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Strategic management of tax disclosure: asymmetric timeliness of tax footnote modifications

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Abstract

Previous studies have shown that qualitative disclosure contains information that facilitates the assessment of future firm outcomes. We first connect to this literature on early signals by showing that qualitative disclosure also specifically contains information about future ETR as one relevant firm outcome. Using the tax footnote from 10-K filings of all publicly traded U.S. firms over the period from 2000 to 2021, we show that year-over-year tax footnote modifications are an early signal of impending changes in ETR. When specifically considering the timeliness of this signal, we find that tax footnote modifications are associated with future changes in ETR at least three years in advance. Second, we investigate, as our main focus of analysis, asymmetry in timeliness. Here, we find that tax footnote modifications preceding increases in ETR occur relatively earlier (and are greater) than do (are) tax footnote modifications preceding decreases in ETR. We additionally use word lists to directly identify relevant underlying processes for changes in ETR and to investigate asymmetric timeliness conditional on the underlying process. Overall, our results indicate that firms strategically manage their tax disclosure in accordance with the “accounting conservatism” hypothesis proposed by Basu (1997).

Keywords Financial disclosure · Tax footnote · Effective tax rate · Natural language processing · Disclosure similarity

JEL Classification H25 · H29 · H32 · M41

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1 Introduction

It is well established that qualitative financial disclosure enables better assessment of future firm outcomes. Prior studies in this realm have shown that qualitative disclosure contains information about future earnings (Li 2010; Cohen et al. 2020; Chen et al. 2022), future sales (Bryan 1997; Sun 2010), future operating cash flows (Bryan 1997), future profitability (Sun 2010; Cohen et al. 2020), future firm-level bankruptcies (Cohen et al. 2020), and the number of analysts following a firm (Lehavy et al. 2011). It is also well established that firms manage the quality of their financial disclosure both to highlight favorable changes in firm outcomes (Li 2010; Bozanic and Thevenot 2015) and to conceal unfavorable changes in firm outcomes (Li 2008; Dyer et al. 2017; Cazier and Pfeiffer 2017).

We relate to the literature that investigates whether tax disclosure contains early signals about future ETR as one relevant firm outcome. Prior studies in this realm have shown that both disclosure of tax risk factors (Campbell et al. 2019) and more elaborate discussion of tax strategies (Bogacheck et al. 2023) enable better assessment of future ETRs. Confirming the relevance of such findings, further research has demonstrated that higher quality tax disclosure also improves analysts' forecasts of ETR (Hutchens 2017; Burd 2022; Chychyla et al. 2022). Another body of literature has shown deliberate tax disclosure management. To this end, firms primarily highlight favorable changes in ETR while concealing unfavorable changes in ETR (Hope et al. 2013; Akamah et al. 2018; Inger et al. 2018; Flagmeier et al. 2021; Chychyla et al. 2022). Moreover, firms choose to voluntarily disclose nonmandatory tax information to preempt negative stakeholder reactions which may arise from relying solely on insufficient or unclear mandatory tax information (Balakrishnan et al. 2019; Bedard et al. 2010; Chen et al. 2023).

We examine tax footnotes by means of natural language processing and assess firm-level tax disclosure similarity year-over-year. In our analysis, we focus specifically on the tax footnote as being arguably the most relevant source of tax information and allow for any type of modification, i.e., capturing changes in content and changes in wording and complexity. As our measure of tax footnote modifications, we use the difference score developed by Brown and Tucker (2011). We connect to previous literature (Campbell et al. 2019; Bogacheck et al. 2023) by first investigating timeliness and confirming that firm-level tax footnote modifications are indeed an early signal of impending changes in ETR. Second, as our main analysis, we investigate asymmetry in timeliness conditional on the direction of the impending change in ETR.¹ Hence, we add to the long standing debate between the "accounting conservatism" hypothesis (e.g., Basu 1997) and the "good news early, bad news late" hypothesis (e.g., Begley and Fischer 1998).

¹ Note that we do not specifically aim to predict the economic magnitude of future changes but are merely interested in the asymmetry of timeliness of the early signal.

In general, an increasing ETR is considered bad news due to reduced resources being available to the firm. Finally, we investigate whether these effects are conditional on common types of underlying processes that may ultimately impact ETR. Naturally, tax footnote modifications do not by themselves cause changes in ETR. However, both are likely initiated by the same underlying process, such as a tax audit, that tends to run for multiple periods and impacts with different timing the tax footnote and ETR. To identify conditional effects, we construct word lists for four distinct underlying processes, namely tax audits, capital structure (e.g., changes in ownership), legislation&litigation (e.g., pending tax-related lawsuits), and tax avoidance (e.g., incorporation of foreign subsidiaries in tax havens).

Using 10-K filings of all publicly traded U.S. firms over the period from 2000 to 2021, our timeliness analysis shows that tax footnote modifications are associated with future changes in ETRs of at least three years in advance. Regarding specifically the asymmetry of timeliness, we find that tax footnote modifications preceding increases in ETR occur relatively earlier and have greater economic magnitude than do tax footnote modifications preceding decreases in ETR. Furthermore, we observe tax footnote modifications in the year of the change of the ETR itself, indicating that the tax footnote is also utilized to explain changes in ETR that have already materialized. We observe these effects both for increases and decreases in ETR; but the economic magnitude of this effect is again greater for increases in ETR.

We also find that asymmetric timeliness is conditional on the underlying process that is associated with tax footnote modifications.² Specifically, tax footnote modifications that speak to tax avoidance occur three years prior to the corresponding increase in ETR, whereas they occur only one year prior to decreases in ETR. Moreover, tax footnote modifications that speak to tax audits and capital structure changes occur two years prior to increases in ETR, and we find no effect prior to decreases in ETR. Finally, tax footnote modifications that speak to legislation&litigation occur one year prior to both increases and decreases in ETR.

Considered jointly, we contribute to the literature first by showing that firms strategically manage their tax disclosure, resulting in asymmetric timeliness of tax footnote modifications as early signals of impending changes in ETR. Second, we provide support specifically for the "accounting conservatism" hypothesis as proposed by Basu (1997). Consequently, outside stakeholders must consider asymmetric timeliness when assessing future ETR from tax disclosure information.

The remainder of the paper is structured as follows. Section 2 summarizes the related literature, and building on this, Sect. 3 presents the development of our hypotheses. Section 4 discusses the corresponding empirical strategy, whereas Sects. 5 and 6 present the data and the results. Finally, we provide an array of robustness tests in Sect. 7 and Sect. 8 concludes the paper.

² We note that there is no underlying process that can unambiguously be associated with either increases or decreases in ETR. We more elaborately discuss potential directional effects of the underlying processes in Sect. 3.3.

2 Background and related literature

2.1 Association of tax disclosure and future ETR

Any changes in ETR are ultimately initiated by a tax-related underlying process. Tax disclosures aim to reduce information asymmetry regarding these ongoing underlying processes between a firm's inside and outside stakeholders. Hence, higher quality tax disclosure enables better prediction of ETR. Prior studies have shown that tax disclosure contains early signals for future ETRs. For instance, Campbell et al. (2019) show an association between the level of disclosure of tax risk factors and future lower Cash ETRs. In addition, they show that tax risk factor disclosures are positively associated with stock returns, indicating that investors incorporate the association between tax-related risks and future ETR into stock prices at the time of disclosure. More recently, Bogacheck et al. 2023 show that discussion of tax planning in the 10-K is associated with future Cash ETRs. Specifically, they use topic modeling techniques to identify topics discussed throughout the 10-K. Building on Wilde and Wilson (2018), Bogacheck et al. (2023) then map the identified topics to the three categories of agency, implementation and outcome factors and show that more elaborate discussion of these three categories in the 10-K enables better prediction of future ETR.

Confirming the relevance of these findings, research has demonstrated that higher quality tax disclosure also improves analysts' forecasts of ETR. To this end, Hutchens (2017) finds that disclosing more quantitative information and fewer complex words in the tax footnote as well as a discussion of year-to-year changes in ETR reduces analysts' ETR forecast errors. Similarly, Burd (2022) shows that the volume of tax-related numbers in 10-Ks reduces ETR forecast errors, despite the fact that a higher volume of tax-related numbers is also associated with greater tax complexity. Furthermore, Burd et al. (2022) match tax-related numbers and the corresponding discussion in the 10-K to measure the number of tax-related numbers supported by qualitative information. In doing so, they show that ETR forecast errors decrease when tax-related numbers in the 10-K are contextualized by qualitative information.

Some related papers do not explicitly seek but still find indications that disclosures can provide relevant information about future ETR. For instance, Law and Mills (2015) use a new measure of firm-level financial constraints on the basis of the use of negative words in the 10-K and then observe that firms that display high financial constraints in that measure are also more tax aggressive, i.e., have lower current and future GAAP ETR and Cash ETR. Moreover, in a methodological paper, Allen et al. (2021) aim mainly to address technical issues related to the subject of "bag of word" dictionaries. Nonetheless, their empirical application also shows that tax disclosures provide information on the direction of future changes in ETR. Furthermore, Wang (2022) develops a word list measuring a firm's ability to avoid taxes and shows a positive relationship between the measured ability to avoid taxes and several tax avoidance measures. As one tax avoidance measure, he uses average Cash ETR over the periods following disclosure

and finds that firms using more tax avoidance words in their 10-K have lower average Cash ETR in the periods following the disclosure.

Overall, research shows that assessment of ETR is conditional on tax disclosure, i.e., on the quality of information about the underlying processes that initiate the change in ETR. Furthermore, the available literature indicates that specific tax-related underlying processes can indeed be identified from textual analysis of 10-Ks and the tax footnote contained therein. We connect to this strand of literature by first confirming that tax footnotes contain early signals for future changes in ETRs.

2.2 Timeliness

Prior empirical literature has also investigated the timeliness of early signals from disclosure. This research has focused mostly on non-tax firm outcomes. For instance, Bryan (1997) finds that information contained in the MD&A section of the 10-K is associated with future sales, future earnings per share, future operating cash flows, and future capital up to three years in advance. Correspondingly, Sun (2010) shows that explanations of inventory changes in the MD&A section which include expectations of higher future sales are positively associated with a firm's profitability and sales growth in the subsequent three years. Moreover, Li (2010) focuses on the information content specifically of so called forward-looking statements in 10-Ks and shows a significant association between the tone of forward-looking statements and future earnings up to three years into the future. Related to tax, and hence also most related to our study, Campbell et al. (2019) and Bogacheck et al. (2023) show significant associations between qualitative tax disclosure and Cash ETRs up to three years into the future. We relate to this strand of literature by investigating the timeliness of signals in tax footnotes and their association with future ETR.

2.3 Asymmetric timeliness

Previous studies have also shown that information is often made available to the capital markets with asymmetric timeliness. Most of the empirical literature focuses on the timeliness with which good and bad news are disclosed (for a literature review, see Mora and Walker 2015). To this end, Basu (1997) introduces a measure for asymmetric timeliness, demonstrating that bad news is disclosed earlier than is good news (often referred to as "accounting conservatism"). Numerous subsequent studies confirm the "accounting conservatism" hypothesis (see, e.g., Beaver and Ryan 2005; for a more recent literature review, see Ruch and Taylor 2015 and Mora and Walker 2015). In contrast, previous studies also find evidence that firms disclose good news earlier and bad news later in their annual reports (often referred to as "good news early, bad news late" hypothesis) (see, e.g., Begley and Fischer 1998; Conover et al. 2008; Kothari et al. 2009).

Closely related, research has shown that asymmetric timeliness is also caused by conditional bunching of information. Specifically, empirical literature has developed the "big bath" hypothesis, wherein managers opt to disclose substantially bad news

in a singular instance (i.e., take a big bath) while good news is disclosed in small portions. The motivations for such an approach are multifaceted: first, big baths are more likely after CEO turnover, since the bad news (in most cases high losses) can be blamed on the former CEO (Moore 1973; Murphy and Zimmermann 1993; Elliott and Shaw 1988). Second, big baths are used as a method of earnings management as profits can be shifted to later periods and hence, earning targets are easier to meet in the future (Kirschenheiter and Melumad 2002; Hope and Wang 2018). Third, managers use big baths because of their signaling effect on investors since big baths are perceived as singular events, which are anticipated to be followed by positive information (Francis et al. 1996; Frantz 1999).

