column 5 and 6 report summary statistics based on Compustat percentiles, measured for each fiscal year. Panel A reports firm summary measures. *Assets* is total assets. *Market Cap* is the market capitalization according to Compustat, measured at the fiscal year end. *Book-to-Market* is the book value of common equity divided by *Market Cap*. *ROA* is the pre-tax income less special items scaled by lagged assets. *GAAP ETR* is the income tax expense scaled by pre-tax income less special items. Panel B reports amounts used in the estimation. All continuous variables in this panel are reported as a percent of lagged total assets. *Current Period Reserve* is the sum of increases and decreases related to current period UTB positions. *Pre-tax Profit* is pre-tax income, less special items. R_t is ending UTB reserve balance less current period reserve. Settle and lapse data are measured at $t+1$. *Audit Indicator* is an indicator for whether the firm reported a non-zero settle amount. *Lapse Amount* is the amount of UTB reserve for which the statute of limitations has expired. *Lapse Ratio* is the ratio of lapse amount and ending UTB reserve (i.e., R + current period reserve). *Settle Amount* is the amount of UTB reserve which has been settled with the taxing authority. *Settle Ratio* is the ratio of settle amount to ending UTB reserve. All unbounded variables in this table are winsorized at 5% and 95%.

		Levels			Compustat Percentile	
	N	Mean	Median	SD	Mean	Median
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Firm Variables						
Assets	9,038	8,386	2,257	14,308	69.4	72.0
Market Cap	8,591	7,827	2,383	12,678	77.5	82.0
Book-to-market	8,588	0.64	0.63	0.25	43.4	41.0
ROA	9,038	0.11	0.09	0.08	74.0	76.0
GAAP ETR	7,786	0.28	0.30	0.11	51.8	52.0
Panel B: Data used in Estimation						
Current period reserve	9,038	0.18	0.09	0.22		
Pre-tax Profit	9,038	10.71	8.99	7.56		
R	9,038	1.08	0.67	1.10		
Audit Indicator	9,038	0.50	1.00	0.50		
Lapse Amount	9,038	0.06	0.02	0.09		
Lapse Ratio	9,038	0.08	0.02	0.13		
Settle Amount	9,038	0.05	0.00	0.10		
Settle Ratio	9,038	0.06	0.00	0.10		

TABLE 3: Parameter Estimates and Implications

This table presents the parameter estimates and implications from minimizing Equation 12 using the method described in Section 5. The sample comprises of 9,038 firm-year observations that satisfy the requirements specified in Section 4. Panel A, reports parameter estimates and standard errors are in parentheses. Panel B reports the summary statistics derived from the parameter estimates. Column 1 (2) for Panel B reports results based on mean (median) amounts. *Unobserved Effective Tax Rate* is the imputed value of τ_t from inverting $r(\tau_t)$ from Equation 5. *Non-tax Costs* is the percent change in pre-tax profit relative to paying the statutory tax rate of 35% (i.e., Equation 13). *Increase in NI from Tax Avoidance* is the percent change in pre-tax profit less the tax payment for the mean and median value of τ_t relative to the firm paying the statutory rate. *Reserve to Expected Repayment* is the ratio of $r(\tau_t)$ (Equation 5) to the expected repayment, $\sigma(\tau_t)$ (Equation 4). *Reserve to Expected Repayment with audit rate* is the ratio of the reserve (Equation 5) to the expected repayment after including audit and inspection probabilities. *Inspection rate* is the inspection rate for mean and median values of R_t, $r(\tau_t)$, and $r(\tau_{t-1})$. *Increased Scrutiny from Variance* is the percent increase in the inspection rate from the variance in reserves and is calculated according to Equation 14.

