Stock Price Informativeness and Corporate Tax Avoidance

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Abstract

We show that private information incorporated by outside investors into stock prices has an economically significant effect on the sensitivity of corporate tax avoidance to stock price. Corporate tax avoidance is much more sensitive to stock price when the price contains new information to managers. The result holds after accounting for endogeneity employing an exogenous policy shock as a quasi-experiment as well as an instrumental variable approach. The managerial learning effect is robust to the inclusion of a battery of alternative channels including managerial private information, various sources of public information, and firms' financial constraints. Furthermore, the effect is stronger for firms with foreign operations. Overall, the results suggest that managers learn from the private information in stock prices and incorporate this information into their corporate tax avoidance decisions.

JEL classification: G14; G31; G32

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1. Introduction

Do managers learn from stock markets when avoiding corporate taxes? There is ample evidence that corporate income tax structure affects investment decisions and that managers learn from their stock prices. However, the relation between managerial learning from prices and corporate tax avoidance decisions has been relatively underexplored. Hall and Jorgenson (1967) were the first to show that firms alter their investment behavior depending on tax policies. Firms may invest in a tax-preferred asset that provides a higher after-tax return even if the pre-tax return of this asset is lower than that of a fully taxed asset of identical risk (Scholes and Wolfson 1992).[1] Firms also avoid taxes to obtain cash savings, especially valuable when firms are financially constrained and future financing is not frictionless (Gamba and Triantis 2008; Riddick and Whited 2009; Graham et al. 2017).

We posit that a firm's corporate tax avoidance strategies are implemented in conjunction with its policies on corporate investment and cash holdings. Previous studies show that managers learn external information from their stock price and incorporate this information to their decisions on corporate investments and cash savings (Chen et al. 2007; Fresard 2012).[2] Stock prices aggregate diverse pieces of information through the trading activity of many different investors. As a result, stock prices may contain private information that managers do not possess. Market prices may, for example, contain specific information about firm fundamentals such as the firm's growth prospects and future external financing costs, the firm's reputation in capital and product

[1] Hanlon and Heitzman (2010) provide an excellent review of tax research. For a more recent review of this literature, see Wang et al. (2020). Several studies examine the effect of taxes on investment location decision, foreign direct investment, and corporate mergers and acquisition decisions (Maydew 2001; Cloyd et al. 2003; Shackelford et al. 2011; Djankov et al. 2010; and Graham et al. 2014).

[2] Durnev, Morck, and Yeung (2004) find that firms' capital investments are more efficient and value-enhancing when stock price is more informative. Luo (2005) shows that that merging firms extract information from stock prices. Bakke and Whited (2010) confirm that managers incorporate private investor information when making investment decisions. Mathers et al (2017) find that firms' innovation outcomes improve with price informativeness.

markets, and other strategic issues involving the firm's relationship with various stakeholders.[3] To the extent that stock prices convey useful new information to managers, this information will also guide managers' decisions on tax avoidance together with other corporate decisions and therefore, affect the sensitivity of firms' tax avoidance to the stock price.

Tax-avoiding firms engage in activities that, in general, represent a continuum of tax planning strategies from investing in municipal bonds to sheltering taxes through investing in projects with tax credits or operating in international tax havens (Hanlon and Heitzman 2010). These firms provide necessary incentives for managers to obtain technical skills and expertise in tax planning such as hiring tax directors or external auditors to reduce the level of corporate tax expenses (Armstrong et al. 2012; Huseynov and Klamm 2012). Additionally, institutional investors such as hedge funds can provide such expertise to firm managers to increase the value-efficiency of tax avoidance (Cheng et al. 2012). These investors may also introduce incentive mechanisms for managers to avoid more taxes to increase firm value. For example, Khan et al. (2017) show that institutional investors are unlikely to "explicitly" promote tax avoidance, but managers "deliver" tax avoidance when institutional ownership increases. However, these efforts may not be sufficient to equip managers with all the necessary tools to avoid taxes optimally. Stock prices may reflect new information that is not readily available for managers. The nature of this incremental new information to managers may be diverse and relevant to corporate tax avoidance for several reasons.

First, avoiding corporate taxes entails making specific investment decisions. According to the "economic substance doctrine" in tax law, the tax strategy must have a valid business purpose

[3] Dow and Gorton (1997) and Subrahmanyam and Titman (1999) theoretically show that managers can use the information they infer from their stock prices to improve the efficiency of their corporate decisions and thus enhance the value of their firm. See also Dye and Sridhar (2002) and Goldstein and Guembel (2008).

and economic substance other than financial accounting benefits that arise solely from tax savings (Scholes et al. 2014). In Graham et al. (2014), which surveys corporate tax executives, 86 percent of respondents state that the most important reason for not implementing a tax strategy is because the transaction lacked business purpose or economic substance. Stock prices may contain specific information that may help managers to assess the economic substance of their tax-preferred investment decisions. By learning this information, managers can reduce the probability of facing challenges and potential denial of future tax benefits by the IRS.

Second, one reason why firms engage in less tax avoidance is related to concerns regarding agency issues and reputational matters. Firms are concerned that engaging in tax avoidance is potentially harmful to firm reputation and may lead to negative publicity and backlash by stakeholders (Huseynov and Klamm 2012; Graham et al. 2014). While Gallemore et al. (2014) do not find evidence that reputation significantly influences the likelihood of tax shelter usage, Khurana and Moser (2013) show that firms with long-term institutional shareholders engage in less tax avoidance, especially if such activities encourage managerial opportunism and reduce transparency. It is possible that managers obtain some relevant information from the markets prior to avoiding taxes and do not engage in tax avoidance to the extent that it would exacerbate agency costs or harm the firm's reputation. We consider this possibility given the increased public scrutiny, at least, over the question whether large firms pay their fair share of taxes.

Third, firms avoid taxes to achieve financial flexibility through tax savings. Prior literature shows that one of the reasons for cash hoarding is to finance future investment projects in the presence of capital market frictions (Almeida et al. 2004; Acharya et al. 2007). The value of cash holdings increases especially when firms are financially constrained and future external financing is uncertain (Gamba and Triantis 2008; Denis and Sibilkov 2010; Fresard 2012). Investing in tax-

efficient assets enables a firm to funnel some of the cash tax savings into liquid assets that can later be turned into physical investments. Therefore, if prices are more informative about the productivity of future investments when future financing is not frictionless, managers will adjust their propensity to obtain cash savings through corporate tax avoidance based on the information they learn from market prices.

Therefore, we argue that a firm's decision to avoid corporate taxes is intertwined with the firm's investment policies, motivations to save cash, and managers' assessment of potential direct and indirect costs of tax avoidance. To the extent that managers can learn from stock prices necessary information about future strategic issues, including stakeholders' perception of tax avoidance, managerial learning from stock prices should also determine the manager's propensity to engage in corporate tax avoidance.

We follow the methodology of Chen et al. (2007) and Fresard (2012) and examine how the informativeness of stock prices affects the sensitivity of tax avoidance to stock price. According to the learning hypothesis, when managers decide on the optimal level of corporate tax avoidance, they will use all the information available to them. This includes both the information aggregated in the stock price and managers' private information that has not yet been incorporated into the price. Managers are more likely to learn from stock prices when the price conveys more investors' private information new to managers. Therefore, tax avoidance should be more sensitive to stock price when it contains a larger fraction of investors' private information.

We start our analysis of the empirical relation between price informativeness and corporate tax avoidance in a panel regression framework with firm fixed effects and industry-by-year fixed effects. Using firm fixed effects addresses potential endogeneity concerns that may arise due to unobservable time-invariant firm characteristics (omitted variables) which could affect both stock

price informativeness and tax avoidance behavior. We use a large sample of U.S. firms over the period 1970-2018. Following prior literature, we use stock price nonsynchronicity as the measure of price informativeness. This measure was first developed by Roll (1988) to capture stock return variation that is not explained by market and industry fluctuations. Several studies have used this measure and related stock price informativeness to corporate investment decisions (Durnev et al 2003, 2004; Chen et al. 2007; Mathers et al. 2017). We construct firms' tax sheltering propensity to measure firms' inclination to avoid corporate taxes. As noted in Wilson (2009), tax sheltering reflects more aggressive tax avoidance strategies, but could be associated with wealth creation for shareholders if coupled with proper governance. We also employ firms' long-term cash effective tax rate (ETR), following the extant literature (Dyreng et al. 2008; Koester et al. 2017), as an alternative measure for tax avoidance. Compared to tax sheltering, ETR is an aggregate measure for firms' actual tax paid, and a lower value in ETR indicates greater corporate tax avoidance.