Prior empirical tax-related literature also specifically considers firms' motives for asymmetric timeliness in tax disclosures. Primarily, firms manage tax disclosure quality both to highlight favorable changes in ETR and to conceal unfavorable changes in ETR. For instance, Hope et al. (2013) show that firms reduce the quality of tax disclosure to conceal tax avoidance. In a related, more granular analysis, Akamah et al. (2018) find that geographic disclosures are less transparent for firms operating in tax havens. Moreover, firms voluntarily disclose nonmandatory information to avoid possible negative outside stakeholder reactions caused by merely relying on insufficient or unclear mandatory tax information (Balakrishnan et al. 2019; Bedard et al. 2010; Chen et al. 2023). Consistently, Chychyla et al. (2022) explore the setting that, in the tax footnote, firms can decide whether to explicitly report their ETR in the percentage format or use the currency format. They argue that the currency format provides less information because it decreases comparability, e.g., within industries. Confirming their priors, results show that firms with low ETRs and firms with foreign income, as well as firms facing high media coverage, prefer to use the currency format. Similarly, Flagmeier et al. (2021), relying on a game theoretic model, empirically test ETR visibility within tax disclosures. They observe higher ETR visibility for ETRs that are either smooth over time, close to the industry average or decreasing, i.e., when ETR information is favorable.

We contribute to this strand of literature by investigating whether firms strategically manage their tax disclosure, resulting in asymmetric timeliness of tax footnote modifications as early signals of impending changes in ETR. Hence, our research contributes to the debate between the "accounting conservatism" hypothesis (e.g., Basu 1997) and the "good news early, bad news late" hypothesis (e.g., Begley and Fischer 1998).

2.4 Natural language processing

In general, empirical accounting research on firm-level disclosure in more recent years has methodically relied heavily on natural language processing. Bochkay et al. (2023) extensively summarize the relevant literature by clustering it according to the major methodical approaches. Most studies within this realm focus on the analysis of readability (Morton et al. 2022; Inger et al. 2018; Nguyen 2021) or sentiment (Lin 2020; Law and Mills 2015). Our investigation relies on a third methodical approach categorized by Bochkay et al. (2023), which is disclosure similarity. Disclosure

similarity measures differences between disclosures, with most studies investigating year-over-year modifications of disclosure.

Using this methodical approach, Brown and Tucker (2011) investigate modifications in the management discussion analysis of the 10-K and find greater stock price reactions associated with greater modifications of the textual data. Furthermore, Peterson et al. (2015) use modifications of accounting policy notes to measure accounting consistency and examine its relationship with earnings quality. Moreover, and closely related to our study, Cohen et al. (2020) use modifications of 10-Ks and show that these modifications have strong implications for future earnings, profitability, and even future firm-level bankruptcies. Specifically, they argue that the textual modifications of the 10-K themselves contain relevant information about underlying processes that will take effect in the future but that investors are inattentive to this subtle information. Also related to our study, Bozanic et al. (2017) use tax footnote modifications and changes in words and numbers to examine how firms change their tax footnote disclosure following a change in scrutiny by tax authorities. They argue that public and nonpublic disclosures jointly enable tax authorities to assess audit targets. Specifically, Bozanic et al. (2017) use 10-K download statistics to show that tax authorities strongly rely on this channel of public information in audit target assessment and that reliance on 10-Ks decreased after regulatory changes that increased nonpublic mandatory disclosure. Methodically similar to our study, Bozanic et al. (2017) use natural language processing to identify tax-related underlying processes to better assess the specific reasons for tax footnote modifications.

3 Hypothesis development

3.1 T1–Timeliness

We start our investigation by connecting to previous literature, particularly to findings of Bogacheck et al. (2023); Campbell et al. (2019), and Allen et al. (2021), who provide first indication that qualitative disclosure provides early signals associated with future ETRs. We thereby also connect to the broader accounting literature that finds that qualitative disclosure provides early signals that enable better prediction of future firm outcomes (e.g., Bryan 1997; Li 2010; Cohen et al. 2020; Chen et al. 2022). Doing so provides a reference point for our own analysis. Hence, we formulate test *T1* in the alternative form as follows.

T1 : Changes in ETR are preceded by tax footnote modifications.

If *T1* is confirmed, then tax footnote modifications are an early signal of impending changes in ETR. We note that, obviously, tax footnote modifications cannot technically cause changes in ETR. However, changes in ETR are initiated by an underlying process that may run for some time and, along its path, also causes a tax footnote modification. Hence, some level of disclosure about the ongoing underlying processes in the tax footnote should occur prior to any change in ETR.

Naturally, tax footnote modifications that aim at providing early signals on an underlying process can precede changes in ETR by many periods. However, the exact (symmetric) timeliness of the early signal is not our main concern. Moreover, firms can also use tax footnote modifications to merely justify an ETR change that has already occurred, i.e., to discuss the relevant underlying process in the exact same period as the corresponding change in ETR.

3.2 H1–Asymmetric timeliness

In our first and main hypothesis, we aim to investigate the asymmetry in the timeliness of tax footnote modifications conditional on the direction of change in ETR. Theoretically speaking, the overall effects expected from *T1* could be symmetric in timelines, i.e. driven by an equitable discussion of the relevant underlying processes preceding both increases and decreases in ETR. To the contrary, firms could manage the timing of tax disclosure conditional on the expected effects on outside stakeholders. While previous research has shown that firms manage the content of their tax disclosure (Akamah et al. 2018; Inger et al. 2018; Chychyla et al. 2022), the management of tax disclosure via asymmetric timeliness has not yet been investigated.

With respect to the direction of asymmetry in timeliness, we relate to the debate on the "accounting conservatism" hypothesis (Basu 1997) and the "good news early, bad news late" hypothesis (Begley and Fischer 1998). It ultimately remains an empirically question whether good (bad) tax-related information, such as changes ETR, is disclosed earlier in the tax footnote. In our study, an increase in the ETR is interpreted as bad news for the firm,³ as it results in fewer financial resources being available to the firm. This interpretation of an increase in ETR as bad news corresponds to common perception (e.g., Lev and Thiagarajan 1993; Swenson 1999; Frischmann et al. 2008; Dyreng et al. 2008; Desai and Dharmapala 2009; Flagmeier et al. 2021) although the interpretation may be conditional on other factors such as tax risk (Kim et al. 2011; Bozanic et al. 2017; Jacob and Schütt 2020) and reputational risk (Hanlon and Slemrod 2009; Blaufus et al. 2019).

Correspondingly, we first separately investigate the timeliness of tax footnote modifications that precede increases and decreases in ETR. We state our hypotheses *H1a* and *H1b* in their alternative forms as follows:

H1a : Increases in ETR are preceded by tax footnote modifications.

H1b : Decreases in ETR are preceded by tax footnote modifications.

If both *H1a* and *H1b* are confirmed, then results from *T1* are not driven solely by underlying processes that precede increases or decreases in ETR, respectively. We then investigate whether asymmetric timeliness exists with the early signal of tax footnote modification. Ultimately we have no prior on the direction of

³ Naturally, a decrease in ETR is then interpreted as good news.

the asymmetry in timeliness, but merely consider the contradiction between the "accounting conservatism" hypothesis (Basu 1997) and the "good news early, bad news late" hypothesis (Begley and Fischer 1998). We note that we have no specific prior on the economic magnitude of future changes but are merely interested in the asymmetry of timeliness. Correspondingly, we state our hypotheses *H1c* in its alternative form as follows:

H1c : Tax footnote modifications occur with asymmetric timeliness conditional on the direction of change in ETR.

If *H1c* is confirmed in that we find relatively earlier tax footnote modifications in case of increases (decreases) in ETR, then we provide additional support for the "accounting conservatism" hypothesis ("good news early, bad news late" hypothesis). Regardless of its direction, any asymmetric timeliness indicates strategic management of tax disclosure by firms.

3.3 H2–Asymmetric timeliness conditional on underlying process

Next, we extend some efforts to identify underlying processes on the firm-level that are relevant for changes in ETR. Doing so enables us to investigate asymmetric timeliness conditional on four specific underlying processes. Nonetheless, we must note that no underlying process related to tax is unambiguously associated with increases or decreases in ETR.

First, we consider tax avoidance as an underlying process (e.g., incorporation of foreign subsidiaries in tax havens). Tax avoidance aims at reducing ETRs and has been widely studied in the literature (e.g., Kim et al. 2011; Hasan et al. 2014; Balakrishnan et al. 2019). While tax avoidance should generally lead to decreases in ETR, an elaborate discussion of tax avoidance in the tax footnote could also be indicative of future increases in ETR as tax avoidance strategies may be disallowed by fiscal authorities, and discussion of tax avoidance in the tax footnote may even attract the attention of fiscal authorities. Second, we consider tax audits, i.e., the official examinations of firms' tax records by tax authorities to ensure compliance with tax laws. Tax audits are arguably more likely to result in additional tax payments by the firm, and hence, are indicative of an increase in ETR. However, tax audits may also lead to tax refunds or the resolution of a tax dispute, enabling the firm to decrease its tax reserves. Third, we consider changes in capital structure, i.e., changes in the composition of firms' outside financing (e.g., changes in ownership). Capital structure and its association with the ETR have received considerable attention in the literature (e.g., Givoly et al. 1992; Graham 1996; Graham et al. 1998). Changes in capital structure are likely to result in increases in ETR if firms shift from debt to equity financing, thus reducing interest expense deductions and increasing taxable income. However, changes in capital structure can result in decreases in ETR if a shift occurs from equity to debt financing. Fourth, we consider

legislation&litigation, i.e. changes in applicable tax laws⁴ and tax-related litigation.⁵ Naturally, both changes in tax law and in tax-related litigation can be associated with both increases and decreases in ETR.

We then isolate and investigate tax footnote modifications that speak specifically to these four underlying processes and repeat our investigation of asymmetric timeliness. Corresponding to *H1*, we distinguish the outcome between increases and decreases in ETR. Accordingly, we state *H2a*, *H2b* and *H2c* in the alternative forms as follows:

H2a : Increases in ETR are preceded by tax footnote modifications that speak specifically to the four firm-level underlying processes.

H2b : Decreases in ETR are preceded by tax footnote modifications that speak specifically to the four firm-level underlying processes.

H2c : Tax footnote modifications that speak specifically to the four firm-level underlying processes occur with asymmetric timeliness conditional on the direction of change in ETR.

4 Empirical strategy

4.1 Measuring tax footnote modifications

We measure within-firm year-over-year tax footnote modifications following Brown and Tucker (2011), i.e., using the vector space model with TF-IDF⁶ and cosine similarity. Consider a setting with j different documents d_j within the total body D of all documents. W is the m -dimensional vector holding all unique words w_m contained in D . The vector space model then transforms each document d_j into another m -dimensional vector v_j , holding the TF-IDF scores for each unique word w_m from W in d_j (Salton et al. 1975). Term frequency (TF) and inverse document frequency (IDF) are then computed as follows:

$$TF = \left(\frac{\text{count of } w_m \text{ in } d_j}{\text{total count of all words in } d_j} \right) \quad (1)$$

⁴ Obviously, changes in tax law are not firm-specific, but their economic impact is conditional on firm characteristics.

⁵ Note that firms are required to disclose both changes in tax law and tax-related litigation in their tax footnote.

⁶ I.e. Term Frequency - Inverse Document Frequency.

$$IDF = \ln \left(\frac{\text{count of documents } d_j}{\text{count of documents } d_j \text{ containing } w_m} \right) \quad (2)$$

The TF-IDF score contained in each element $v_{j,m}$ in vector v_j is then computed as follows:

$$v_{j,m} = TF \times IDF \quad (3)$$

Obviously, if a unique word w_m does not occur in d_j , the vector element $v_{j,m}$ is set to zero. For all other w_m , the TF-IDF score in $v_{j,m}$ increases in the count of unique word w_m in d_j but decreases if w_m also occurs at least once in many documents d_j , i.e., if w_m is a common word. The TF-IDF score has straightforward interpretability and is widespread in the field (Salton and Buckley 1988). In our setting, each document d_j represents the tax footnote of one firm-year. Hence, D is composed of all tax footnotes for all firms i over all years t in our observation period.

The similarity between two tax footnotes is calculated using the concept of cosine similarity, which essentially measures, in an m -dimensional space, the angle between the two vectors v_j . A smaller angle is indicative of greater similarity between the two tax footnotes. By definition, the value of cosine similarity lies between zero and one. It is one if two vectors v_j are exactly identical. Finally, the difference score *DSCOR* between two tax footnotes is calculated as follows:

$$DSCOR = 1 - \text{Cosine Similarity} \quad (4)$$

Specifically, we compute $\Delta TFN_{i,t}$ as *DSCOR* for all pairs of tax footnotes of firm i in t and firm i in $t - 1$.⁷ Similarly, we compute $\Delta 10K_{i,t}$ as *DSCOR* for all pairs of the entire 10-K excluding the tax footnote of firm i in t and firm i in $t - 1$.

4.2 Measuring changes in ETR

In the empirical tax literature, tax burden is measured using both GAAP ETR and Cash ETR (Hanlon and Heitzman 2010). In our baseline specification, we use GAAP ETR as our measure of *ETR*, since the tax footnote strongly focuses on the GAAP ETR.⁸ Moreover, GAAP ETR is used primarily for tax comparisons between firms including firms in different tax jurisdictions (Graham et al. 2011), serves as a performance measure for tax departments (Robinson et al. 2010) and is the basis for corporate financing and investment decisions (Graham et al. 2017) as well as executive compensation contracts (Armstrong et al. 2012). We measure changes in ETR as the absolute value of the first difference in *ETR* between t and $t - 1$ within firm i , $|\Delta ETR_{i,t}|$.

