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An Analysis of Corporate Tax Avoidance

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Are Risk-based Tax Audit Strategies Rewarded? An Analysis of Corporate Tax Avoidance[*]

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Abstract: This study examines the relation between risk-based tax audit strategies and corporate tax avoidance. We exploit OECD data across 54 countries on risk profiling, predictive modeling, and internal intelligence functions in tax administrations from 2014 to 2017 to investigate whether risk-based tax audits have an incremental effect on tax avoidance beyond enforcement. Our results suggest that the use of risk-based tax audits is associated with lower tax avoidance when controlling for tax enforcement, firm-specific, and country-specific factors. Cross-sectional tests indicate that risk-based tax audit strategies are effective tools to curb tax avoidance across firms of all sizes. The results of additional cross-sectional analyses indicate that risk-based tax audits are more effective in countries with low governance quality, high GDP, and low trust in governments. In additional tests, we use country-level data on tax administration performance and find evidence that countries with a risk-based audit strategy have lower costs of tax enforcement and improve the performance of tax authorities. Overall, our findings indicate that risk-based tax audit strategies have an incremental effect on attenuating firms' tax avoidance and increasing tax revenue.

Keywords: tax audits, tax avoidance, tax compliance, tax enforcement, tax risk
JEL classification: H25, H26, M41, M42, M48

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1. Introduction

We examine the relation between risk-based tax audit strategies employed by tax authorities worldwide to target high-risk taxpayers and corporate tax avoidance. Risk-based tax audits, if harnessed properly, can improve audit effectiveness and help tax authorities adapt to ever-changing tax and tax risk environments. The incremental effect of risk-based tax audits on tax avoidance depends on taxpayers' expectations about tax audits and thus tax authorities' audit strategy, including the capacity to collect, probe, analyze, and detect potential non-compliance from various sources of data. Yet, it is unclear how risk-based tax audit strategies affect firms' tax behavior.

To fill this gap, we aim to explore whether and to what extent the employment of risk-based tax audit strategies is associated with corporate tax avoidance. We make use of recent advances in the employment of risk-based tax audit strategies, specifically risk-profiling, predictive modeling, and internal intelligence, and employ country-specific data from Organization for Economic Co-operation and Development (OECD) to analyze the incremental effect of these strategies on firms' tax avoidance beyond enforcement. Our results suggest that the employment of risk-based tax audits for audit case selection is strongly recommendable for tax administrations. Not only do risk-based tax audits reduce tax avoidance, but also, they reduce the cost of enforcement and improve the performance of tax authorities.

Risk-based tax audits, in general, refer to advanced analytical techniques, which rely on a comprehensive dataset of taxpayers' characteristics such as information from tax returns, historical audits, and third-party information. The audit selection strategy is then based on statistical and automated machine-learning techniques to evaluate the risk of non-compliance. In 2017, one-half of 53 tax administrations reported the use of risk-based audit strategies, such as predictive modeling and risk profiling to improve the match of audits and taxpayers' specific risks (OECD, 2017). Risk-based tax audits promise to improve audit case selection and

incrementally enhance the detection of non-compliance. As a consequence, risk-based tax audits may help to close the tax gap, which can be substantive. For example, the U.S. Internal Revenue Service (IRS) estimated the average annual gross tax gap for all the tax types (i.e., the difference between taxes owed and taxes paid) of $441 billion for the tax years 2011 to 2013 (IRS, 2019).

Single-component selection strategies such as random audits seem less effective since the drivers of taxpayers' compliance behavior are complex and vary substantially across different types of taxpayers (Jackson & Milliron, 1986; Jimenez & Iyer, 2016; Slemrod, 2019). Furthermore, as tax administration resources are limited, risk-based tax audits are assumed to improve audit-cost-effectiveness by devoting the resources to high-risk taxpayers with the highest potential for detecting non-compliance.[1] For instance, since 2016, Canada has spent C$1.1 billion on a risk-based audit strategy (ITR, 2019)[2] to help discover, identify, and target non-compliance cases.