In the first set of results, we find that corporate tax avoidance is positively and significantly associated with stock price, as measured by Tobin's Q. This suggests that firms actively incorporate information from stock prices into their tax avoidance strategies. Furthermore, firms tend to avoid taxes more when stock price contains a greater amount of private information from investors. We show that the price informativeness measure has a significantly positive effect on the price sensitivity of tax avoidance (a greater likelihood of tax sheltering and lower Cash ETRs). This result suggests that stock prices reflecting greater private information transmit useful new information to managers and affect their tax avoidance behavior. Managers learn from this private information and choose to engage in greater tax avoidance.

We recognize in our empirical analysis that unobservable omitted factors (that vary over time) might affect both stock price informativeness and corporate tax avoidance decisions. It is

also conceivable that a firm's tax avoidance behavior may obscure the information content of its stock price and change the level of private information reflected in the stock price, indicating reverse causality. We address the endogeneity concerns using two approaches. First, we employ an exogenous liquidity-increasing shock, the 2001 decimalization for NYSE and Nasdaq firms, as a quasi-experiment to conduct a difference-in-differences analysis. We find that firms that saw the largest change in stock price informativeness exhibit more pronounced increase in the tax avoidance-to-price sensitivity post the event. Most importantly, it is convincing that firms' tax avoidance level is unlikely to predict the introduction of this market-wide reform in stock exchanges.

Second, we account for endogeneity by implementing an instrumental variable (IV) approach with two-stage least squares (2SLS) method. Finding a valid instrument is usually challenging. We instrument stock price informativeness by the Autoquote introduction to NYSE listed firms (following Hendershott et al. 2011). The introduction of Autoquote, which exogenously increases algorithm trading, should directly affect the informativeness in stock prices (Hendershott et al. 2011). Our first-stage IV analysis results indicate that the instrument is unlikely to be weak and there is strong reason to believe that the introduction of Autoquote is not related with firms' tax avoidance. The 2SLS results are consistent with the hypothesis that managers use the private information reflected in the stock price when they make decisions to avoid taxes.

One potential concern is that firm managers may already possess sufficient information about the future benefits and costs of tax avoidance and the information embedded in stock price may not be new to managers. Therefore, we conduct several tests to rule out other possible channels and confirm the robustness of the managerial learning channel. Because the information available to managers is difficult to observe, we use several variables to disentangle managerial

information from new information embedded in prices. First, we investigate the role of managers with greater ability to allocate resources. Koester et al. (2017) show that managers with superior ability avoid corporate taxes more. We use the managerial ability measure developed by Demerjian et al. (2012) in our analysis. We find that the impact of prices on corporate tax avoidance is lower in firms with higher managerial ability. A negative impact is expected because managers who are better at allocating corporate resources possess more information and rely less on the information in stock prices for their tax avoidance decisions. More importantly, we find that the effect of stock price informativeness on the sensitivity of corporate tax avoidance to price is still positive even after controlling for managerial ability. Thus, tax avoidance is more sensitive to stock price when the price contains a larger amount of private information in firms with lower managerial ability.

Next, to examine the effect of private information in price that is not otherwise available to managers on the sensitivity of corporate tax avoidance to price, we control for the stock's overall liquidity and the degree of public information in the equity market. We use the bid-ask spread as a measure of both the market liquidity of the stock and the extent of public information reflected in stock price. We also use analyst coverage as an alternative measure of public information. Financial analysts mostly serve as information conduits between firms and investors, so that their presence implies less new information conveyed in stock price to managers. We find that, after controlling for bid-ask spread and analyst coverage, private information in stock price that is new to managers is still positively associated with the sensitivity of tax avoidance to price.

Third, financially constrained firms may engage in tax planning as a source of funds. In our setting, the tax avoidance-to-price sensitivity may depend on the extent of financial constraints they face. Accordingly, we test how financial constraints affect the tax avoidance-to-price sensitivity using two commonly used constraint measures, Altman Z score and WW score. Our

findings suggest that current financial constraints weaken the effect of private information on the sensitivity of tax avoidance to price. We interpret this as evidence that current financial constraints may impose some restrictions on managerial propensity to avoid taxes and supersede the effect of managerial learning from stock prices. This is consistent with Bayar et al. (2018) that greater tax avoidance may further exacerbate financial constraints.

Lastly, we conduct two extended tests to solidify the learning effect we proposed. First, sorting the full sample into quartiles based on private information and run the model separately for each quartile-based subsample, we find that the sensitivity of tax avoidance to price is stronger with higher levels of private information. These results suggest that managers learn more regarding their tax avoidance activities when there is more private information contained in the market price.

Furthermore, we conduct a cross-sectional test and find that the positive sensitivity of corporate tax avoidance to price informativeness is greater in magnitude for firms with for firms with foreign operations. These findings are consistent with the observation that firms with global operations have a larger number of tax avoidance tools available to them. In addition, learning private information from stock prices may be more valuable for these firms given their need to guide themselves when making global capital investment decisions.

Our paper contributes to the literature in three important ways. First, we document that managers learn from stock prices when making decisions related to corporate taxes. This is a new channel through which stock prices affect managerial actions and to our knowledge, ours is the first study to link corporate tax avoidance to price informativeness. Our findings also show that managers may improve the value efficiency of their tax avoidance decisions based on the feedback they receive from stock market investors through the stock price.

Second, the prior literature on corporate tax avoidance links managerial decisions regarding taxes to various factors, such as managerial incentives, ownership structure, financial constraints, and firm-specific factors. We focus on the informational role played by stock prices and show that one of the driving factors behind corporate tax avoidance is managerial learning from the information embedded in stock prices. In addition, there is a longstanding debate on why firms "under-avoid" taxes (Weisbach 2001; Desai and Dharmapala 2006; Hanlon and Heitzman 2010; Gallemore et al. 2014). Our results show that managerial decisions to avoid taxes are related to information managers glean from stock markets. It is possible that the information that is received by the managers of under-avoiding firms do not clearly convey the value efficiency of tax avoidance, hence curbing their propensity to avoid taxes.

We also contribute to the literature that analyzes how stock prices affect corporate decisions (e.g., Barro 1990; Morck et al. 1990). The paper is related to the growing empirical literature on managerial learning channels: the role of private information in stock prices (e.g., Chen et al. 2007), the informativeness of peers' stock prices (e.g., Foucault and Fresard 2014; Dessaint et al. 2019), firms' capital constraints (e.g., Baker et al. 2003) in driving the investment-to-price sensitivity of firms. We contribute to these studies by showing that stock prices produce new information to managers and increase the efficiency of corporate tax avoidance decisions.

The rest of the paper is organized as follows. Section 2 presents the empirical methodology and describes the sample and the variables. Section 3 discusses the empirical findings of the baseline results as well as the channel tests. Section 4 reports the additional analyses. Finally, Section 5 concludes.

2. Data and Variables

The data used in this study are aggregated from several sources. We draw firms' financial characteristics from Compustat and stock price information from CRSP. The analyst coverage data is available from I/B/E/S. Following the prior tax planning literature, firm-year observations with missing total assets and those with missing or non-positive pretax income are dropped. We also eliminate financial firms and utility firms (SIC codes 4000-4999 and 6000-6999). Our sample consists of 39,425 firm-year observations for US publicly listed firms from 1970 to 2018.