⁷ Sect. A.2 shows examples of tax footnotes with low, average and high ΔTFN .

⁸ We note that other studies use Cash ETR for a variety of reasons (Campbell et al. 2019; Wang 2022; Bogachev et al. 2023) and therefore repeat our analysis using Cash ETR in Sect. 7.4.

4.3 T1–timeliness

To test *T1*, we conduct the following OLS regression⁹

$$|\Delta ETR_{i,t}| = \alpha_0 + \beta_k \Delta TFN_{i,t-k} + \gamma X_{i,t} + \theta_j + \varphi_t + \epsilon_{i,t} \quad (5)$$

Our baseline specification includes, as our main variables of interest, $\Delta TFN_{i,t-k}$ with k in $[0, 3]$. We consider only tax footnote modifications in the three years prior to the change in ETR in reference to the approaches used in prior literature (e.g., Campbell et al. 2019; Allen et al. 2021; Bogachev et al. 2023).¹⁰

We argue that β_0 is positive and significant if the tax footnote is used in t by firm i to merely justify a change in *ETR* that has already occurred. The hypothesis of timelines in *T1* is confirmed if one of the coefficients β_1 , β_2 or β_3 is positive and significant, indicating increasing $|\Delta ETR|$ in t with increasing modification of the tax footnote in years preceding t . We note that tax footnote modifications do not cause changes in ETR, and hence, we cannot interpret any regression results as causal but only as associative.

We include a full array of industry fixed effects θ_j and year fixed effects φ_t , as well as an intercept α_0 and the error term $\epsilon_{i,t}$. We also include common control variables in $X_{i,t}$. First, we include the length of the tax footnote ($LEN_{i,t}$), in its logged form ($LLEN_{i,t}$), because Brown and Tucker (2011) show that *DSCOR* decreases with increasing document length. Second, consistent with Inger et al. (2018), we use the log of total assets ($LSIZE_{i,t}$) as a measure of firm size. Third, we use the ratio of intangible assets to total assets ($INT_{i,t}$), and fourth, we employ the ratio of research and development expenses to total revenue ($RD_{i,t}$). Both allow us to control for the fact that firms with more intangible assets, *ceteris paribus*, have a higher propensity to shift profits (Gravelle 2009). Obviously, *INT* and *RD* are economically somewhat related, as higher research and development expenses are also associated with higher intangible assets. However, technically, *INT* is indicative of the existing intangible assets, while *RD* shows the firm's innovativeness, i.e., future intangible assets (De Simone et al. 2020). Fifth, we include the ratio of property, plant, and equipment to total assets ($PPE_{i,t}$) to control for structurally smaller ETRs with more capital-intensive firms (Stickney and McGee 1982). Moreover, we include *NOL* as a dichotomous variable that equals one if the firm experienced negative EBIT in t until $t - 3$ once to control for a firm's loss history (Drake et al. 2020 Christensen et al. 2022).¹¹ Finally, we include pretax return on assets ($ROA_{i,t}$) as an indicator of firm profitability. Table 1 reports definitions of all relevant variables.

4.4 H1–asymmetric timeliness

To test *H1a*, *H1b* and *H1c*, we extend Equation (5) as follows:

⁹ We repeat our analyses using a Tobit Model in Sect. 7.2.6.

¹⁰ We also investigate higher k of lagged $\Delta TFN_{i,t-k}$ in Sect. 7.2.1.

¹¹ To ensure that our results are not driven by loss firms, we exclude all firms that experience negative income before taxes once in our observation period in Sect. 7.3.2.

Table 1 Variable Description

Variable	Description	Calculation
$ \Delta ETR_{i,t} $	Absolute Change in (GAAP) ETR for firm i between t and $t - 1$.	$ \Delta ETR_{i,t} = ETR_{i,t} - ETR_{i,t-1} $
$POS_{i,t}$	Increase in ETR.	Dichotomous variable that equals one if $\Delta ETR_{i,t} > 0$.
$NEG_{i,t}$	Decrease in ETR.	Dichotomous variable that equals one if $\Delta ETR_{i,t} < 0$.
$\Delta TFN_{i,t}$	Within-firm year-over-year tax footnote modification.	$\Delta TFN_{i,t} = 1 - \text{Cosine Similarity}$. Cosine Similarity measures the angle between the two vectors of tax footnotes of firm i in t and firm i in $t - 1$ when using Vector Space Model with TF-IDF to transfer tax footnotes to vectors.
$\Delta TOPIC_{i,t}^{UP}$	Increase of text that speaks to specific underlying process UP .	First difference between the count of words associated with the underlying process UP in both t and $t - 1$. Set to zero for negative values of $\Delta TOPIC_{i,t}^{UP}$.
$LEN_{i,t}$	Length of tax footnote.	Word count of tax footnote.
$LLEN_{i,t}$	Log of length of tax footnote.	Log of word count of tax footnote.
$LEN^{10K}_{i,t}$	Length of 10-K excluding tax footnote.	Word count of 10-K excluding tax footnote.
$PPE_{i,t}$	Property, Plant and Equipment.	Ratio of Property, Plant and Equipment to Total Assets.
$INT_{i,t}$	Intangible Assets.	Ratio of Intangible Assets to Total Assets.
$SIZE_{i,t}$	Firm size.	Total Assets Reported in million.
$LSIZE_{i,t}$	Firm size.	Log of Total Assets Reported.
$ROA_{i,t}$	Return on Assets.	Pretax Return on Assets.
$RD_{i,t}$	Research and Development Expenses.	Ratio of Research and Development Expenses to Total Revenue.
$NOL_{i,t}$	Loss History of Firm	Dichotomous variable that equals one if firm experienced a negative EBIT (earnings before interest and taxes) in t till $t - 3$ once.
$IBT_{i,t}$	Income before Taxes.	Income before Taxes in million.

Table 1 reports definitions of all relevant variables

$$|\Delta ETR_{i,t}| = \alpha_0 + \beta_k \Delta TFN_{i,t-k} \times POS_{i,t} + \beta_{4+k} \Delta TFN_{i,t-k} \times NEG_{i,t} + \gamma X_{i,t} + \theta_j + \varphi_t + \epsilon_{i,t} \quad (6)$$

where we now include an interaction term with $\Delta TFN_{i,t-k}$ to separate the effects for increases (*POS*) and decreases (*NEG*) in ΔETR . Specifically, $POS_{i,t}$ ($NEG_{i,t}$) is set to one if $\Delta ETR_{i,t} > 0$ ($\Delta ETR_{i,t} < 0$), zero otherwise. Hence, we allow for a small base group that includes all firm-years with $\Delta ETR_{i,t} = 0$.¹² We do not include *POS* and *NEG* without interactions in our regression as the overall level of the dependent variable $|\Delta ETR_{i,t}|$ should not be impacted by the direction of change in *ETR* (*POS/NEG*).¹³

Similar to Equation (5), in Equation (6) β_0 and β_4 are positive and significant if the tax footnote is used in t by firm i to merely justify a change in *ETR* that has already occurred. *H1a* is confirmed if one of the coefficients β_1 , β_2 or β_3 is positive and significant. Correspondingly, *H1b* is confirmed if one of the coefficients β_5 , β_6 or β_7 is positive and significant. *H1c* is confirmed if the aforementioned significance between β_1 , β_2 or β_3 and β_5 , β_6 or β_7 , respectively, differs conditional on k .

4.5 H2–Asymmetric timeliness conditional on underlying processes

Next, we consider whether ΔTFN is driven by tax footnote modifications that speak to specific underlying processes. This analysis aims merely at confirming that our main analyses regarding *H1* are indeed connected to the more granular analysis in *H2*. To this end, we conduct the following OLS regression:

$$\Delta TFN_{i,t} = \alpha_0 + \beta_1^{UP} \Delta TOPIC_{i,t}^{UP} + \theta_j + \varphi_t + \epsilon_{i,t} \quad (7)$$

where *UP* indicates one of the four underlying processes. We regress $\Delta TFN_{i,t}$ on $\Delta TOPIC_{i,t}^{UP}$ and also include industry fixed effects θ_j and year fixed effects φ_t . $\Delta TOPIC_{i,t}^{UP}$ is computed as the first difference between the count of words associated with the underlying process *UP* in both t and $t - 1$. We concentrate on positive values of $\Delta TOPIC_{i,t}^{UP}$ since they indicate the entry of the underlying process into the tax footnote. Correspondingly, we set $\Delta TOPIC_{i,t}^{UP}$ to zero for negative values since negative values indicate the end of the underlying process. To identify the firm-level underlying processes, we use one unique word list for each *UP*.¹⁴ We expect β_1^{UP} to be positive and significant for all relevant underlying processes.

Second, to test *H2a*, *H2b*, and *H2c*, we modify Equation (6) as follows:

¹² To ensure that our relatively small baseline group of 363 firm-years does not result in overfitting or biased estimates, we conduct several tests (i.e., additional including firm-years with $\Delta ETR_{i,t} = 0$ in *POS* and dropping the firm-years with $\Delta ETR_{i,t} = 0$) in Sect. 7.2.5.

¹³ To ensure that our results are not driven by omitting *POS* and *NEG*, we conduct a robustness test in Sect. 7.2.4.

¹⁴ For details on the four word lists, see Sect. 5.2.

$$|\Delta ETR_{i,t}| = \alpha_0 + \beta_k \Delta TOPIC_{i,t-k}^{UP} \times POS_{i,t} + \beta_{4+k} \Delta TOPIC_{i,t-k}^{UP} \times NEG_{i,t} + \gamma X_{i,t} + \theta_j + \varphi_t + \epsilon_{i,t} \quad (8)$$

where we now include an interaction term with $\Delta TOPIC_{i,t-k}$ to separate the effects for increases (*POS*) and decreases (*NEG*) in ΔETR . Specifically, $POS_{i,t}$ ($NEG_{i,t}$) is set to one if $\Delta ETR_{i,t} > 0$ ($\Delta ETR_{i,t} < 0$), zero otherwise.

The interpretation of the coefficients in Equation (8) is consistent with Equation (6). Hence, *H2a* is confirmed if one of the coefficients β_1 , β_2 or β_3 is positive and significant, indicating that increases in *ETR* are preceded by tax footnote modifications that speak specifically to the given *UP*. Correspondingly, *H2b* is confirmed if one of the coefficients β_5 , β_6 or β_7 is positive and significant. Again, β_0 and β_4 are positive and significant if the tax footnote is used in *t* by firm *i* to merely justify a change in *ETR* that has already occurred. *H2c* can be confirmed based on significance, in correspondence with interpretation of respective differences in Equation (6) for *H1c*.

5 Data

5.1 Tax footnotes and ETR

We use 10-K filings of all publicly traded U.S. firms available for the period from 2000 to 2021 on the SEC website.¹⁵ Our raw textual data consist of 165,876 10-Ks (firm-years) from 19,774 different firms. We then drop all 10-Ks where the tax footnote cannot be extracted (50,284 10-Ks dropped).¹⁶ Figure 1 shows a histogram of *LEN* (Panel A) and ΔTFN (Panel B) over all firm-years.

Figure 1 shows that our textual data contain a small number of outlier firm-years with relatively large *LEN* or ΔTFN . When manually investigating these outliers, we find that they derive mostly from errors in the extraction of the tax footnote (e.g., end of the tax footnote is not correctly identified). After closer investigation, we decide to exclude all firm-years with *LEN* greater than 2,000 words (3,873 firm-years dropped) and then all firm-years with ΔTFN greater than 0.7 (1,218 firm-years dropped).¹⁷

¹⁵ <https://www.sec.gov/edgar>

¹⁶ We follow Inger et al. (2018) for the tax footnote extraction process. We locate the starting and ending point of the tax footnote using common expressions and extract the text in between. The exact starting point of the tax footnote differs between firms (e.g., "Note (5) Income Taxes" or "10. Federal Income Taxes"), so we manually identify several possible starting points. To find the corresponding ending point, we then rely on consistency in the format of headlines. For instance, if the starting point of the tax footnote is indicated by "Note (5) Income Taxes", we conjecture that the ending point is indicated by "Note (6) [...]".

¹⁷ To ensure that our results are not driven by this design choice, we vary the exclusion as follows: we exclude firm-years with *LEN* greater than 3,000 (4,000) [5,000] and ΔTFN greater than 0.8 (0.6) [0.5]. Our results remain similar in economic magnitude and significance for all combinations of limits of *LEN* and ΔTFN . Moreover, our results are also robust to not dropping firm-years based on limits of *LEN* and ΔTFN and instead truncating at the 98th percentile of *LEN* and ΔTFN .