(a) Parameter Results

α	x	ϕ	θ	p	η_1	η_2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.86	7.42	2.26	0.03	0.32	0.03	13.92
(0.11)	(0.07)	(0.06)	(0.04)	(0.00)	(0.02)	(0.01)

(b) Implications from Estimation

	Mean	Median
	(1)	(2)
Unobserved Effective Tax Rate	0.234	0.282
Non-tax Costs	0.147	0.086
Increase in NI from Tax Avoidance	0.006	0.010
Reserve to Expected Repayment	0.633	0.548
Reserve to Expected Repayment with audit rate	3.829	19.129
Inspection Rate	0.516	0.089
Increased Scrutiny from Variance	0.956	0.737

TABLE 4: Model Fit

This table reports the analysis of model fit. The top five rows compare five empirical averages to five simulated averages using estimated parameters. Simulated averages are calculated by Monte Carlo where I draw 10,000 sets of 9,038 firm-year observations. The reported simulated averages are the mean of these 10,000 sets. Column 1 (2) is the empirical (simulated) averages while Column 3 is the fraction of simulated moments that are as far as the mean simulated average as the empirical average. Row 1 (2) is the average current UTB reserve (pre-tax income). Row 3 is the average audit rate which is defined as the fraction with a non-zero settlement amount. Row 4 (5) report the unconditional lapse (inspection) rate. The bottom row reports the value of the J-test of overidentifying restrictions and corresponding p-value.

	Emprical	Simulated	p-Value
	(1)	(2)	(3)
Current UTB Reserve	0.18	0.47	0.00
Pre-Tax Income	10.71	11.44	0.00
Audit Rate	0.50	0.32	0.00
Lapse Rate	0.08	0.03	0.00
Inspection Rate	0.06	0.17	0.00

	χ^2	p-value
J-Test	1.46	0.23

TABLE 5: Comparing Low to High ETR Firms

This table reports averages for various proxies of tax avoidance and risk for firms with 3-year cash ETRs above and below the sample median. Column 1 (2) reports the average for low (high) ETR observations. Column 3 reports the difference. *3-Year Cash ETR* is the 3-year average cash ETR, calculated as in Dyreng et al. (2008). *Multinational Indicator* is an indicator if the firm reported non-zero foreign sales. *R&D Intensity* is the R&D expense, scaled by sales. *Forward Cash ETR Volatility* is the 5-year standard deviation of cash ETRs as calculated in Guenther et al. (2016). *Ending UTB Balance* is the ending UTB balance, scaled by lagged assets. *Predicted UTB* is the expected UTB amount after controlling for avoidance ability as specified in Rego and Wilson (2012). In Column 3, ***, **, * represents two-sided significance at the 1%, 5%, and 10% level.

(a) Comparison of Risk Measures for Subsamples

	Low ETR	High ETR	Difference
	(1)	(2)	(3)
3-Year Cash ETR	0.150	0.321	-0.171***
Multinational Indicator	0.780	0.731	0.049***
R&D Intensity	0.072	0.036	0.036***
Forward Cash ETR Volatility	0.160	0.198	-0.038***
Ending UTB Balance	0.015	0.011	0.004***
Predicted UTB	0.016	0.014	0.002***

TABLE 6: Parameter Estimates and Implications for Low and High ETR Firms

This table presents parameters estimates and implications for firms with 3-year cash ETRs above and below the sample median. Panel A reports parameter estimates (rows 1 and 3) and standard errors (rows 2 and 4) for each subsample. Rows 1 and 2 (3 and 4) pertains to Low ETR firms (High ETR firms). Panel B reports implications from the estimation for each subsample. Columns 1 (2) reports the mean (median) amounts for Low ETR firms. Columns 3 (4) reports the mean (median) for High ETR firms. Row 1 is the unobserved tax rate imputed from parameter estimates and Equation 5. Row 2 is the non-tax costs defined according to Equation 13. Row 3 reports the non-tax costs when the tax rate is set to the mean (Columns 1 and 3) or median (Columns 2 and 4) tax rate for High ETR firms.