2.1 Tax Avoidance Measures

Our main measure of corporate tax avoidance is the tax sheltering propensity. Following Wilson (2009), we estimate the propensity of firms to engage in tax sheltering based on the shelter probability computed by using the estimates from the following logit regression model:

$$Shelter\ Prob. = -4.30 + 6.63 \times BTD - 1.72 \times Lev + 0.66 \times Size + 2.26 \times ROA + 1.62 \times FI + 1.56 \times RD \quad (1)$$

where *BTD* is the book tax difference, *Lev* is the long-term debt scaled by total assets; *Size* is the log of total assets; *ROA* is the net-income scaled by total assets; *FI* is a dummy variable, coded one for firms with foreign income and zero otherwise; and *RD* is the research and development expenses scaled by total assets. We follow Rego and Wilson (2012), Hoi, Wu, and Zhang (2013), and Khurana and Moser (2013) and construct a dummy variable, *Tax Sheltering*, that equals one if a firm's estimated shelter probability belongs to the top quartile and zero otherwise.

We also use the *Long-term Cash ETR*, estimated as the five-year-centered moving sum of cash paid for income taxes over five years scaled by the sum of pretax income (net of special items) over the same period (see Dyreng et al. 2008), as an alternative measure for tax avoidance. As noted by Koester et al. (2017), *Cash ETR* reflects permanent and temporary tax deferral strategies, which retains cash resources within the firm. Compared to the short-term *Cash ETR*, our measure

generates an effective cash tax rate that more closely tracks the firm's tax costs over the long run, and it avoids year-to-year volatility in annual ETRs. We note that our results do not qualitatively change when we employ the one-year *Cash ETR*. Firms that conduct more tax avoidance activities should have higher tax sheltering propensity and lower ETRs.

2.2 Price Informativeness Measures

Our empirical analysis is focused on managers learning from private information in prices in tax management. We use price nonsynchronicity to determine the extent of private information contained in stock prices. Roll (1988) introduced this measure as an indication of private information and empirically demonstrated that price nonsynchronicity has only a very small correlation with public news. Subsequent studies find additional evidence that price nonsynchronicity measures more private information than just noises (Durnev et al. 2003; Durnev et al. 2004). Therefore, many empirical studies use price nonsynchronicity to measure private information in stock prices (Chen, et al. 2007; Ferreira and Laux 2007; Ferreira et al. 2011; Fresard 2012; Mathers et al. 2017). We compute this measure by estimating 1-R^2, where R^2 is the R-square from the following regression:

$$r_{i,j,t} = \beta_{i,0} + \beta_{i,m} \times r_{m,t} + \beta_{i,j} \times r_{j,t} + \varepsilon_{i,t}, \quad (2)$$

where $r_{i,j,t}$ is the return of firm *i* in industry *j* at time *t*, $r_{m,t}$ is the market return at time *t*, and $r_{j,t}$ is the return of industry *j* at time *t*. The idea is that if a firm's stock return is less correlated with the market and industry returns, then the firm's stock price is more likely to convey firm-specific information, which is useful for managerial tax planning decisions. Thus, a higher value in 1-R^2 should indicate more private information impounded in stock prices (Roll 1988; Chen et al. 2007).

2.3 Managerial Ability Measures

We measure *Managerial Ability* by the MA-Score developed in Demerjian et al. (2012). The measure is constructed using a two-stage approach as the first stage uses data envelopment analysis (DEA) to capture how efficiently firm resources are managed to generate revenues relative to a firm's industry competitors. This is achieved by optimizing total sales using the vector of inputs including cost of goods sold, SG&A, net PP&E, operating leases, R&D, purchased goodwill and intangibles.

$$max\ \theta_t = (Sales_t) \cdot (v_1 COGS_t + v_2 SG\&A_t + v_3 PPE_t + v_4 OpsLease_t + v_5 R\&D_t + v_6 Goodwill_t + v_7 OtherIntan_t)^{-1} \quad (3)$$

The DEA optimization determines a firm-specific vector of optimal weights on the seven input variables by comparing the inputs of firm *i* to the inputs of all other firms within the same industry-year and computes a firm efficiency score θ that takes a value between 0 (least efficient firms) and 1 (most efficient firms). The second stage isolates the portion of the efficiency score attributable to managerial ability by estimating the following cross-sectional regression on firm-year level:

$$\theta_{i,t} = \alpha_0 + \beta_1 \cdot \ln(Total\ Assets_{i,t}) + \beta_2 \cdot Market\ Share_{i,t} + \beta_3 \cdot Positive\ Free\ CF_{i,t} + \beta_4 \cdot \ln(Age_{i,t}) + \beta_5 \cdot Business\ Segment\ Concentration_{i,t} + \beta_6 \cdot Foreign\ Currency\ Indicator_{i,t} + Year\ FEs + \varepsilon_{i,t} \quad (4)$$

Managerial Ability is constructed using the unexplained portion of θ, e.g., the residual of this regression, ranked with its industry peers. Unlike other measures of managerial ability used in prior literature (e.g., longer CEO tenure, higher CEO pay, higher historical stock and accounting

performance, more CEO media mentions, etc.), this measure directly captures executives' capability to manage resources efficiently.

2.4 Other Variables

We control for several firm level characteristics. *Firm Size* is the natural logarithm of total book assets. *ROA* is net income divided by firm's book assets. *EBIT/Sale* is the firms' EBIT scaled by total sales revenue. *Leverage* is the sum of long-term and short-term debt scaled by firm's book assets. *Cash Holdings* is the balance of cash scaled by firm's book assets. We measure firm's capital intensity by *Capital Expenditure*, which is firm's capital expenditure scaled by book assets. We measure the firm's earnings quality by *Discretionary Accruals*. Following Hong et al. (2014), we estimate the absolute value of discretionary accruals using the performance-controlled cross sectional modified Jones (1991) model to control for aggressive financial reporting practices (Kothari et al. 2005). Larger values in *Discretionary Accruals* indicate higher earnings management and lower earnings quality. We also construct an *Earnings Volatility* measure as the standard deviation of its operating income over the last five years scaled by book assets. We additionally control for firm's operating cash flow (*Net Operating Loss*), cash dividend (*Dividend Payer*), and tangible asset ratio (*Tangibility*). Definitions of all the variables are provided in Appendix I.

In our extended tests, we control for public information using *Analyst Coverage*, which is the number of analysts covering the firm *i* in year *t*. We measure market liquidity using the bid-ask spread.[4] We use two measures of financial constraints suggested by the prior literature. The

[4] Bid-ask spread is calculated as (Ask-Bid)/(midpoint of ask and bid price) from CRSP.

first is Altman Z score based on Altman (1968).[5] The second measure is WW score based on White and Wu (2006).[6] Lastly, firms with tax avoidance incentives may intentionally allocate portions of assets overseas to exploit jurisdictional variance in tax rates. We create a dummy variable, *Foreign Income* indicating if the firm has foreign earnings in year t.

2.5 Summary Statistics

We report the summary statistics of all variables in Table 1. The mean value in *Tax Sheltering* is 0.327, comparable with descriptive statistics reported in prior studies (Khurana and Moser, 2013; Bayar et al. 2018). The mean *Long-term Cash ETR* in our sample is 26.3 percent (median is 26.1 percent), which is consistent with descriptive statistics in relative studies (Dyreng et al. 2010; Edwards et al. 2016; Koester et al. 2017).[7] The mean value in $1\text{-}R^2$ is 0.814, indicating that on average, the market and industry returns can explain only about 20 percent of firms' return variations, consistent with Chen et al. (2007). The average Q in our sample is 2.24. The mean value in *Managerial Ability* is about 0.02, which is comparable with the MASCORE in Koester et al. (2017).

[Insert Table 1 about here]

[5] Altman Z-Score is modeled as 1.2*(working capital / total assets) + 1.4*(retained earnings / total assets) + 3.3*(earnings before interest and tax / total assets) + 0.6*(market value of equity / total liabilities) + 1.0*(sales / total assets).

[6] WW score is modeled as -0.091*(cash flow/total assets) - 0.062*positive dividend + 0.021*(long-term debt/total assets) - 0.044 * (log of total assets) + 0.102*industry sales growth-0.035 * firm sales growth. Positive dividend is an indicator that equals 1 if the firm pays cash dividends.