It is unclear whether tax avoidance—defined in line with prior literature as "any activity that reduces the firm's explicit taxes in any manner, including tax positions that may or may not be challenged" (Lisowsky et al., 2013)—subsides when tax authorities implement risk-based tax audit strategies.[3] A first intuitive prediction is that corporations revise their tax avoidance behavior in the face of upcoming changes in audit probability and effectiveness. Therefore, they may reduce risky tax behaviors, abstain from rather aggressive tax avoidance strategies, implement better internal tax control systems, and become more diligent in their tax assessment when risk-based audits are implemented.[4] However, there are several reasons to expect that

[1] Risk classification is typically based on a combination of non-compliance factors: (1) firms' inherent risk as a function of size, complexity, nature of business and prior compliance behavior, and (2) firms' actions, attitude, as well as their internal control systems and processes to mitigate tax risk (HM Revenue & Customs, 2016). See HM Revenue & Customs 2016, https://www.gov.uk/hmrc-internal-manuals/tax-compliance-risk-management.
[2] See International Tax Review, March 19, 2019, https://www.internationaltaxreview.com.
[3] In prior literature, the terms "tax avoidance", "tax aggressiveness", "tax non-compliance", and "tax evasion" are all used to describe aspects of aiming to lower the tax burden.
[4] They can be informed about risk-based audit through public information, their experience, interaction with other firms, or tax professionals.

corporations are insensitive to risk-based tax audits. For instance, small firms or firms with an advanced tax compliance system might pay limited attention to audit strategies, while large businesses may face permanent audits and operate under continuous scrutiny, resulting in only marginal changes in their expectations of tax audits and audit strategies. Thus, these firms may not adjust their behavior in response to the employment of risk-based tax audits. Risk-based tax audits may even increase tax avoidance if firms start or improve anticipating the risk-based tax audit strategies and build on their own and tax intermediaries' expertise to facilitate tax avoidance outside the scope of risk-based tax audits.

To analyze the association between risk-based tax audits and corporate tax behavior, we exploit annual data on audit selection strategies across 54 countries from 2014 to 2017. The data is publicly available from the OECD *Tax Administration Series*. We use this data to proxy for risk-based audits and construct a binary measure depending on whether the tax administration explicitly reports that they employ either risk profiling (business rules), or predictive modeling, or internal intelligence function in their audit case selection criteria.

Through our analysis of a cross-country panel of 15,920 firms from 54 countries between 2014 to 2017, we find evidence that risk-based tax audit strategies are associated with a lower level of tax avoidance. We measure corporate tax avoidance by the cash taxes paid relative to the expected amount following Atwood et al. (2012)[5] and control for the level of enforcement, i.e., the number of employees in tax administration, and for other country-level controls and firm-specific variables that might affect tax avoidance. In robustness tests, we use a difference-in-differences design and compare the incremental changes in tax behavior of firms in countries

[5] Firms' intentions about tax avoidance and tax evasion typically cannot be observed, and distinguishing between not-intended and intended tax evasion is notoriously hard. Therefore, in our empirical design, we cannot differentiate between tax planning activities as part of a firm's compliant tax planning strategy that will be considered compliant in an audit and those activities that are requalified as tax evasion in an audit.

switching to a risk-based tax audit with those of firms in countries that never implemented risk-based tax audits. These tests support our main results.

In cross-sectional tests, we explore the heterogeneity in the association of risk-based tax audits and tax avoidance across firms and countries. We expect different tax behavior conditional on firms' perceived audit probability, based on firm characteristics. Tax authorities, for example, often refer to firm size as a prominent indicator of a firm's non-compliance propensity. We find that the deterrence effect of risk-based tax audits holds for firms of all sizes. Under risk-based tax audits, firms are not able to respond strategically by actively managing the magnitude of the key indicators below the threshold to avoid audits. Furthermore, cross-sectional analyses on country characteristics suggest that the employment of risk-based tax audits is more effective in curbing tax avoidance in countries with lower governance quality, higher GDP levels, and lower levels of trust in government.