In the next step, we prepare the tax footnote for natural language processing. First, we remove HTML codes, punctuation, white spaces and stop words and change upper-case words into lower-case words. Second, we remove headlines and convert total numbers (not each digit) into hashtags.¹⁸ Finally, the tax footnote is stemmed, i.e., the words are returned to their root words.¹⁹ Doing so enables us to focus on the underlying word choice (Manning and Schütze 1999) and reduces the dimension of the TF-IDF vectors, which also reduces computing time (Brown and Tucker 2011). Our final textual dataset consists of 110,501 tax footnotes (firm-years) from 6,284 different firms.

We merge this textual dataset with data on *ETR* and the control variables X that we derive from *Refinitiv*. We merge on the Central Index Key conditional on closing date. We then drop all firm-years i with negative income before taxes because ETRs in cases of negative income before taxes are often not meaningful (Dyrend et al. 2017). Moreover, we winsorize the *ETR* to 0% and 100%, following, among others, Dyrend et al. (2008). We then compute ΔETR and ΔTFN . We drop all firm-years for which ΔTFN or ΔETR cannot be calculated, resulting in our final dataset. To avoid our results being driven mainly by large changes in ETR, we also drop firm-years with $|\Delta ETR_{i,t}|$ above the 95th percentile.²⁰ For sensitivity analysis, we report in Table 2 the number of both firm-years and firms when imposing alternative data requirements.

For instance, Row (2) in Table 2 shows results for a full set of $\Delta TFN_{(t-1)}$, ΔETR_t , and control variables in X_t and consists of 11,810 firm-years.

5.2 Underlying process identification

We create four vectors W_{UP} , which hold the word lists specific to each underlying process UP . We present the four word lists W_{UP} for each underlying process UP in Table 3.

For tax avoidance (W_{TA}), we rely on previous research and use all nonconforming words from Wang (2022) word list. W_{TA} measures activities to avoid taxes, such as operating in foreign subsidiaries.

For our other three UP s, we create W_{UP} manually: tax audits (W_{AU}), capital structure (W_{CS}), and legislation&litigation (W_{LL}). W_{AU} measures ongoing audits, proposed audit adjustments, or audit appeals. W_{CM} measures changes in capital structure, such as changes from debt to equity financing, share-based compensation, or stock options. W_{LL} measures tax-related lawsuits and changes in tax legislation. We aim to capture changes in tax legislation because they affect firms with varying degrees of severity (especially in the case of changes in legislation in foreign countries). We technically create our word lists W_{UP} in a two-step procedure, with the second

¹⁸ Hence, modifications of numbers are not seen as modifications of tax footnotes, but we still measure whether more numbers are added to the tax footnote.

¹⁹ Following Brown and Tucker (2011), we stem each word using the Porter stemming algorithm (Porter 1980).

²⁰ Our results are robust to truncation at the 98th or 99th percentile and to tests without truncation.

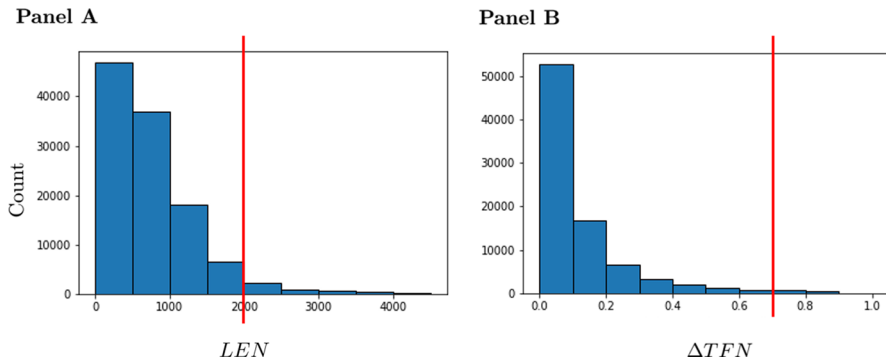


Fig. 1 Sample Selection: Histogram of LEN and ΔTFN . Panel A presents a histogram of LEN , and Panel B presents a histogram of ΔTFN when treating the sample as cross-sectional, before excluding firm-years with $LEN > 2,000$ and firm-years with $\Delta TFN > 0.7$

step being less scalable than the first step. First, we randomly select 50 tax footnotes and one of the authors and one research assistant extract, by hand, all unique words related to the underlying processes UP .²¹ Second, we extend the word lists W_{UP} by again randomly choosing 200 new tax footnotes and this time, research assistants extract further words related to each underlying process.²² These words selected in this two-step procedure then compose the respective word lists W_{UP} . Note that our word lists contain not only single words but also technical terms consisting of more than one word (e.g., tax refund, global intangible low-taxed income). With respect to the single words, in a final step to avoid mismatches, all single words on W_{UP} are again reviewed against 10 new randomly selected tax footnotes containing the word in question. To reduce the length of the word lists, we remove technical terms from any word list W_{UP} if a fraction of the technical terms is already included in W_{UP} as a single word because then the technical term will in any case be considered.²³ Finally, the counts of all technical terms and single words associated with UP used in the tax footnote of firm i in year t are summed up to compute $TOPIC_{i,t}^{UP}$.

²¹ To ensure due process, only words considered to be related to UP by both the author and the independent person are included in the word list without further testing. Words extracted only by the author or only by the independent person are reviewed against 10 new randomly selected tax footnotes containing the word in question and are included in the word list only if the word is used in the context of the UP in all 10 new selected tax footnotes.

²² Again, to ensure due process, each tax footnote is read by two independent persons (research assistants who were not involved in the first step) to extract further words related to each underlying process. Only new words related to a UP by both independent persons are included in the word list without further testing. Words extracted only by one of the independent persons are reviewed by one of the authors against 10 new randomly selected tax footnotes containing the word in question and are included in the word list only if the word is used in the context of the UP in all 10 new selected tax footnotes.

²³ For instance, we remove "tax audit" and "audit conclusion" from W_{AU} because "audit" is already a single word in W_{AU} . Hence, "tax audit" and "audit conclusion" would in any case be considered in $\Delta TOPIC_{i,t}^{UP}$ when using W_{AU} .

Table 2 Sample Size Conditional on Data Requirements

#	firm-years	firms	ΔETR_t	ΔTFN_t	$\Delta TFN_{(t-1)}$	$\Delta TFN_{(t-2)}$	$\Delta TFN_{(t-3)}$	$X_{i,t}$
(1)	14,998	2,587	YES	YES				YES
(2)	11,810	2,174	YES	YES	YES			YES
(3)	9,444	1,849	YES	YES		YES		YES
(4)	8,247	1,715	YES	YES			YES	YES

Table 2 reports the number of firm-years and firms for alternative data requirements. $X_{i,t}$ imposes a full set of control variables ($LLEN$, PPE , INT , $LSZIZE$, ROA , RD)

5.3 Descriptive statistics

Table 4 reports descriptive statistics for all relevant variables, when imposing data requirements as shown in Row (1) in Table 2, corresponding to our most restrictive model specification.

Table 4 shows that ETR has a mean of 0.28 over all firm-years, whereas the mean of ΔETR is -0.001 .²⁴ Moreover, the average ΔTFN is 0.096 and thus ten times as large as the average $\Delta 10K$ of 0.01. This indicates that large parts of the 10-K are standardized with only numbers changed year-over-year, which we do not measure as modifications.

Figure 2 visualizes the correlation matrix of all relevant variables. The correlation coefficient between each variable pair is represented by the size and color of the circle. Positive correlation coefficients are blue, whereas negative correlation coefficients are red.

We observe in Fig. 2 that the correlation coefficient of ΔETR and ΔTFN_t ($\Delta TFN_{(t-1)}$) is small, with a magnitude of 0.023 (0.036), but significantly greater than 0, with a p-value of 0.002 (0.000). This finding provides an initial indication that changes in ETR are associated with contemporaneous and preceding tax footnote modifications.

Figure 3 shows the average ΔTFN over all firms i separately for each year t in our dataset. The whiskers in black (dark gray) [light gray] represent the 0.9 (0.95) [0.99] confidence intervals. The horizontal red line is the average ΔTFN over all firm-years.

We observe in Fig. 3 a structural break for average ΔTFN in 2009. Starting after 2009, tax footnotes are considerably less modified year-over-year. This is likely due to the implementation of FIN 48 Accounting for Uncertainty in Income Taxes under U.S. GAAP (implementation for financial years beginning after December 15, 2006). Nonetheless, we observe a peak in 2017, which is likely caused by the introduction of the 2017 TCJA and the considerable changes in corporate taxation for U.S. firms. Both effects are captured by our year fixed effects φ_t .²⁵

²⁴ The negative mean in ΔETR is likely caused by a general decrease in corporate taxes over time, resulting from both globalization (Dyregre et al. 2017) and the 2017 Tax Cuts and Jobs Act (TCJA), with the latter reducing the statutory tax rate on corporate profits for U.S. firms from 35% to 21%.

²⁵ Note that we conduct robustness tests to ensure that our results are not driven by the pre-2009 period or the TCJA in Sects. 7.3.4 and 7.3.3.

Table 3 Word Lists Specific for each Underlying Process Tax Audit, Capital Structure, Legislation & Litigation, and Tax Avoidance

Underlying Process	Wordlist		
W_{TA} (Tax Avoidance)	accelerate	accelerated	acceleration
	accrual	accruals	accrued
	accrue	accumulate	allocate
	allocation	allowable	allowances
	allowance	appreciation	bermuda
	branch	carryforward	carryforwards
	cayman islands	cost	costs
	currency	demerger	depreciated
	depreciating	depreciation	devalue
	devaluation	discount	discounted
	discounting	discounts	evaluate
	evaluated	evaluating	evaluation
	expenditure	expenditures	expense
	financing	foreign	geographical
	geographic	geographically	geographies
	global	globally	goodwill
	group	headquarters	heaven
	impaired	impairment	impairments
	improvement	improvements	installment
	insurance	intangible	intangibles
	intellectual	interest	international
	internationally	ireland	jurisdiction
	lease	leasehold	leases
	luxembourg	netherlands	outsource
	outsourced	outsourcing	overseas
	region	regional	regions

Table 3 (continued)

Underlying Process	Wordlist	
	expiration of open tax years formal review in open years internal revenue service issue in dispute national tax service nopa open tax years petition proposed changes rar refund remain open revenue agent reports stages of completion tax adjustment tax authorities tax filings timing of the completion unaudited	formal notices fully cooperating internal revenue code ir's letter of determination no material adjustments number of issues open years proposed adjustments pursuant to the competent authority receive penalties regulatory authorities remains open stage of completion submitting documentation tax agency tax compliance taxing authority unagreed issue
<i>W_{CS}</i> (Capital Structure)	acquisition business structure capital loss carryback credits	acquisitions capital and tax structure capitalized software costs debt repayment

Table 3 (continued)

Underlying Process	Wordlist	
<i>W_{LL}</i> (Legislation & Litigation)	debt securities	divestiture
	dividend	equity
	exchange rate	hedging
	inflation	investees
	investible capital	loan
	merger	net investment hedges
	nondividend distributions	paidin capital
	pension	phc
	price earnings ratio	repatriate
	share	shareholder
	shareholders	stock
	stockbased	stockholders
	stocks	
	accounting method	accounting principles
	accounting principles board opinion	accounting standards
	adopt	adoption
	affordable care act	alternative minimum tax relief act
	american jobs creation act	are subject to
	asc	base erosion and antiabuse tax
	bermuda exempted undertakings tax protection act	changes in state statutory tax rates
<i>W_{LL}</i> (Legislation & Litigation)	changes to statutory tax rates	coronavirus aid relief and economic security act
	cost reimbursement arrangements	education jobs and medicaid assistance act
	effective date	enact

Table 3 (continued)

Underlying Process	Wordlist
enacted	enactment
fasb	fdii
financial accounting standard board	gilti
guidance	guideline
holiday	implementing
interpretation no 48	judicial
lawsuit	lawsuits
legislations	legislative
litigations	passage of the act
published	regulation
regulatory	relocation
requirements	requires
rules	ruling
sab	SEC
tax act	tax code
tax hikes act	tax holidays
tax incentive programs	tax increase prevention act
tax jurisdictions	tax pioneer status
tax reform act	tax reforms
tax status	tax statutes
taxing jurisdiction	tcja
voted	
	fas
	fin 48
	global intangible lowtaxed income
	guidelines
	in accordance
	law
	legislation
	litigation
	president
	regulations
	relocations
	requiring
	rulings
	staff accounting bulletin
	tax cuts and jobs act
	tax incentive program
	tax jurisdiction
	tax reform
	tax regimes
	tax system
	territorial tax system