[7] This rate is much lower that the statutory federal tax rate of 35 percent. In dollar terms, reducing tax liability by 1% of pretax income of an average firm can result in savings of about $3.2 million per year (mean pretax income in our sample is about $320 million). For most profitable firms, tax savings from a similar reduction in the tax rate may amount as high as $280 million during a year. Thus, saving cash taxes by a few percentage points can have a significant positive impact on a firm's financial flexibility.

Table 2 presents the Pearson correlations between variables. We find a significant negative relation between ETR and *Q*, indicating that corporate tax avoidance is positively related to stock prices. On the other hand, tax sheltering is negatively correlated with $1\text{-}R^2$, implying that greater price informativeness is associated with lower corporate tax avoidance. Most of the firm characteristics exhibit significant correlations with our tax avoidance measures, highlighting the importance of controlling for these variables in our multivariate analysis.

[Insert Table 2 about here]

3. Empirical Design and Results

3.1 Baseline Results

In this section, we empirically assess the hypothesis that managers learn from the private information in stock price when they make tax planning decisions. We perform panel regressions at the firm-year level to examine the effect of private information on the sensitivity of corporate tax avoidance to price. Our baseline regression is as follows:

$$Tax\ Avoidance_{i,t} = \alpha_0 + \beta_1 \cdot Q_{i,t} + \beta_2 \cdot (1 - R^2)_{i,t} + \beta_3 \cdot (1 - R^2) \cdot Q_{i,t} + \gamma \cdot X'_{i,t} + Firm\ FEs + Industry * Year\ FEs + \varepsilon_{i,t} \quad (5)$$

The dependent variables are corporate tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. *Q* represents the firm's stock price. $1\text{-}R^2$ is our measure for price informativeness and captures private information contained in prices. $(1\text{-}R^2)*Q$ is their interaction and our independent variable of interest. $X'_{i,t}$ stands for the set of firm characteristics presented in Table 1. We also control for firm fixed effects and industry-by-year fixed effects. All continuous variables

are winsorized at the 1% and 99% levels and standard errors are clustered at the firm level to reflect the dependencies of observations that belong to same firms.

Table 3 reports our baseline regression estimates. We first investigate whether managers learn from stock prices to conduct tax avoidance activities by estimating the Eq.5 without interactions. In columns (1) and (2), we find that tax avoidance is positively associated with stock price, as the coefficient for *Q* in the model estimating *Tax Sheltering* is significantly positive and the coefficient for Q in the model estimating ETR is significantly negative. The coefficients are statistically significant at 1%. This finding confirms our hypothesis that managers learn from stock prices to invest more in tax efficient assets. Our variable of interest is $(1\text{-}R^2)*Q$, which measures how firm-specific information in stock price that is new to managers affects the sensitivity of tax avoidance to stock price. In column (3), the coefficient for $(1\text{-}R^2)*Q$ is significantly positive at the 1% level in the model featuring *Tax Sheltering*, and in column (4), the coefficient for $(1\text{-}R^2)*Q$ is significantly negative at the 1% level in the model featuring *Long-term Cash ETR*. The findings suggest that tax avoidance is more sensitive to stock price when the stock price contains a larger amount of private information that is new to managers. For instance, the tax avoidance-to-price sensitivity will increase by 37 percent if a firm's $1\text{-}R^2$ increases from a median value (0.888) to a 75th percentile value (0.962). In other words, managers obtain larger corporate tax savings following a positive shock to Tobin's Q (stock price) when this signal contains a larger amount of investors' private information.[8]

[Insert Table 3 about here]

[8] Our findings are qualitatively similar when we use the probability of informed trading (PIN) measure developed in by Easley, Hvidkjaer, O'Hara (2002) and estimated by Brown and Hillegeist (2007). Their updated PIN estimate covers our sample period from 1993 to 2010. The results are available upon request.

3.2 Difference-in-Differences Analysis

Endogeneity concerns may arise in multiple ways in the relation between price informativeness and the tax avoidance-to-price sensitivity. We note that the potential endogeneity problem where price informativeness and tax avoidance-to-price sensitivity are jointly determined could be mitigated by using the fixed effects regression method. Firm fixed effects address endogeneity concerns in which unobserved time-invariant firm-specific variables simultaneously determine both price informativeness and tax avoidance-to-price sensitivity. This is also equivalent to looking only at within-firm changes in price informativeness $1\text{-}R^2$.[9] Industry-by-year fixed effects could also alleviate omitted variables concerns where time-varying industry-specific factors drive both firm's stock price informativeness and tax avoidance intentions.

To further mitigate endogeneity concerns, we employ one exogenous liquidity-improving shock – the decimalization of quoted prices in the U.S. exchanges in 2001. The 2001 decimalization of quoted stock prices enables trading at minimum price increments of $0.01 compared to $1/16, or $0.0625 before the reform. Decimalization started on January 29, 2001 for NYSE stocks and on April 9, 2001 for Nasdaq stocks. Bessembinder (2003) documents a substantial decline in quoted and effective bid-ask spreads after decimalization and it was greater for stock that had narrower spreads for which decimalization relaxed the lowest bound constraint. Since several relative studies noted that price informativeness measures captures stock illiquidity, and both have similar explanatory power for cost of equity (Duarte and Young, 2009; Bakke and Whited, 2010; Ferreira, et al., 2011; Balakrishnan et al., 2014), we thus expect that stocks with the largest change in their price informativeness should experience a greater increase in their price

[9] Another approach to alleviate endogeneity concern is to use lagged price informativeness and explanatory variables. In unreported tests, our findings confirm a positive enhanced relation between price informativeness and tax avoidance-to-price sensitivity.

sensitivity of tax avoidance. Therefore, we use this reform as a quasi-experiment in a difference-in-differences specification estimated using the below equation:

$$Tax\ Sheltering_{i,t} = \alpha_0 + \beta_1 \cdot Post\ 2001 + \beta_2 \cdot Post\ 2001 \cdot Treatment + \beta_3 \cdot Post\ 2001 \cdot Treatment \cdot Q + \beta_4 \cdot Q + \beta_5 Post\ 2001 \cdot Q + \beta_6 Treatment \cdot Q + \gamma \cdot X'_{i,t} + Firm\ FEs + Industry * Year\ FEs + \varepsilon_{i,t} \quad (6)$$

The sample window for this study is 1991-2011. We select the treatment group as the firms that saw the above-median change in stock price informativeness (*1-R^2*) pre-2001 and the control group is vice versa. Alternatively, we designate the treatment group as the firms that saw the largest change (top quartile) in stock price informativeness (*1-R^2*) pre-2001 and the control group as the firms that saw the least change (bottom quartile) in stock price informativeness (*1-R^2*) pre-2001. We are interested in the coefficient β_3 on the triple interactions $Post\ 2001 \cdot Treatment \cdot Q$, which is expected be positive if the tax avoidance-to-price sensitivity is enlarged for the most informative firms post the reform.

The results of the difference-in-differences regressions are reported in Table 4. We find positive coefficients on $Post\ 2001 \cdot Treatment \cdot Q$ in both models, and the coefficients are significant at 5% level (t=2.416 and 2.089 respectively). This is also economically meaningful, given that compared with the below-median informative stock before the reform, firms with the above-median price informativeness witnessed a 25-percentage increase in their tax avoidance-to-price sensitivity after the reform. This finding reinforces our hypothesis that managers acquire more private information from stock prices regarding their tax avoidance decisions when prices become more informative.

[Insert Table 4 about here]

3.3 Instrumental Variable Analysis

Furthermore, we conduct an instrumental variable (IV) analysis using the two-stage least squares (2SLS) regression method to directly address the potential endogeneity of price informativeness. The instrumental variable analysis allows us to mitigate omitted variable biases that vary with time and potential reverse causality from tax avoidance to stock price informativeness. Finding a valid instrument is challenging in that we require the instrument to be correlated with price informativeness but uncorrelated with tax avoidance. We instrument (1-R2) by the instruction of Autoquote to NYSE listed firms.[10] Autoquote is a structural change in NYSE market, and according to Hendershott et al. (2011), it exogenously causes increase in algorithm trading and as a result improves market liquidity and affects informativeness in stock quotes. We create an indicator variable *Event* that equals zero for the years before the Autoquote introduction and one afterwards, and another indicator variable *Treatment* that equals one for NYSE-listed firms and zero for Nasdaq listed firms. The instrument is *Event*Treatment*. While Autoquote strongly impacts stock price informativeness, there is no theory or evidence suggesting that Autoquote affects firms' tax avoidance level. Hence, we believe this instrument meets both the relevance and exclusion restrictions.