(a) Results

	α	x	ϕ	θ	p	η_1	η_2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low ETR Firms	0.86	6.46	2.35	0.09	0.53	1.77	28.58
	(0.04)	(0.03)	(0.04)	(0.02)	(0.01)	(0.07)	(0.06)
High ETR Firms	3.37	8.51	1.64	0.08	0.39	0.70	5.66
	(0.04)	(0.07)	(0.06)	(0.01)	(0.00)	(0.08)	(0.34)

(b) Implications from Estimation

	Low ETR		High ETR	
	Mean	Median	Mean	Median
	(1)	(2)	(3)	(4)
Unobserved Effective Tax Rate	0.228	0.229	0.230	0.278
Non-tax Costs	0.158	0.156	0.125	0.075
Non-tax Costs at High ETR	0.158	0.109	0.125	0.075

TABLE 7: Model Fit for Low and High ETR Subsamples

This table reports model fit by comparing five empirical averages to five simulated averages. Panel A (B) reports results for the low (high) ETR subsample. Simulated averages are calculated by Monte Carlo where I draw 10,000 sets of 9,038 firm-year observations. The reported simulated averages are the mean of these 10,000 sets. Within each panel, Column 1 (2) is the empirical (simulated) averages while Column 3 is the fraction of simulated averages that are as far as the mean simulated average as the empirical average. Row 1 (2) is the average current UTB reserve (pre-tax income). Row 3 is the average audit rate which is defined as the fraction of observations with a non-zero settlement amount. Row 4 (5) report the unconditional lapse (inspection) rate. The bottom row of each panel reports the value of the J-test of overidentifying restrictions and corresponding p-value.

(a) Low ETR Model Fit

	Emprical	Simulated	p-Value
	(1)	(2)	(3)
Current UTB Reserve	0.20	0.07	0.00
Pre-Tax Income	9.80	9.84	0.00
Audit Rate	0.45	0.53	0.00
Lapse Rate	0.07	0.06	0.00
Inspection Rate	0.05	0.36	0.00

	χ^2	p-value
J-Test	1.58	0.21

(b) High ETR Model Fit

	Emprical	Simulated	p-Value
	(1)	(2)	(3)
Current UTB Reserve	0.15	0.44	0.00
Pre-Tax Income	11.62	11.83	0.00
Audit Rate	0.56	0.39	0.00
Lapse Rate	0.10	0.05	0.00
Inspection Rate	0.06	0.24	0.00

	χ^2	p-value
J-Test	0.96	0.33

TABLE 8: Counterfactual Analysis

This table presents counterfactual analysis for four counterfactuals. The first row reports the counterfactual where firms are required to set a reserve equal to the expected repayment amount but continue to assume a 100% audit and inspection rate (i.e., $r(\tau_t) = \sigma(\tau_t)$). The second row reports the effect if firms are not required to set a reserve for risky projects. Under this counterfactual, I assume reserves and lapses do not affect net income. Row 3 assumes the tax authority is not strategic. Under this scenario, the inspection rate is fixed so that the inspection rate function, $\eta(\cdot)$, equals a constant. I set the inspection rate to be the average (median) rate observed in the data when reporting averages (medians). The fourth row assumes the only cost in tax avoidance is the non-tax cost. Under this counterfactual, firms are never audited and are not required to set a reserve. Column 1 and 2 report the change for the mean and median effective tax rate, τ_t, relative to the main specification in Table 3. Columns 3 and 4 report the mean and median percent change in pre-tax profit relative to the main specification. Columns 5 and 6 report the mean and median percent change in firm value. All values are reported in percentage points.

	τ_t		Pre-tax Profit		Price	
	Mean	Median	Mean	Median	Mean	Median
	(1)	(2)	(3)	(4)	(5)	(6)
Reserve is expected repayment	1.21	2.13	1.78	2.94	0.69	0.79
No reporting requirements	-0.79	-1.80	-1.18	-2.49	1.02	0.58
Fixed inspection rates	0.61	1.24	0.90	1.71	0.94	0.95
Only cost is non-tax cost	-1.84	-2.33	-1.49	-1.85	1.88	1.80