Table 4 Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	1st Qu.	Median	3rd Qu.	Max
<i>ETR</i>	14,998	0.280	0.150	0.000	0.200	0.310	0.370	1.000
ΔETR	14,998	-0.001	0.120	-0.440	-0.039	-0.002	0.028	0.440
<i>POS</i>	14,998	0.460	0.500	0.000	0.000	0.000	1.000	1.000
<i>NEG</i>	14,998	0.520	0.500	0.000	0.000	1.000	1.000	1.000
ΔTFN	14,998	0.096	0.100	-0.000	0.029	0.063	0.130	0.700
$\Delta TOPIC^{CS}$	14,998	1.100	2.500	0.000	0.000	0.000	1.000	103.000
$\Delta TOPIC^{LL}$	14,998	2.100	6.000	0.000	0.000	0.000	1.000	69.000
$\Delta TOPIC^{TA}$	14,998	2.700	5.100	0.000	0.000	0.000	3.000	87.000
$\Delta TOPIC^{AU}$	14,998	1.300	2.800	0.000	0.000	0.000	1.000	66.000
$\Delta 10K$	14,997	0.010	0.017	-0.000	0.003	0.005	0.010	0.450
<i>LEN</i>	14,998	734.000	331.000	54.000	491.000	702.000	933.000	1,984.000
<i>LEN</i> ^{10K}	14,998	33,483.000	14,481.000	7,268.000	24,543.000	31,189.000	39,403.000	292,119.000
<i>SIZE</i>	14,998	8,299.000	32,575.000	0.910	445.000	1,429.000	4,832.000	1,119,796.000
<i>INT</i>	14,998	0.084	0.100	0.000	0.015	0.047	0.120	0.880
<i>PPE</i>	14,998	0.200	0.190	0.000	0.060	0.140	0.280	0.980
<i>ROA</i>	14,998	0.059	0.220	-22.000	0.017	0.062	0.120	1.800
<i>RD</i>	14,998	0.087	6.200	0.000	0.000	0.000	0.035	758.000
<i>IBT</i>	14,998	612.000	2,049.000	0.005	35.000	118.000	406.000	71,115.000

Table 4 reports descriptive statistics for all relevant variables when imposing data requirements as shown in Row (1) in Table 2

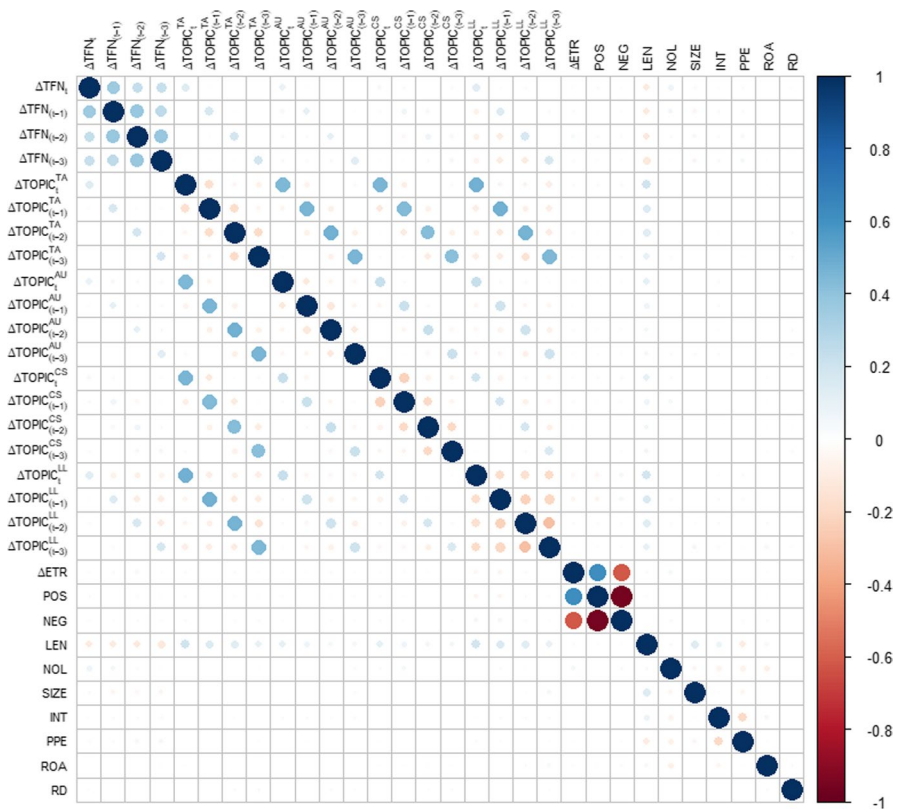


Fig. 2 Correlation Plot. This figure visualizes the correlation matrix of all relevant variables. The correlation coefficient between each variable pair is represented by the size and color of the circle, where positive (negative) correlation coefficients are blue (red) (color figure online)

6 Results

6.1 T1-timeliness

Table 5 reports the regression results from Eq. 5. We are again particularly interested in the coefficients of $\Delta TFN_{i,t-k}$.

We observe in Table 5, Column (1), that β_0 is positive and significant, indicating that firms use the tax footnote in t to justify changes in ETR that have already occurred. In Column (2), we find a significant positive coefficient of β_1 , indicating that changes in ETR in t are preceded by tax footnote modifications already observable in $t - 1$. The coefficient β_2 is positive but barely non-significant at the 10% level (p-value: 0.1023), whereas we again find a significant positive β_3 in Column (4).²⁶ In theory, we expect firms to modify their tax footnote during the entire duration of the underlying process to some extent. Correspondingly, we expect decreasing

²⁶ We note that results are robust to dropping industry fixed effects.

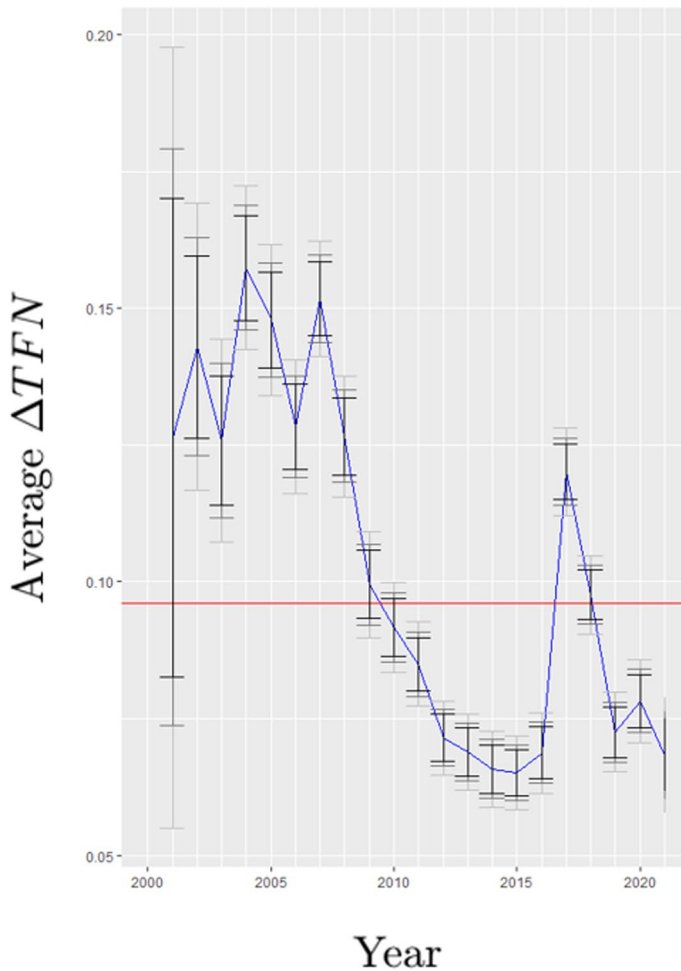


Fig. 3 Average ΔTFN Over Time. This figure presents average ΔTFN over all firms i and the corresponding 0.9 (0.95) [0.99] confidence intervals in black (dark gray) [light gray] separately for each year t in our dataset. The horizontal red line is the average ΔTFN over all firm-years (color figure online)

coefficients from $t - 1$ to $t - 3$ because firms should disclose additional information as the underlying process progresses in time, resulting in the corresponding change in ETR . We find that tax footnote modifications are associated with future changes in ETR of at least three years in advance.²⁷

To further investigate the magnitude of the effect, we now multiply the coefficients on ΔTFN from Table 5 by the standard deviation of ΔTFN over all firm-years (0.100) as reported in Table 4. Doing so enables us to interpret the corresponding coefficients as the effect of a one-standard-deviation increase in $\Delta TFN_{i,(t-k)}$ on $|\Delta ETR_{i,t}|$. When applying this standardization approach to Columns (2), (3) and

²⁷ We conduct robustness tests in Sect. 7.2.1 to further investigate if signals in the tax footnote associated with future changes in ETR may be observable in $t - 4$ and $t - 5$.

Table 5 Timeliness: Tax Footnote Modifications as Early Signals for Changes in ETR - Regression Results of T1

ΔETR					
		(1)	(2)	(3)	(4)
ΔTFN_t	β_0	0.0266 *** (0.0082)			
$\Delta TFN_{(t-1)}$	β_1		0.0355 *** (0.0084)		
$\Delta TFN_{(t-2)}$	β_2			0.0147 (0.0090)	
$\Delta TFN_{(t-3)}$	β_3				0.0168 * (0.0101)
<i>LLEN</i>		0.0316 *** (0.0026)	0.0299 *** (0.0029)	0.0282 *** (0.0031)	0.0294 *** (0.0035)
<i>NOL</i>		0.0377 *** (0.0037)	0.0433 *** (0.0060)	0.0561 *** (0.0156)	0.0316 *** (0.0091)
<i>PPE</i>		0.0063 (0.0064)	0.0025 (0.0067)	0.0050 (0.0074)	0.0073 (0.0081)
<i>INT</i>		0.0432 *** (0.0103)	0.0348 *** (0.0112)	0.0393 *** (0.0126)	0.0497 *** (0.0149)
<i>LSIZE</i>		-0.0054 *** (0.0006)	-0.0053 *** (0.0007)	-0.0053 *** (0.0007)	-0.0057 *** (0.0008)
<i>ROA</i>		-0.0147 (0.0133)	-0.0630 *** (0.0108)	-0.0680 *** (0.0129)	-0.0649 *** (0.0135)
<i>RD</i>		-0.0000 ** (0.0000)	-0.0000 *** (0.0000)	0.0566 *** (0.0184)	0.0547 ** (0.0225)
Industry Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Num. obs.		14998	11810	9444	8247
R ²		0.0605	0.0664	0.0670	0.0667
Adj. R ²		0.0574	0.0625	0.0623	0.0614

Table 5 explores whether changes in *ETR* are preceded by tax footnote modifications ΔTFN . $|\Delta ETR_{i,t}|$ is the absolute value of the first difference in *ETR* between t and $t - 1$. $\Delta TFN_{i,t-k}$ with k in $[0, 3]$ are indicative of (previous) tax footnote modifications. We include the following control variables: *LLEN* as the log of the length of the tax footnote, *NOL* as a dichotomous variable that equals one if the firm experienced negative EBIT in t until $t - 3$ once, *LSIZE* as the log of total assets, *INT* as the ratio of intangible assets to total assets, *PPE* as the ratio of property, plant, and equipment to total assets, *RD* as the ratio of research and development expenses to total revenue and *ROA* as pretax return on assets. An intercept term is included but not displayed. We report robust standard errors clustered at the firm level in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively. Coefficients β_0 to β_3 correspond to Eq. 5

Table 6 Asymmetric Timeliness conditional on the Direction of Change in ETR - Regression Results of *H1*

ΔETR		(1)	(2)	(3)	(4)	
ΔTFN _{<i>t</i>} × POS	β ₀	0.0772 (0.0105)	***			
ΔTFN _{<i>t</i>} × NEG	β ₄	0.0272 (0.0094)	***			
ΔTFN _(<i>t</i>-1) × POS	β ₁		0.0892 (0.0114)	***		
ΔTFN _(<i>t</i>-1) × NEG	β ₅		0.0276 (0.0091)	***		
ΔTFN _(<i>t</i>-2) × POS	β ₂			0.0495 (0.0116)	***	
ΔTFN _(<i>t</i>-2) × NEG	β ₆			0.0079 (0.0099)		
ΔTFN _(<i>t</i>-3) × POS	β ₃				0.0384 (0.0124)	***
ΔTFN _(<i>t</i>-3) × NEG	β ₇				0.0178 (0.0117)	
Industry Fixed Effects	YES	YES	YES	YES	YES	
Year Fixed Effects	YES	YES	YES	YES	YES	
Controls	YES	YES	YES	YES	YES	
Num. obs.	14998	11810	9444	8247		
R ²	0.0639	0.0710	0.0690	0.0677		
Adj. R ²	0.0607	0.0671	0.0641	0.0622		

Table 6 explores whether increases (i.e., $POS = 1$) and decreases (i.e., $NEG = 1$) in ETR are preceded by tax footnote modifications $\Delta TFN_{i,t-k}$ with k in $[0, 3]$. $|\Delta ETR_{i,t}|$ is the absolute value of the first difference in ETR between t and $t - 1$. We include the following control variables: $LLEN$ as the log of the length of the tax footnote, NOL as a dichotomous variable that equals one if the firm experienced negative EBIT in t until $t - 3$ once, $LSIZE$ as the log of total assets, INT as the ratio of intangible assets to total assets, PPE as the ratio of property, plant, and equipment to total assets, RD as the ratio of research and development expenses to total revenue and ROA as pretax return on assets. An intercept term is included but not displayed. We report robust standard errors clustered at the firm level in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively. Coefficients β_0 to β_7 correspond to Eq. 6

(4), we find that a one-standard-deviation increase in $\Delta TFN_{i,t-k}$ is associated with increases in $|\Delta ETR|$ of 0.355, 0.147 and 0.168 percentage points, respectively.