Our 2SLS regression results are presented in Table 5. In each model, we first regress the endogenous variable ($1\text{-}R^2$) and its interaction $(1\text{-}R^2)*Q$ on the instrumental variables *Event*Treatment* and *Event*Treatment*Q*, together with other control variables. In the first stage regressions, consistent with our expectation, we document a significant relation between our instruments and the endogenous variables. The first-stage F-statistics are significantly large

[10] The NYSE began to phase in the Autoquote software on January 29, 2003, starting with six active, large-cap stocks. During the next 2 months, over 200 additional stocks were phased in at various dates, and all remaining NYSE stocks were phased in on May 27, 2003.

rejecting the null hypothesis that the instruments are weak. In the second stage regression, we are still able to find a positive relation between private information in prices and tax avoidance-to-price sensitivity. The coefficient for the instrumented $(1-R^2)*Q$ is 0.128 with a t-statistic of 2.26, suggesting that managers learn from stock prices to conduct tax sheltering when there is more private information contained in prices. Moreover, we note that Sargan-Hansen statistic for overidentifying test is 3.62, which indicates we cannot reject the joint null hypothesis that the instruments are valid instruments (uncorrelated with the error term). The results are also robust when we include additional firm characteristics, firm fixed effects and industry-by-year fixed effects. Taken together, our baseline results and endogeneity tests support the hypothesis that managers use part of the private information embedded in stock price when they make tax avoidance decisions.

[Insert Table 5 about here]

3.4 Alternative Channels

To lend further support for the findings in our baseline results above, in this section, we extend the empirical analysis by also controlling for alternative channels that might also affect the tax avoidance-to-price sensitivity.

3.4.1 Controlling for Managerial Ability

Koester et al. (2017) argue that executives with greater ability to manage resources efficiently engage in greater corporate tax avoidance. High-ability managers have a superior understanding of their firms' operating environment, enabling them to better align business decisions with tax strategies and identify tax saving opportunities. Therefore, we test whether the

previous results are robust to the insertion of the managerial ability proxy in the baseline specification (Eq. 5) and estimate its effect on the estimated tax avoidance-to-price sensitivity.

The results are reported in Table 6. We use the *Managerial Ability* variable following the methodology of Demerjian et al. (2012) as described in Section 3.3. We find that *Managerial Ability* is significantly positively related to tax sheltering and significantly negatively associated with long-term cash ETR. This is consistent with the finding of Koester et al. (2017) that managers with superior ability engage in more tax planning activities. Notably, the coefficients of *Managerial Ability*Q* are significantly negative in the model featuring *Tax Sheltering* and significantly positive in the models featuring *Long-term Cash ETR*. This negative effect of *Managerial Ability* on tax avoidance-to-price sensitivity is consistent with the notion that when managers possess superior ability, they rely less on the information in stock price in their tax planning decisions and the marginal learning effect is smaller. We conclude that our main results are robust to the inclusion of managerial ability.

[Insert Table 6 about here]

3.4.2 Controlling for Public Information

So far, our results are consistent with the prediction that managers learn some private information from prices and use this information in their tax planning activities. However, the significant association we document would only be reflective of managerial learning to the extent that the private information in price is *new* to managers (they have not learned it elsewhere). Testing this hypothesis is difficult because we do not directly observe the information set used by managers for their tax management decisions. However, to overcome this potential problem of identification, we gauge whether other competing sources of information affect the tax avoidance-

to-price sensitivity. We expect that the extent of available public information attenuates the sensitivity of tax avoidance to stock price because managers already know this information through other channels. To test this conjecture, we first measure the public information contained in market liquidity captured by bid-ask spread. *BA Spread* is calculated by the spread between the bid and ask price scaled by the midpoint and reflects the market liquidity of the stock.

We report this result in Panel A of Table 7. As shown in columns (3) and (4), the *BA Spread* is significantly positively associated with tax sheltering. This indicates lower market liquidity is associated with greater corporate tax avoidance (higher values in *BA Spread* indicates lower market liquidity). Furthermore, the coefficients for *BA Spread*Q* are significantly positive in the model characterizing tax sheltering and significantly negative in the model characterizing *Cash Long-run Cash ETR*. This finding implies that the price sensitivity of tax avoidance is attenuated when managers learn from other (public) information channels, specifically the observed liquidity reflected by order flows (when investors have more information, the order flows tend to increase, and this consequently increases the stock's market liquidity and lowers the bid-ask spread).

Our second measure to quantify public information is the number of analysts covering a firm, which constitutes an important source of information in financial markets. The effects of analyst coverage may arise in two opposite ways. If the information produced by analysts and impounded in the stock price is new to managers, we should expect a positive relation between analyst coverage and tax avoidance-to-price sensitivity. A more commonly held view is that if analysts mainly transfer information from managers to investors, the content of information they release is unlikely to be new to managers (Chen et al. 2007; Fresard 2012) and thus suggesting a negative relation between analyst coverage and tax avoidance-to-price sensitivity.

We report this result in Table 7, Panel B. Although we find a significant positive association between analyst coverage and tax avoidance as shown in columns (1) and (2), we do not observe any significant coefficient for *Analyst Coverage*Q*. Therefore, we cannot draw conclusions on whether the information released by analysts is new to managers or not and whether it affects the managerial learning from private information in stock prices. However, we can confirm that the main results are not affected by the inclusion of measures of alternative sources of information.

[Insert Table 7 about here]

3.4.3 Controlling for Financial Constraints

Several empirical studies documented that financial constraints are associated with more aggressive tax planning strategies (Law and Mills 2015; Edwards et al. 2016; Bayar et al. 2018). Financially constrained firms may employ tax planning as a source of funds and in our setting, the tax avoidance-to-price sensitivity may depend on the extent of financial constraints they face. Therefore, we test how financial constraints affect the tax avoidance-to-price sensitivity using two commonly used constraint measures, Altman Z score and WW score, as described in Section 3.4

Panel A of Table 8 reports the results using Altman Z score. We find a significant negative relation between Altman Z score and tax sheltering and a significant positive association between Altman Z score and Long-run Cash ETR. Since higher values in Altman Z score indicate lower financial constraints, this result is consistent with prior literature on the view that more financially constrained firms intend to accrue more cash tax savings. On the other hand, we observe that higher financial constraints reduce the tax avoidance-to-price sensitivity, as the coefficients of *Altman Z*Q* are significantly positive for *Tax Sheltering*.

When we use an alternative proxy for financial constraints, *WW score*, the results are consistent with those reported above. In Panel B of Table 8, we find that the coefficient for *WW score*Q* is significantly negative in the model featuring *Tax Sheltering*. Hence, we confirm that financial constraints decrease the tax avoidance-to-price sensitivity. A plausible explanation is that when managers face strong financial constraints, the pressure to conduct tax avoidance activities and save for internal funds dominates the marginal learning effect from private information obtained in the stock market.

[Insert Table 8 about here]

4. Extended Tests

4.1 Do Managers Learn More When There is More to Learn?

If private information contained in stock price can affect the tax avoidance-to-price sensitivity, it is likely that managers learn more from stock price when there is more to learn. To test this conjecture, we sort the full sample into quartiles based on ($1-R^2$). We repeat the regressions in the specification of Eq.5 for each quartile-based subsample. The dependent variable is *Tax Sheltering*. As shown in Table 9, we find that the coefficients of $(1-R^2)*Q$ are more statistically significant in subsamples with higher quartiles of private information.[11] This finding confirms the managerial learning effect and indicates that managers learn more about their tax avoidance decisions when there is more private information embedded in stock price.

[Insert Table 9 about here]

4.2 Cross Sectional Tests

[11] Our results remain qualitatively unchanged when we use quartile regressions based on *(1-R2)*.

Lastly, we test if the effects we documented are stronger in firms with multinational operations. Firms accused of using more tax shelters are documented to have larger book-tax differences, more foreign operations, subsidiaries in tax havens, and higher pre-tax income (Rego 2003; Wilson 2009; Lisowsky 2010). Firms can delay financial statement recognition of U.S. taxes on repatriations by designating foreign earnings as "permanently reinvested" (Krull 2004). Furthermore, some estimates suggest that little U.S. tax is collected on foreign earnings (Hines and Rice 1994; Dyreng and Lindsey 2009). Therefore, it is possible that managerial learning from private information in prices when making tax strategies may be reinforced if the firm has foreign operations.

To test this conjecture, we perform our baseline regressions in the subsamples split by *Foreign Income*, which indicates if a firm has foreign earnings in a given year t. We report this result in Table 10. We find that the coefficients for $(1\text{-}R^2)$ are larger in statistical significance and economic magnitude in the firms with foreign income, as well as the coefficient for $(1\text{-}R^2)*Q$ in the models characterizing tax sheltering and cash ETR. Model explanatory power is also greater in the subsample with foreign income. The Chow-test statistics are at least above 20.0 indicating we reject the null hypothesis that the estimates across the two subsamples are equal. This finding provides some support for the conjecture that for the firms with foreign earnings, tax avoidance-to-price sensitivity is stronger when stock prices contain more private information.

[Insert Table 10 about here]

5. Conclusion

In this paper, we investigate whether managers learn information from the stock market and use this information when forming corporate tax avoidance strategies. Our first important

finding is that tax avoidance is positively associated with stock price information, confirming managerial learning from stock prices in tax planning activities. Using price nonsynchronicity as the measure for price informativeness, we document that corporate tax avoidance is more sensitive to stock price when the price contains a larger amount of private information.

To address the potential endogeneity issue in the relation between a firm's stock price informativeness and tax avoidance, we use an exogenous liquidity-improving policy shock as a quasi-experiment and an instrumental two-stage least squares approach. Our results still hold after accounting for endogeneity. We further validate that the relation is robust to the inclusion of alternative channels that might affect tax avoidance-to-price sensitivity including managerial ability, other sources of public information, and financial constraints. The effect we document is stronger in the firms with higher stock price informativeness and foreign operations. Overall, our results are consistent with the hypothesis that managers extract valuable private information from stock prices to use in their tax-related decisions. This outcome supports the prior literature indicating that financial markets affect the real economy. Our findings also imply that the private information contained in the stock price may reflect investors' assessment of the cost-benefit tradeoff of corporate tax avoidance.

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Table 1: Summary Statistics

This table presents the summary statistics for tax avoidance, managerial ability measure, financial constraint measures, information asymmetry measures, corporate governance measures, as well as the control variables in the firm-year data that covers the period of 1970-2018. All continuous variables are winsorized at the 1% and 99% levels. Descriptions of each variable are provided in Appendix I.

	N	Mean	SD	p25	Median	p75
Tax Sheltering	39425	0.327	0.469	0.000	0.000	1.000
Long-term Cash ETR	39425	0.263	0.161	0.153	0.261	0.350
(1-R2)	39425	0.814	0.189	0.713	0.888	0.962
Q	39425	2.235	2.580	1.142	1.568	2.433
Firm size	39425	5.744	2.425	3.847	5.604	7.450
ROA	39425	-0.043	0.270	-0.043	0.036	0.081
EBIT/Sale	39425	-0.303	1.612	-0.009	0.062	0.120
Discretionary Accruals	39425	0.020	0.349	-0.074	0.005	0.092
Leverage	39425	0.200	0.193	0.024	0.164	0.310
Capital Expenditure	39425	0.052	0.050	0.020	0.038	0.068
Cash Holdings	39425	0.201	0.214	0.038	0.119	0.296
Earnings Volatility	39425	0.074	0.096	0.025	0.043	0.080
Net Operating Loss	39425	0.245	0.430	0.000	0.000	0.000
Dividend Payer	39425	0.356	0.479	0.000	0.000	1.000
Tangibility	39425	0.238	0.185	0.096	0.192	0.332
Managerial Ability	38570	0.017	0.132	-0.060	-0.007	0.055
Altman Z	38971	4.942	7.152	1.993	3.445	5.766
WW score	39297	-0.273	0.131	-0.367	-0.268	-0.173
Analyst Coverage	39425	2.424	4.329	0.000	0.000	3.000
BA Spread	32439	0.024	0.038	0.002	0.011	0.031
Institutional Ownership	25683	0.473	0.331	0.154	0.480	0.756
Foreign Income	39425	0.488	0.500	0.000	0.000	1.000

Table 2: Pairwise Correlations

This table reports Pearson pairwise correlations. Two-tailed p-values are reported under the coefficients. All continuous variables are winsorized at the 1% and 99% levels. Descriptions of each variable are provided in Appendix I.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1] Tax Sheltering	1.000											
[2] Long-term Cash ETR	-0.045	1.000										
	0.000											
[3] 1-R^2	-0.492	0.076	1.000									
	0.000	0.000										
[4] Q	0.004	-0.161	0.010	1.000								
	0.216	0.000	0.055									
[5] Firm Size	0.718	0.037	-0.588	-0.152	1.000							
	0.000	0.000	0.000	0.000								
[6] ROA	0.290	0.116	-0.191	-0.230	0.373	1.000						
	0.000	0.000	0.000	0.000	0.000							
[7] EBIT/Sale	0.184	0.136	-0.122	-0.263	0.261	0.590	1.000					
	0.000	0.000	0.000	0.000	0.000	0.000						
[8] Discretionary Accruals	0.049	-0.030	0.001	0.001	0.006	0.202	0.092	1.000				
	0.000	0.000	0.797	0.784	0.239	0.000	0.000					
[9] Leverage	0.033	0.003	-0.043	-0.115	0.214	-0.068	0.060	-0.056	1.000			
	0.000	0.676	0.000	0.000	0.000	0.000	0.000	0.000				
[10] Capital Expenditure	0.014	0.019	-0.003	0.032	0.060	0.060	0.059	0.007	0.042	1.000		
	0.007	0.005	0.521	0.000	0.000	0.000	0.000	0.187	0.000			
[11] Cash Holdings	-0.160	-0.173	0.054	0.297	-0.263	-0.262	-0.411	-0.017	-0.374	-0.178	1.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000		
[12] Earnings Volatility	-0.254	-0.157	0.204	0.277	-0.440	-0.586	-0.363	-0.043	-0.087	-0.048	0.278	1.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Table 3: The Impact of Price Informativeness on Tax Avoidance-to-Price Sensitivity

This table presents estimates of panel regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity. The dependent variables are tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. The effect of price informativeness on the tax avoidance-to-price sensitivity is measured by *(1-R2)×Q*. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.006***	-0.006***	0.002**	-0.002
	(8.610)	(-9.251)	(1.981)	(-1.543)
(1-R2) × Q			0.010***	-0.007***
			(5.160)	(-3.813)
(1-R2)			-0.158***	0.029***
			(-12.895)	(4.173)
Firm size	0.128***	0.013***	0.123***	0.013***
	(44.838)	(7.676)	(41.863)	(7.812)
ROA	0.123***	-0.096***	0.121***	-0.093***
	(12.946)	(-11.075)	(12.773)	(-10.673)
EBIT/Sale	-0.004***	0.004**	-0.004***	0.005**
	(-2.622)	(2.119)	(-2.594)	(2.190)
Discretionary Accruals	0.057***	-0.001	0.057***	-0.001
	(9.679)	(-0.294)	(9.588)	(-0.314)
Leverage	-0.237***	-0.032***	-0.234***	-0.034***
	(-19.997)	(-4.471)	(-19.723)	(-4.674)
Capital Expenditure	0.029	0.027	-0.000	0.033
	(0.698)	(1.310)	(-0.001)	(1.575)
Cash Holdings	-0.057***	-0.016*	-0.065***	-0.014
	(-4.325)	(-1.856)	(-4.878)	(-1.630)
Earnings Volatility	0.404***	-0.101***	0.391***	-0.094***
	(16.722)	(-4.831)	(16.188)	(-4.474)
Net Operating Loss	-0.038***	0.023***	-0.037***	0.023***
	(-8.282)	(8.048)	(-8.078)	(7.995)
Dividend Payer	0.032***	0.010***	0.032***	0.010***
	(5.350)	(3.400)	(5.276)	(3.400)
Tangibility	0.008	0.020*	0.018	0.019
	(0.358)	(1.691)	(0.812)	(1.598)
Constant	-0.355***	0.157***	-0.210***	0.135***
	(-10.958)	(8.072)	(-6.066)	(6.592)
Observations	39432	36815	39425	36813
R^2	0.777	0.546	0.779	0.547
Adjusted R^2	0.737	0.459	0.739	0.460
Firm FE	Yes	Yes	Yes	Yes
Industry*Year FE	Yes	Yes	Yes	Yes