6.2 H1–Asymmetric timeliness

Table 6 reports the regression results from our main analysis in Eq. 6. We are particularly interested in the coefficients of the interaction terms with POS and NEG , since they show the correlation between tax footnote modifications and the absolute

change in *ETR* separately for increases and decreases in ΔETR . We do not display coefficients for control variables *X* to foster readability.

In Table 6, regarding increases in *ETR*, we observe that the coefficients of $\Delta TFN_{(t-k)} \times POS$ are positive and significant for all *k* in [1, 3], indicating that increases in *ETR* are preceded by tax footnote modifications up to three years.²⁸ We thus confirm *H1a*. With regard to decreases in *ETR*, we find that the coefficient β_5 is also positive and significant in Column (2), i.e., for $t - 1$, but find only non-significant positive coefficients β_6 and β_7 , i.e. for $t - 2$ and $t - 3$. Considering the results in Table 6 jointly, we confirm *H1b*. Moreover, we confirm *H1c*, as tax footnote modifications preceding increases occur relatively earlier than do tax footnote modifications preceding decreases in *ETR*.

Regarding asymmetry in magnitude of tax footnote modifications, preceding tax footnote modifications in $t - 1$ (Column (2)) in case of increases in *ETR* are significantly greater than in case of decreases in *ETR* (Wald test, p-value=0.000).²⁹ Furthermore, we find tax footnote modifications also in the year of the change in *ETR* itself, both for increases and decreases in *ETR* (Column (1)). Again, the economic magnitude of this effect is greater for increases in *ETR* (Wald test, p-value=0.000). These findings indicate that firms use tax footnotes to justify both directions of changes in *ETR* that already occurred, but more so if the changes in *ETR* are considered bad news.

Overall, we find asymmetric timeliness of tax disclosure prior to changes in *ETR*. In particular, our results indicate that firms strategically manage their tax footnotes in accordance with the "accounting conservatism" hypothesis proposed by Basu (1997).

6.3 H2–Asymmetric timeliness conditional on underlying processes

Table 7 reports the regression results from estimating Eq. 7. Here, we are particularly interested in the coefficients β_1^{UP} , conditional on *UP*.

In Table 7, we observe significant positive coefficients for $\Delta TOPIC^{UP}$ for *TA*, *AU*, *CS* and *LL* in Columns (1), (2), (3) and (4), respectively. Hence, we conclude that tax footnote modifications are at least in part driven by each of our four underlying processes tax avoidance *TA*, tax audits *AU*, capital structure *CS*, and legislation&litigation *LL*.

²⁸ We conduct robustness tests in Sect. 7.2.1 to further investigate if signals in the tax footnote associated with future changes in *ETR* may be observable in $t - 4$ and $t - 5$. Moreover, we note that the coefficient of $t - 3$ tends to become non-significant in some robustness tests and hence should be viewed with caution.

²⁹ To interpret the magnitude of the coefficients, we again multiply the coefficients in Table 6 by the standard deviation of ΔTFN over all firm-years, as reported in Table 4. Considering Column (2), we find that an one-standard-deviation increase in $\Delta TFN_{i,t(t-1)}$ is associated with an increase in $|\Delta ETR|$ of 0.89 (0.27) percentage points for increases (decreases) in *ETR*.

Table 8 then reports the regression results from estimating Eq. 8. The results for tax avoidance *TA*, tax audits *AU*, capital structure *CS*, and legislation&litigation *LL* are reported in Panels A, B, C, and D, respectively.

Regarding tax avoidance *TA*, in Panel A, we find significant positive coefficients of $\Delta TOPIC_{(t-1)}$ for increases and decreases in *ETR* in Column (2), indicating that both increases and decreases in *ETR* are preceded by tax footnote modifications that speak to tax avoidance. Moreover, we find asymmetries in timeliness, as tax footnote modifications that speak to tax avoidance occur three years prior to the corresponding increase in *ETR* (β_1 , β_2 and β_3), whereas they occur only one year prior to the corresponding decrease in *ETR* (β_5). Regarding economic magnitude, tax footnote modifications that speak to tax avoidance in $t - 1$ are significantly greater in case of increases in *ETR* than in case of decreases in *ETR* ($\beta_1 - \beta_5$, Wald test, p-value=0.0009). We argue that these results indicate that firms provide less tax disclosure when concealing tax avoidance activities that successfully result in lower *ETR*, whereas firms extensively discuss failed or detected tax avoidance activities that are expected to lead to higher *ETR*. Moreover, an elaborate discussion of tax avoidance activities in the tax footnote can in itself be indicative of future increases in *ETR*, as tax avoidance activities can be more easily discovered by fiscal authorities and the discussion of tax avoidance in the tax footnote may even attract the attention of fiscal authorities. Furthermore, we find tax footnote modifications also in the year of the change in *ETR* itself, but only for increases in *ETR* (Column (1)). Hence, firms arguably justify increases in *ETR* due to detected and failed tax avoidance.

Regarding tax audits *AU*, in Panel B, we find significant positive β_1 and β_2 coefficients in Column (2) and Column (3). Hence, tax footnote modifications that speak to tax audits occur two years prior to increases in *ETR*. However, we find no effect indicating early signals from tax footnote modifications that speak to tax audits for decreases in *ETR*. Furthermore, we find tax footnote modifications also in the year of the change in *ETR* itself, but, again, only for increases in *ETR* (Column (1)). Hence, firms arguably justify increases in *ETR* due to tax audits that have already occurred.

Regarding capital structure *CS*, in Panel C, we find significant positive coefficients in Column (2) and Column (3) for β_1 and β_2 . Hence, tax footnote modifications that speak to capital structure changes occur two years prior to increases in *ETR*. Similar to Panel B, we also find no effect indicating early signals from tax footnote modifications that speak to capital structure changes for decreases in *ETR*. Furthermore, we find tax footnote modifications also in the year of the change in *ETR* itself, but only for increases in *ETR* (Column (1)). Hence, firms arguably justify increases in *ETR* due to capital structure changes that have already occurred.

Regarding legislation&litigation *LL*, in Panel D, we find significant positive coefficients of $\Delta TOPIC_{(t-1)}$ for increases and decreases in *ETR* (Column (2), β_1 and β_5). These results indicate that tax footnote modifications that speak to legislation&litigation occur one year prior to any changes *ETR*.

Overall, we find indication that increases in *ETR* are preceded by tax footnote modifications that speak to tax avoidance, tax audits, capital structure changes, and legislation&litigation. We thus confirm *H2a* for all our four underlying processes.

Table 7 Underlying Processes and Tax Footnote Modifications

ΔTFN					
		(1)	(2)	(3)	(4)
$\Delta TOPIC^{TA}$	β_1^{TA}	0.0067 *** (0.0002)			
$\Delta TOPIC^{AU}$	β_1^{AU}		0.0087 *** (0.0003)		
$\Delta TOPIC^{CS}$	β_1^{CS}			0.0110 *** (0.0005)	
$\Delta TOPIC^{LL}$	β_1^{LL}				0.0048 *** (0.0002)
Industry Fixed Effects		YES	YES	YES	YES
Year Fixed Effects		YES	YES	YES	YES
Num. obs.		28040	28040	28040	28040
R ²		0.1530	0.1165	0.1352	0.1044
Adj. R ²		0.1517	0.1151	0.1338	0.1030

Table 7 considers whether ΔTFN is driven by four underlying processes, namely tax audits AU , capital structure CS , legislation&litigation LL , and tax avoidance TA . We regress our measure of tax footnote modifications ΔTFN on modifications associated with underlying processes $\Delta TOPIC^{UP}$. $\Delta TOPIC^{UP}$ is the first difference between the count of words associated with the underlying process UP in both t and $t - 1$, but is set to zero for negative values of $\Delta TOPIC^{UP}$. An intercept term is included but not displayed. We report robust standard errors clustered at the firm level in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively. Coefficients β_1^{UP} correspond to Eq. 7

Moreover, we find that decreases in ETR are preceded by tax footnote modifications that speak to tax avoidance and legislation&litigation, confirming $H2b$ for these two underlying processes. Most importantly, we find asymmetric timeliness confirming $H2c$ for tax avoidance, tax audits and capital structure. Considering all four underlying processes jointly, tax footnote modifications in general tend to occur relatively earlier for increases in ETR than for decreases in ETR . We recall that our four underlying processes differ in terms of their potential directional effects as discussed in Sect. 3.3. Nonetheless, our findings strongly indicate that firms strategically manage their tax footnotes with respect to our four underlying processes, and moreover, that firms do so in accordance with the “accounting conservatism” hypothesis proposed by Basu (1997).

7 Robustness tests

7.1 Intensity of treatment

In our baseline specification, we investigate the timeliness of tax footnote modifications conditional on the mere direction of $|\Delta ETR|$. However, asymmetric timeliness may also be dependent on the intensity of treatment, i.e. conditional on the magnitude of $|\Delta ETR|$. Hence, we repeat the analysis from Table 6 using quantile regression

Table 8 Asymmetric Timeliness Conditional on Underlying Processes - Regression Results of *H2**PANEL A: Tax Avoidance*

$ \Delta ETR $		(1)	(2)	(3)	(4)
$\Delta TOPIC_t \times POS$	β_0	0.0012 (0.0003)	***		
$\Delta TOPIC_t \times NEG$	β_4	0.0002 (0.0002)			
$\Delta TOPIC_{(t-1)} \times POS$	β_1		0.0015 (0.0003)	***	
$\Delta TOPIC_{(t-1)} \times NEG$	β_5		0.0005 (0.0002)	**	
$\Delta TOPIC_{(t-2)} \times POS$	β_2			0.0007 (0.0003)	***
$\Delta TOPIC_{(t-2)} \times NEG$	β_6			0.0000 (0.0002)	
$\Delta TOPIC_{(t-3)} \times POS$	β_3				0.0005 (0.0003)
$\Delta TOPIC_{(t-3)} \times NEG$	β_7				0.0003 (0.0002)
Industry Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Num. obs.	14998	11810	9444	8247	
R^2	0.0614	0.0683	0.0676	0.0669	
Adj. R^2	0.0582	0.0644	0.0628	0.0615	

PANEL B: Tax Audits

$ \Delta ETR $		(1)	(2)	(3)	(4)
$\Delta TOPIC_t \times POS$	β_0	0.0015 (0.0004)	***		
$\Delta TOPIC_t \times NEG$	β_4	0.0000 (0.0004)			
$\Delta TOPIC_{(t-1)} \times POS$	β_1		0.0017 (0.0004)	***	
$\Delta TOPIC_{(t-1)} \times NEG$	β_5		0.0004 (0.0004)		
$\Delta TOPIC_{(t-2)} \times POS$	β_2			0.0016 (0.0005)	***
$\Delta TOPIC_{(t-2)} \times NEG$	β_6			-0.0005 (0.0003)	
$\Delta TOPIC_{(t-3)} \times POS$	β_3				-0.0001

Table 8 (continued)*PANEL B: Tax Audits*

ΔETR				
	(1)	(2)	(3)	(4)
$\Delta TOPIC_{(t-3)} \times NEG$	β_7			(0.0005) 0.0002 (0.0004)
Industry Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Num. obs.	14998	11810	9444	8247
R ²	0.0607	0.0662	0.0684	0.0664
Adj. R ²	0.0575	0.0623	0.0636	0.0609

PANEL C: Capital Structure

ΔETR				
	(1)	(2)	(3)	(4)
$\Delta TOPIC_t \times POS$	β_0	0.0026 *** (0.0006)		
$\Delta TOPIC_t \times NEG$	β_4	0.0003 (0.0004)		
$\Delta TOPIC_{(t-1)} \times POS$	β_1	0.0020 ** (0.0009)		
$\Delta TOPIC_{(t-1)} \times NEG$	β_5	0.0001 (0.0004)		
$\Delta TOPIC_{(t-2)} \times POS$	β_2		0.0019 *** (0.0006)	
$\Delta TOPIC_{(t-2)} \times NEG$	β_6		0.0000 (0.0004)	
$\Delta TOPIC_{(t-3)} \times POS$	β_3			0.0001 (0.0005)
$\Delta TOPIC_{(t-3)} \times NEG$	β_7			-0.0000 (0.0004)
Industry Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Num. obs.	14998	11810	9444	8247
R ²	0.0617	0.0667	0.0682	0.0664
Adj. R ²	0.0585	0.0627	0.0633	0.0609

PANEL D: Legislation&Litigation

ΔETR				
	(1)	(2)	(3)	(4)
$\Delta TOPIC_t \times POS$	β_0	0.0001		

Table 8 (continued)**PANEL D: Legislation&Litigation**

$ \Delta ETR $		(1)	(2)	(3)	(4)
		(0.0002)			
$\Delta TOPIC_t \times NEG$	β_4	-0.0001 (0.0002)			
$\Delta TOPIC_{(t-1)} \times POS$	β_1		0.0006 *** (0.0002)		
$\Delta TOPIC_{(t-1)} \times NEG$	β_5		0.0005 *** (0.0002)		
$\Delta TOPIC_{(t-2)} \times POS$	β_2			0.0000 (0.0002)	
$\Delta TOPIC_{(t-2)} \times NEG$	β_6			-0.0002 (0.0002)	
$\Delta TOPIC_{(t-3)} \times POS$	β_3				0.0001 (0.0003)
$\Delta TOPIC_{(t-3)} \times NEG$	β_7				0.0003 (0.0002)
IndustryFixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Num. obs.	14998	11810	9444	8247	
R ²	0.0598	0.0659	0.0669	0.0665	
Adj. R ²	0.0565	0.0619	0.0621	0.0610	

Table 8 explores whether increases (i.e., $POS = 1$) and decreases (i.e., $NEG = 1$) in ETR are preceded by increases in text that speaks specifically to one underlying process $\Delta TOPIC_{i,t(t-k)}$ with k in $[0, 3]$. $\Delta TOPIC^{UP}$ is the first difference between the count of words associated with the underlying process UP in both t and $t - 1$, but is set to zero for negative values of $\Delta TOPIC^{UP}$. $|\Delta ETR_{i,t}|$ is the absolute value of the first difference in ETR between t and $t - 1$. Panel A reports results for the underlying process tax avoidance TA , Panel B for tax audits AU , Panel C for capital structure CS , and Panel D for legislation&litigation LL . We include the following control variables: $LLEN$ as the log of the length of tax footnote, NOL as a dichotomous variable that equals one if the firm experienced negative EBIT in t until $t - 3$ once, $LSIZE$ as the log of total assets, INT as the ratio of intangible assets to total assets, PPE as the ratio of property, plant, and equipment to total assets, RD as the ratio of research and development expenses to total revenue and ROA as pretax return on assets. An intercept term is included but not displayed. We report robust standard errors clustered at the firm level in parentheses. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively. Coefficients β_0 to β_7 correspond to Eq. 8

and setting τ in $[0.2, 0.4, 0.6, 0.8]$. Doing so allows us to compare the significance and economic magnitude of relevant coefficients across quantiles of $|\Delta ETR|$. Results are reported in Table 9.

When investigating asymmetry in timeliness in terms of significance in Table 9, we find significant coefficients across all columns (1) to (4) for both $\Delta TFN_{(t-1)} \times POS$

Table 9 Intensity of Treatment - Quantile Regression

ΔETR		Quantiles							
		(1)		(2)		(3)		(4)	
		$\tau = 0.2$		$\tau = 0.4$		$\tau = 0.6$		$\tau = 0.8$	
$\Delta TFN_i \times POS$	β_0	0.0119	***	0.0207	***	0.0563	***	0.1583	***
		(0.0021)		(0.0040)		(0.0082)		(0.0187)	
$\Delta TFN_{(t-1)} \times POS$	β_1	0.0149	***	0.0288	***	0.0674	***	0.1837	***
		(0.0023)		(0.0041)		(0.0080)		(0.0175)	
$\Delta TFN_{(t-2)} \times POS$	β_2	0.0011		0.0017		0.0290	***	0.0613	***
		(0.0029)		(0.0046)		(0.0095)		(0.0213)	
$\Delta TFN_{(t-3)} \times POS$	β_3	0.0005		0.0010		0.0059		0.0542	**
		(0.0032)		(0.0049)		(0.0101)		(0.0229)	
$\Delta TFN_i \times NEG$	β_4	0.0167	***	0.0219	***	0.0395	***	0.0391	**
		(0.0020)		(0.0038)		(0.0078)		(0.0178)	
$\Delta TFN_{(t-1)} \times NEG$	β_5	0.0185	***	0.0275	***	0.0401	***	0.0483	***
		(0.0022)		(0.0039)		(0.0077)		(0.0169)	
$\Delta TFN_{(t-2)} \times NEG$	β_6	0.0053		0.0032		0.0111		0.0178	
		(0.0057)		(0.0043)		(0.0090)		(0.0201)	
$\Delta TFN_{(t-3)} \times NEG$	β_7	-0.0005		-0.0037		0.0069		0.0204	
		(0.0031)		(0.0048)		(0.0098)		(0.0220)	
Industry Fixed Effects		YES		YES		YES		YES	
Year Fixed Effects		YES		YES		YES		YES	
Controls		YES		YES		YES		YES	

Table 9 repeats Table 6 using quantile regressions with τ in [0.2, 0.4, 0.6, 0.8]. Instead of providing four separate tables (one table separately for each τ including the quantile regression on that τ over all the Columns (1) to (4) as in Table 6), we report only the coefficients of interaction terms of $\Delta TFN_{i,(t-k)}$ with either *POS* or *NEG* over k in [0, 3]. Hence, each separate column (1) to (4) in Table 9 shows quantile-specific coefficients of one complete set of regressions over all columns (1) to (4) in Table 6. We also in Table 9 rearrange the order of interaction terms with *POS* and *NEG*. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively. Coefficients β_0 to β_7 correspond to Table 6 and Eq. 6

and $\Delta TFN_{(t-1)} \times NEG$. However, when considering interaction terms with $\Delta TFN_{(t-2)}$ ($\Delta TFN_{(t-3)}$), we find significant coefficients only for the interaction with *POS* in Columns (3) and (4), i.e. with the two highest τ (in Column (4), i.e., with only the highest τ). When considering magnitude of coefficients, we find that significant coefficients in all rows increase with increasing τ . Considered jointly, we generally confirm our baseline result of asymmetry in timeliness of tax footnote modifications. Moreover and more importantly, we show that asymmetry in timeliness increases in the magnitude of | ΔETR |.

7.2 Alternative regression model specifications

7.2.1 Testing for earlier signals in the tax footnote

In our baseline specifications of Eqs. 5 and 6 and corresponding Tables 5 and 6, we test for early signals associated with future *ETR* in the three years prior to the change in *ETR*. This design choice follows prior literature (Campbell et al. 2019; Allen et al. 2021; Bogacheck et al. 2023). Now, we repeat Eqs. 5 and 6 with k in [4, 5] to avoid missing potentially relevant information. When investigating symmetric timeliness, i.e. repeating the analysis corresponding to Table 5, we find no significant coefficient for $\Delta TFN_{(t-4)}$ and $\Delta TFN_{(t-5)}$, indicating that signals in tax footnotes can be observed with a maximum foresight period up to three years.³⁰ When investigating asymmetric timeliness, i.e., repeating the analysis corresponding to Table 6, we find significance at the 10% level for one coefficient for increases in *ETR* in $t - 4$, indicating that increases in *ETR* may even be preceded by tax footnote modifications up to four years in advance.³¹

7.2.2 Inclusion of all lagged variables of ΔTFN in one regression

In our baseline specification, we decide to include only one coefficient of $\Delta TFN_{i,(t-k)}$ with k in [0, 3] per regression. The main reason for this is to reduce multicollinearity.³² Furthermore, prior literature (Bogacheck et al. 2023; Campbell et al. 2019; Allen et al. 2021) has also generally considered only one year per regression. To, nonetheless, test for the effects of this design choice, we now combine $\Delta TFN_{i,(t-k)}$ with k in [0, 3] in one regression.³³ Repeating our analyses corresponding to Tables 5 and 6,³⁴ we continue to find significant coefficients for $\Delta TFN_{(t-1)}$ as well as for the interaction terms $\Delta TFN_{(t-1)} \times POS$ and $\Delta TFN_{(t-1)} \times NEG$. We do not find significant coefficients for $k > 1$, potentially due to multicollinearity.

7.2.3 Inclusion of all variables $\Delta TOPIC^{UP}$ in one regression

In Eq. 8, we include only coefficients of one *UP* per regression for better readability of the tables and due to correlation between $\Delta TOPIC^{UP}$. As an alternative, we rerun Eq. 8 and the analysis corresponding to Table 8 but include all four $\Delta TOPIC^{UP}$ at

³⁰ The results are tabulated in Table 10 in the Online Resource.

³¹ The results are tabulated in Table 11 in the Online Resource.

³² Note that the correlation between $\Delta TFN_{i,(t-k)}$ with k in [0, 3] as shown in Fig. 2 lies within [0.22, 0.35]

³³ The simultaneous inclusion of all terms $\Delta TFN_{i,(t-k)}$ with k in [0, 3] results in a reduced number of observations, since this specification requires subsequent tax footnotes without missing values over t until $t - 4$.

³⁴ The results are tabulated in Tables 12 and Table 13 in the Online Resource.

once. We again find evidence of asymmetric timeliness.³⁵ However, due to the correlation between the $\Delta TOPIC^{UP}$ underlying processes, significance of coefficients decreases.

7.2.4 Inclusion of baseline effects of *POS* and *NEG*

In Eq. 6, we do not include *POS* and *NEG* outside of the interaction terms. Omitting *POS* and *NEG* implies that from an interpretation point of view the direction of change in ETR (i.e. *POS/NEG*) should not impact on the intercept, i.e. the level of the dependent variable $|\Delta ETR_{i,t}|$, ceteris paribus.

To ensure that omitting *POS* and *NEG* does not impact on our results, we repeat our analysis corresponding to Table 6 including *POS* and *NEG*. The coefficients of the interaction terms with *POS* and *NEG* do not significantly differ in economic magnitude or significance.³⁶

7.2.5 Avoidance of a small baseline group

When testing *H1*, we include interaction terms with $\Delta TFN_{i,(t-k)}$ to separate the effects for increases (*POS*) and decreases (*NEG*) in ΔETR . In our baseline specification, $POS_{i,t}$ ($NEG_{i,t}$) is set to one if $\Delta ETR_{i,t} > 0$ ($\Delta ETR_{i,t} < 0$), zero otherwise. In consequence, our baseline group consists of all observations with unchanged ETRs (i.e. firm-years with $\Delta ETR_{i,t} = 0$), containing only 363 firm-years.

To ensure that this small baseline group in our baseline specification does not impact on results, we replicate Table 6 in two separate tests, both without the small baseline group. First, we redefine $POS_{i,t}$ and $NEG_{i,t}$ as follows: $POS_{i,t}$ ($NEG_{i,t}$) is set to one if $\Delta ETR_{i,t} \geq 0$ ($\Delta ETR_{i,t} < 0$), zero otherwise. Hence, we now include all firm-years with $\Delta ETR_{i,t} = 0$ in the group with $POS = 1$, ultimately labeling an unchanged ETR as a form of bad news for the firm. Second, we omit firm-years with $\Delta ETR_{i,t} = 0$. When repeating our analysis with these adjusted samples corresponding to Table 6, regression results remain structurally unchanged.³⁷

7.2.6 Tobit model

The OLS regression model used in our baseline specification allows for predicted values outside the interval $[0,1]$ and, hence, could suffer from functional form misspecification in our data where $|\Delta ETR|$ is limited to $[0, 1]$. Hence, we repeat our analyses using the Tobit Model (not tabulated) and find that the coefficients remain similar in size and significance to our baseline specification when repeating our analysis corresponding to Table 5. Repeating our analysis corresponding to Table 6,

³⁵ The results are tabulated in Table 14 in the Online Resource.

³⁶ The results are tabulated in Table 15 in the Online Resource.

³⁷ The results are tabulated in Tables 16 and 17 in the Online Resource.

we find coefficients similar in size and significance to our baseline regression. Moreover, the coefficient of $\Delta TFN_{(t-3)} \times NEG$ is significant positive.³⁸

7.3 Alternative sample selections

7.3.1 General discussion

The main intention of the following tests is to show that our results are not driven by our sample selection process. In particular, we aim to demonstrate that structural results in significance of coefficients does not change when altering the sample in a reasonable way.