Table 4: Difference-in-Differences Analysis using an Exogenous Shock

This table presents estimates of difference-in-differences specifications using the 2001 decimalization as an exogenous shock. The sample window is 1991-2011. *Post 2001* is an indicator variable for the years post 2001. In Model (1), *Treatment* is a dummy variable that equals 1 for firms that saw the above-median change in stock price informativeness (1-R2) pre-2001. In Model (2), the *Treatment* group is the firms that saw the largest change (top quartile) in stock price informativeness (1-R2) pre-2001 and the control group is the firms that saw the least change (bottom quartile) in stock price informativeness (1-R2) pre-2001. *Year 2001* is an indicator variable for the event year. The dependent variable is *Tax Sheltering*. The t-stats are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

	(1) Tax Sheltering	(2) Tax Sheltering
Post 2001	0.182***	0.223**
	(3.515)	(2.189)
Post 2001 × Treatment	-0.032***	-0.066***
	(-3.217)	(-4.191)
Post 2001 × Treatment × Q	0.009**	0.014**
	(2.416)	(2.089)
Q	0.004***	0.004**
	(2.961)	(2.055)
Post 2001 × Q	0.004*	0.003
	(1.767)	(1.020)
Treatment × Q	0.005**	0.006*
	(2.353)	(1.755)
Year 2001	0.027	0.070
	(0.645)	(0.918)
Constant	0.297***	0.354***
	(5.785)	(3.524)
Observations	37624	22162
R^2	0.728	0.760
Adjusted R^2	0.681	0.728
Firm FE	Yes	Yes
Industry × Year FE	Yes	Yes
Controls	Yes	Yes

Table 5: Instrumental Variable Analysis

This table presents estimates of 2SLS instrumental variable regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity. *Event* is an indicator equal 1 for years after the Autoquote introduction and *Treatment* is an indicator equal 1 for firms listed on NYSE and zero for Nasdaq firms. *Event*Treatment* is the instrument for (1-R2). Panel A presents the first stage estimations where the dependent variables are *(1-R2)* and *(1-R2)*Q* (endogenous variables). Panel B presents the second stage estimations where the dependent variable is *Tax Sheltering*. The t-stats are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

Panel A	*First Stage Estimations*	
	(1)	(2)
	1-R2	(1-R2)*Q
Event × Treatment	-0.225***	-0.394***
	(-22.53)	(-8.08))
Event × Treatment × Q	0.051***	0.109***
	(10.63)	(4.62)
Q	-0.001***	0.453***
	(-1.62)	(126.32)
Constant	1.377***	2.643***
	(73.33)	(28.74)
F-statistics	296.22	1533.23

Panel B	*Second Stage Estimations*
	Tax Sheltering
Instrumented (1-R2)	-0.691***
	(-4.009)
Instrumented (1-R2) × Q	0.128**
	(2.259)
Q	-0.047**
	(-2.051)
Constant	0.068
	(0.409)
Observations	32549
Firm FE	Yes
Industry × Year FE	Yes
Other controls	Yes

Table 6: Managerial Ability, Price Informativeness, and Tax Avoidance-to-Price Sensitivity

This table presents estimates of panel regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity after controlling for managerial ability. The dependent variables are tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. Managerial Ability is the MA score from Demerjian et al. (2012), computed using data envelopment analysis (DEA) where total sales is optimized using the vector of inputs including net PP&E, operating leases, R&D, purchased goodwill and intangibles, cost of goods sold, and SG&A. The DEA is optimized at the industry and year levels, and a firm efficiency score is computed. The firm efficiency score is then regressed on firm characteristics (size, market share, positive free cash flow, age, business segment concentration, a foreign currency indicator, and year indicators), and the residual from this regression is the managerial ability score. See Demerjian et al. (2012) for additional details. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.007***	-0.007***	0.002**	-0.002*
	(7.966)	(-9.597)	(2.035)	(-1.693)
(1-R2)			-0.153***	0.031***
			(-12.179)	(4.367)
(1-R2) × Q			0.009***	-0.009***
			(4.170)	(-4.427)
Managerial Ability	0.156***	-0.064***	0.156***	-0.065***
	(5.593)	(-4.169)	(5.612)	(-4.238)
Managerial Ability × Q	-0.027***	0.029***	-0.032***	0.030***
	(-2.781)	(4.536)	(-3.235)	(4.763)
Constant	-0.372***	0.159***	-0.228***	0.136***
	(-10.701)	(7.926)	(-6.167)	(6.476)
Observations	38577	36434	38570	36432
R^2	0.776	0.544	0.777	0.545
Adjusted R^2	0.736	0.457	0.737	0.458
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 7: Public Information, Price Informativeness, and Tax Avoidance-to-Price Sensitivity

This table presents estimates of panel regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity after controlling for market information. Panel A presents the regression results after controlling for *BA spread*, which is calculated as (Ask-Bid)/(midpoint of ask and bid price). Panel B presents the regression results after controlling for *Analyst Coverage*, which is the natural logarithm of the number of analysts covering the firm each year. The dependent variables are tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

Panel A	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.007***	-0.004***	0.002*	-0.002
	(6.654)	(-5.491)	(1.726)	(-1.435)
(1-R2)			-0.140***	0.024***
			(-10.265)	(3.211)
(1-R2) × Q			0.010***	-0.004**
			(4.375)	(-2.163)
BA Spread	0.775***	0.022	0.823***	-0.007
	(9.248)	(0.379)	(9.684)	(-0.112)
BA Spread × Q	0.085***	-0.151***	0.066**	-0.132***
	(2.874)	(-5.137)	(2.204)	(-4.337)
Constant	-0.428***	0.148***	-0.299***	0.128***
	(-12.082)	(7.221)	(-7.854)	(5.919)
Observations	32439	31695	32439	31694
R^2	0.781	0.547	0.782	0.547
Adjusted R^2	0.740	0.457	0.742	0.458
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Panel B	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.005***	-0.006***	0.002*	-0.002
	(6.947)	(-7.699)	(1.864)	(-1.509)
(1-R2)			-0.151***	0.027***
			(-12.299)	(3.913)
(1-R2) × Q			0.009***	-0.007***
			(4.400)	(-3.629)
Analyst Coverage	0.012***	-0.005**	0.013***	-0.005**
	(2.903)	(-2.176)	(3.113)	(-2.378)
Analyst Coverage × Q	0.003**	-0.000	0.001	-0.000
	(2.305)	(-0.603)	(0.936)	(-0.082)
Constant	-0.337***	0.152***	-0.199***	0.132***
	(-10.369)	(7.754)	(-5.752)	(6.414)
Observations	39432	36815	39425	36813
R^2	0.777	0.546	0.778	0.546
Adjusted R^2	0.737	0.460	0.739	0.460
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 8: Financial Constraints, Price Informativeness, and Tax Avoidance-to-Price Sensitivity

This table presents estimates of panel regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity after controlling for financial constraints. Panel A presents the regression results after controlling for *Altman Z*, which is modeled as 1.2*(working capital / total assets) + 1.4*(retained earnings / total assets) + 3.3*(earnings before interest and tax / total assets) + 0.6*(market value of equity / total liabilities) + 1.0*(sales / total assets), following Altman (1968). Panel B presents the regression results after controlling for *WW score*, which is modeled as -0.091*(cash flow/total assets) - 0.062 * positive dividend + 0.021 * (long-term debt/total assets) - 0.044 * (log of total assets) + 0.102 * industry sales growth-0.035 * firm sales growth, following White and Wu (2006). The dependent variables are tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