7.3.2 Exclusion of loss firms

In our baseline specification, we exclude all firm-years with negative income before taxes. Since Christensens et al. (2022) demonstrate that most low *ETR* values do not result from tax planning but from large loss carryforwards (negative income before taxes in previous periods), we now instead exclude all firms *i* that experience negative income before taxes at least once in our observation period. The remaining dataset contains 6,695 firm-years from 875 firms when imposing data requirements as shown in Row (1) of Table 2. Repeating our analysis corresponding to Table 5, we still find a significant positive coefficient of $\Delta TFN_{(t-1)}$. In contrast, ΔTFN_t , $\Delta TFN_{(t-2)}$, and $\Delta TFN_{(t-3)}$ are positive but nonsignificant at the 10% level, likely due to the smaller sample size. Repeating our analysis corresponding to Table 6, we again find significant positive coefficients of $\Delta TFN_{(t-1)}$ for increases and decreases in *ETR*. The coefficients of $\Delta TFN_{(t-2)}$ and $\Delta TFN_{(t-3)}$ are nonsignificant, likely due to the smaller sample size.³⁹

7.3.3 Exclusion of the TCJA period

In Fig. 3, we observe a peak in ΔTFN in 2017, which is likely caused by the introduction of the TCJA. We aim to ensure that our results are not driven by the one-time implementation of the TCJA. Hence, we drop all observations from 2017 and 2018. The remaining dataset contains 13,185 firm-years from 2,527 firms. Repeating our analyses corresponding to Table 5 and 6, the results do not significantly differ in economic magnitude or significance.⁴⁰

³⁸ The results are tabulated in Table 18 in the Online Resource.

³⁹ The results are tabulated in Table 19 in the Online Resource.

⁴⁰ The results are tabulated in Table 20 in the Online Resource.

7.3.4 Exclusion of years prior to 2009

In Fig. 3, we observe a structural break for average ΔTFN in 2009; after this date, tax footnotes are considerably less modified per year. We aim to ensure that our results are not driven solely by the pre-2009 period. Hence, we drop all observations from the pre-2009 period. The remaining dataset contains 11,080 firm-years from 2,414 firms. Repeating our analyses corresponding to Table 5 and 6, the results remain structurally unchanged. We do not find any significant coefficients in Column (4), i.e., in $t - 3$, likely due to the smaller sample size.⁴¹

7.4 Alternative specification for ΔETR

In our baseline specification, we use GAAP ETR as our measure of the impact on corporate taxation. We now instead use Cash ETR for the computation of $|\Delta ETR|$. We note that Cash ETR is more volatile than GAAP ETR since tax deferral strategies affect Cash ETR (not GAAP ETR; see Hanlon and Heitzman 2010). Moreover, Cash ETR also reflects the tax benefits of employee stock options but is not impacted by changes in tax accounting accruals (Hanlon and Heitzman 2010) or changes in estimates such as valuation allowance or tax cushion (Dyreng et al. 2008). Repeating our analyses corresponding to Table 5 and 6, results do not significantly differ in economic magnitude or significance.⁴²

7.5 Alternative specifications for ΔTFN

7.5.1 General discussion

We use alternative specifications of ΔTFN . The main intention of these tests is to show that our results are not driven by real changes in business models at the firm level that contain similar information about ETR , as they are contained in the tax footnote, cannot be obtained from other parts of the 10-K.

7.5.2 Relationship between ΔTFN and $\Delta 10K$

We begin our investigation using graphical analysis. Figure 4 shows a hexagonal heatmap of the relationship between $\Delta TFN_{i,t}$ and $\Delta 10K_{i,t}$. The number in each hexagon describes the count of firm-years that are located in each hexagon, treating the data as cross-sectional. The histogram of ΔTFN is included at the top, and the histogram of $\Delta 10K$ is included on the right. The regression line (red solid line) is included with confidence intervals (shaded area).

We observe in Fig. 4 that large ΔTFN values are not associated with large $\Delta 10K$, i.e., the top-right first quadrant of the graph holds almost no observations; there are many more observations in the bottom-right fourth quadrant than in the top-left second quadrant. Correspondingly, the regression line has a slope coefficient close to

⁴¹ The results are tabulated in Table 21 in the Online Resource.

⁴² The results are tabulated in Table 22 in the Online Resource.

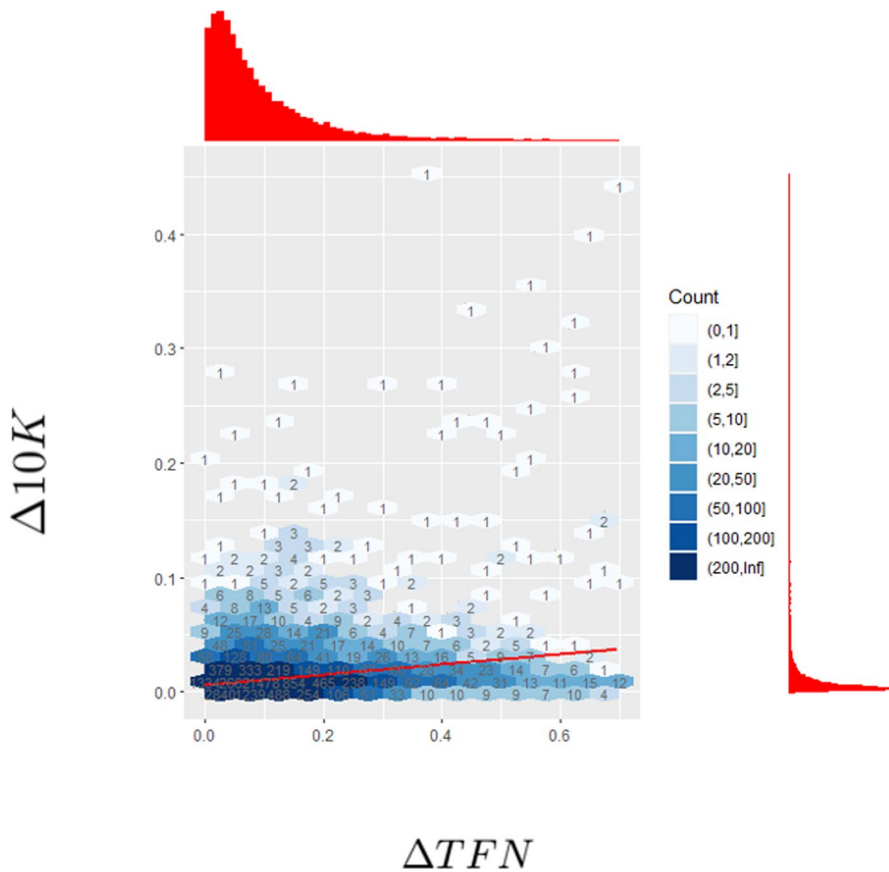


Fig. 4 Relationship between ΔTFN and $\Delta 10K$. This figure shows a hexagonal heatmap of the relationship between ΔTFN and $\Delta 10K$. The number in each hexagon shows the count of firm-years belonging to the corresponding hexagon. The red line represents the corresponding regression line. We print the histogram of ΔTFN at the top and the histogram of $\Delta 10K$ on the right

zero at 0.045, which is significantly smaller than one (p -value=0.000). Note, however, that the 10-K generally holds a relatively large volume of standard text that is hardly ever altered, i.e., $\Delta 10K$ may be expected to be systematically smaller than ΔTFN in absolute terms. In light of this, we create two dichotomous variables that are set to one if the modification in the 10-K or the tax footnote in a given firm-year is above the respective median (25%-percentile) [10%-percentile] and zero otherwise. Pairwise Pearson correlation of these two dichotomous variables is low at 0.21 (0.18) [0.16] and significantly smaller than one (p -value=0.008 (0.008) [0.008]). Overall, we conclude that modifications in the 10-K, which are in essence a firm-level indicator of changes in real business activity, are not a key driver of tax footnote modifications.

7.5.3 Ratio of ΔTFN over $\Delta 10K$

We replace ΔTFN with the ratio $R\Delta TFN$ computed as ΔTFN over $\Delta 10K$. Intuitively, $R\Delta TFN_{i,t}$ measures how strongly firm i modifies its tax footnote relative to the modifications in the entire 10-K between t and $t - 1$. A low $R\Delta TFN_{i,t}$ with a corresponding high $\Delta TFN_{i,t}$ indicates that firms merely modify their tax footnote due to changes in real business activity (such as switching industries or losses). We exclude loss firms, i.e., firms that experience negative income before taxes at least once in our observation period since we expect that losses will also initiate modifications of the 10-K.⁴³ We replicate our analysis corresponding to Table 5 and still find a significant positive coefficient of $R\Delta TFN_{t-1}$. Replicating our analysis corresponding to Table 6, we find only a significant coefficient of $R\Delta TFN_{t-1} \times NEG$, indicating that decreases in ETR are preceded by modifications not associated with real business changes.⁴⁴ This is likely caused by tax avoidance strategies resulting in decreases in ETR.

7.5.4 Modifications of 10-K

We replace ΔTFN with $\Delta 10K$ to again test whether changes in ETR are driven by changes in real business activity. Recall that $\Delta 10K$ is computed by excluding the tax footnote. We exclude loss firms, i.e., firms that experienced negative income before taxes at least once in our observation period since we expect that losses will also initiate modifications of the 10-K.⁴⁵ When replicating our analysis corresponding to Table 5, we observe no significant coefficients for $\Delta 10K_{i,(t-k)}$ with k in $[0, 3]$ at the 10% significance level or lower. This indicates that changes in ETR for non-loss firms are not preceded by significant modifications of the 10-K excluding tax footnotes.⁴⁶ When replicating our analysis corresponding to Table 6, we observe significant positive coefficients for $\Delta 10K_t \times POS$ and $\Delta 10K_t \times NEG$, indicating that increases and decreases in ETR are associated with contemporaneous modifications of the 10-K since changes in ETR will affect cash flows, firm value, etc. Moreover, we find one significant positive coefficient for $\Delta 10K_{(t-1)} \times POS$, indicating that increases in ETR are preceded one period in advance by modifications of the entire 10-K (vs. three periods in advance in the tax footnote).⁴⁷

⁴³ See Sect. 7.3.2.

⁴⁴ The results are tabulated in Table 23 in the Online Resource.

⁴⁵ See Sect. 7.3.2.

⁴⁶ Note that we find significant positive coefficients for $\Delta 10K_{(t-k)} \times POS$ with k in $[0, 3]$ when not excluding loss firms. This is likely caused by increases in ETR after firms have recovered from their losses.

⁴⁷ The results are tabulated in Table 24 in the Online Resource.

7.5.5 Controlling for $\Delta 10K$

Our baseline specification does not control for whether information contained in tax footnote modifications can be obtained from modifications of other parts of the 10-K. To ensure that information in the tax footnote is incrementally predictive of future changes in ETR, we include $\Delta 10K$ as an additional control variable in our baseline specification (note that we do not exclude loss firms as we do above). Replicating our analyses corresponding to Table 5 and 6, regression results do not significantly differ in economic magnitude or significance.⁴⁸ This indicates that the tax footnote contains additional information beyond that in the 10-K, which is relevant for predicting forthcoming changes in ETR.

7.6 Alternative specifications for $\Delta TOPIC$

Methodically, in our word lists technical terms, i.e., multiple word phrases, may be harder to flag in tax footnotes than may single words. Hence, results using $\Delta TOPIC$ may be conditional on the number of technical terms included in each of the word lists for the four *UP*. Hence, we omit all technical terms from the word lists for tax audits, capital structure changes and legislation&litigation.⁴⁹ Then we repeat the analysis corresponding to Table 8, Panels B to D of the manuscript.⁵⁰ Our regression results do not significantly differ in economic magnitude or significance.

8 Conclusion

We contribute to the emerging literature that examines tax disclosures by means of natural language processing. Using a combined dataset of both textual data and financial data for all publicly traded U.S. firms over the period from 2000 to 2021, we confirm that firm-level tax footnote modifications are an early signal of impending changes in ETR. When considering the timeliness of this signal, we find that tax footnote modifications are associated with future changes in ETR of at least three years in advance. Moreover, firms strategically manage tax footnotes as evidenced by the asymmetric timeliness of tax disclosure. Here, we find that tax footnote modifications preceding increases in ETR occur relatively earlier (and are greater) than do (are) tax footnote modifications preceding decreases in ETR. Moreover, we identify relevant underlying processes for these changes in ETR and again investigate asymmetric timeliness conditional on the underlying process.

We conclude that firms may strategically manage their tax disclosure. Our findings specifically support the "accounting conservatism" hypothesis proposed by Basu (1997). In consequence, external stakeholders can in fact use natural language processing to facilitate assessment of future ETR. However, they must also be

⁴⁸ The results are tabulated in Table 25 in the Online Resource.

⁴⁹ There are no technical terms on the word list for tax avoidance, which is taken from Wang (2022).

⁵⁰ The results are tabulated in Table 26 in the Online Resource.

cautious to incorporate asymmetric timeliness when investigating the early signal of tax footnote modifications.

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