Panel A	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.006***	-0.006***	0.003***	-0.003*
	(6.890)	(-6.320)	(2.826)	(-1.915)
(1-R2)			-0.160***	0.031***
			(-12.664)	(4.283)
(1-R2) × Q			0.010***	-0.008***
			(4.408)	(-3.594)
Altman Z	-0.002***	0.001**	-0.002***	0.001**
	(-4.934)	(2.084)	(-5.018)	(2.103)
Altman Z × Q	0.001***	-0.000**	0.001***	-0.000
	(5.829)	(-2.455)	(2.852)	(-0.636)
Constant	-0.365***	0.152***	-0.216***	0.127***
	(-11.184)	(7.696)	(-6.185)	(6.144)
Observations	38978	35960	38971	35958
R^2	0.775	0.546	0.776	0.546
Adjusted R^2	0.735	0.458	0.736	0.458
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Panel B	(1) Tax Sheltering	(2) Long-term Cash ETR	(3) Tax Sheltering	(4) Long-term Cash ETR
Q	0.003***	-0.003***	0.002*	-0.001
	(3.357)	(-3.115)	(1.730)	(-0.957)
(1-R2)			-0.145***	0.024***
			(-11.402)	(3.295)
(1-R2) × Q			0.005**	-0.005**
			(2.061)	(-2.380)
WW score	0.343***	0.258***	0.291***	0.271***
	(4.709)	(5.223)	(3.913)	(5.450)
WW score × Q	-0.049***	0.016***	-0.032***	0.009
	(-6.817)	(3.111)	(-3.668)	(1.472)
Constant	-0.361***	0.153***	-0.219***	0.135***
	(-11.114)	(7.816)	(-6.292)	(6.575)
Observations	39304	36787	39297	36785
R^2	0.777	0.546	0.778	0.546
Adjusted R^2	0.737	0.460	0.738	0.460
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 9: Quartile Regressions of the Effect of Price Informativeness on Tax Avoidance-to-Price Sensitivity

This table presents estimates of quintile regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity. The sample is split into four groups based on the quartiles of (1-R2). The dependent variable is *Tax Sheltering*. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

	Lowest Quartile of (1-R2)			Highest Quartile of (1-R2)
	(1) Tax Sheltering	(2) Tax Sheltering	(3) Tax Sheltering	(4) Tax Sheltering
(1-R2) × Q	0.007	0.009	0.010**	0.005***
	(1.138)	(1.405)	(2.438)	(2.588)
(1-R2)	-0.037	-0.177*	-0.069	0.088
	(-1.517)	(-1.913)	(-0.468)	(0.436)
Q	0.004	0.002	-0.000	-0.000
	(1.472)	(0.626)	(-0.139)	(-0.069)
Constant	-0.593***	-0.383***	-0.155	-0.178
	(-11.795)	(-4.114)	(-1.082)	(-0.893)
Observations	12376	9403	8861	8785
R^2	0.783	0.820	0.847	0.859
Adjusted R^2	0.705	0.675	0.717	0.748
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes

Table 10: Heterogeneity Tests with Foreign Income

This table presents estimates of panel regressions to examine the impact of price informativeness on tax avoidance-to-price sensitivity by firms with foreign income versus without foreign income. The sample is split by *Foreign Income* which is a dummy variable that equals 1 if the firm has foreign income in year t and zero otherwise. The dependent variables are tax avoidance measures *Tax Sheltering* and *Long-term Cash ETR*. The t-statistics are reported in parentheses. All specifications include firm fixed effects and industry*year fixed effects. Standard errors are clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Descriptions of all the variables are provided in Appendix I.

	Firms with Foreign Income		Firms without Foreign Income	
	(1)	(2)	(3)	(4)
	Tax Sheltering	Long-term Cash ETR	Tax Sheltering	Long-term Cash ETR
(1-R2) × Q	0.011**	-0.007**	0.001	-0.007***
	(2.202)	(-2.459)	(0.563)	(-2.782)
(1-R2)	-0.119***	0.026***	-0.011	0.009
	(-5.998)	(2.706)	(-1.041)	(0.797)
Q	0.005*	-0.000	0.000	-0.002
	(1.825)	(-0.149)	(0.771)	(-0.937)
Constant	-0.441***	0.184***	-0.060**	0.167***
	(-7.166)	(6.022)	(-2.394)	(5.921)
Observations	19241	18771	20184	18042
R^2	0.844	0.651	0.761	0.537
Adjusted R^2	0.798	0.538	0.707	0.428
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Chow test statistic	Model (1)&(3)	Model (2)&(4)		
	49.02	20.22		

Appendix I: Variable Definitions

Variables	Definitions
Dependent Variables	
Tax Sheltering	A dummy variable that equals one if a firm's estimated shelter probability (estimated propensity of using tax shelters following Wilson [2009]) belongs to the top quartile, and zero otherwise. Shelter Prob. = -4.30 + 6.63 * book tax difference - 1.72 * (long-term debt scaled by total assets) + 0.66 * (log of total assets) + 2.26 * ROA + 1.62 * foreign income + 1.56 * (R&D expenditure/total assets).
Long-term Cash ETR	Long-term effective tax rate, calculated as five-year-centered moving sum of cash paid for income taxes over five years scaled by the sum of pretax income (net of special items) over the same period.
Independent Variables	
(1-R2)	One minus R2 from regressing firm daily return on market and industry index over year t.
Q	Market value of equity plus book value of assets minus book value of equity, scaled by book value of assets.
Firm size	The natural logarithm of total book assets (at).
ROA	Firms' net income scaled by total book assets.
EBIT/Sale	Firms' EBIT scaled by total sales revenue.
Discretionary Accruals	The absolute value of discretionary accruals following Jones (1991).
Leverage	Firms' long-term and short-term debts scaled by total book assets.
Capital Expenditure	Firm's capital expenditure scaled by total book assets.
Cash Holdings	Firm's balance of cash scaled by total book assets.
Earnings Volatility	Firm's standard deviation of its operating income before depreciation (oibdp) over the last five years scaled by total book assets.
Net Operating Loss	A dummy variable that equals one if the firm's net operating cash flow (oancf) is negative and zero otherwise.
Dividend Payer	A dummy variable that equals one if the firm pays cash dividend in that fiscal year and zero otherwise.
Tangibility	Firm's property, plant, and equipment (ppent) scaled by total book assets.
Managerial Ability	Managerial ability score from Demerjian et al. (2012), computed using data envelopment analysis (DEA) where total sales is optimized using the vector of inputs including net PP&E, operating leases, R&D, purchased goodwill and intangibles, cost of goods sold, and SG&A. The DEA is optimized at the industry and year levels, and a firm efficiency score is computed. The firm efficiency score is then regressed on firm characteristics (size, market share, positive free cash flow, age, business segment concentration, a foreign currency indicator, and year indicators), and the residual from this regression is the managerial ability score. See Demerjian et al. (2012) for additional details.
BA Spread	Bid-ask spread calculated as (Ask-Bid)/(midpoint of ask and bid price) from CRSP.
Analyst Coverage	The number of analysts covering the firm in a given year t from I/B/E/S.
Altman Z	A financial constraint measure based on Altman (1968). Altman Z-Score is modeled as 1.2*(working capital / total assets) + 1.4*(retained earnings / total assets) + 3.3*(earnings before interest and tax / total assets) + 0.6*(market value of equity / total liabilities) + 1.0*(sales / total assets).

WW score	A financial constraint measure based on White and Wu (2006). WW score is modeled as -0.091*(cash flow/total assets) - 0.062 * positive dividend + 0.021 * (long-term debt/total assets) - 0.044 * (log of total assets) + 0.102 * industry sales growth-0.035 * firm sales growth. Positive dividend is an indicator that equals 1 if the firm pays cash dividends.
Foreign Income	A dummy variable that equals 1 if the firm has foreign income in year t.