In supplementary analysis, we investigate the association between risk-based tax audits and the performance of tax administrations in different countries. We use three measures from the United States Agency for International Development (USAID)'s Collecting Taxes Database (CTD) to proxy performance, namely the ratio of the total annual tax administration expenditures with the net tax revenue collected by the tax administration, tax administration's raised tax revenue as a percent of GDP to country tax capacity, and the change of tax revenue relative to a change in GDP. All three measures indicate how effective a country's tax administration is in raising revenue. Our findings suggest that the employment of risk-based tax audits for audit case selection reduces the cost of tax collection and improves the performance of tax administrations.

We contribute to the literature in two ways. First, we examine the incremental effect of risk-based tax audits beyond enforcement for corporations and extend the literature, which so far focuses on the effect of risk-based tax audits on individuals. We build on previous single-country studies on individuals (Alm & McClellan, 2012; Beer et al., 2020; Hashimzade & Myles, 2017;

Loyland et al., 2019) by studying corporations and a cross-country setting instead. The effect of risk-based tax audits may be very different across firms (Hoopes et al., 2012). Firms may be either more or less sensitive to tax audit strategies. Firms may respond differently to audits than individuals due to different social norms and networks (Hasan et al., 2017), different costs of non-compliance (Hanlon et al., 2005; Hanlon & Slemrod, 2009; Jacob et al., 2021), and different risk-taking patterns in their tax behavior (Armstrong et al., 2019). Moreover, firms face the trade-off between financial and tax reporting decisions (Hanlon & Heitzman, 2010). Publicly traded firms that are exposed to capital market pressure may value accounting earnings more than tax payments and thus give up tax avoidance opportunities to inflate financial earnings, with the extreme ones paying taxes on allegedly fraudulent earnings (Erickson et al., 2004). Moreover, we exploit the cross-country setting to alleviate generalizability concerns.

Second, we contribute to the literature regarding corporate tax behavior (Atwood et al., 2012; DeBacker et al., 2015; Gupta & Lynch, 2016). More specifically, we examine how the effect of risk-based audits is related to firm and country characteristics. By doing so, we aim to explore the determinants underlying the effectiveness of a risk-based audit, as suggested by Slemrod (2019). While the effect of enforcement through audit levels and penalties has been intensively studied, we investigate how the risk-based tax audits would incrementally affect the firm's tax avoidance beyond the enforcement level. Moreover, we analyze how this effect could be different across heterogeneous firms and countries.

Our results suggest that for a specific audit level, the risk-based distribution of tax audits across different taxpayers has an incremental effect in reducing their tax avoidance behavior, especially in countries with a lower level of governance quality, more developed countries, and countries with low trust in government. Also, the employment of risk-based audits is associated with a lower cost of tax collection and higher performance of tax administrations. Taken together, our findings suggest that risk-based audits contribute to a more efficient allocation of limited

resources to risky areas and areas with the most potential outcome, in line with Slemrod et al. (2001).[6] Therefore, we also contribute to analyses of the effectiveness of intervention activities (Keen & Slemrod, 2017) and answer the call for a re-examination of tax enforcement from DeBacker et al. (2015).

2. Conceptual Framework

2.1 Prior Research

Individual tax behavior

The economics of crime model (Becker, 1968) which is often applied to tax evasion, argues that the deterrence effect of enforcement is shaped by both audit probability and penalty (Allingham & Sandmo, 1972; Lee & McCrary, 2017). Based on this deterrence effect, a rational individual weighs the expected benefit of tax evasion against the expected probability of detection, post-audit adjustments, and penalties. In recent years, the academic and policy interest in the relation between enforcement and taxpayers' behavior has increased as enforcement is considered a crucial component to ensure tax compliance and combat evasion behavior (Slemrod, 2019).

Prior research has demonstrated the link between the strategic behavior of taxpayers and tax authorities via tax audits. Kleven et al. (2011) show through an audit experiment conducted in Denmark that audits increase the self-reported income of individual taxpayers significantly in the post-audit year. In the same vein, Advani et al. (2019) investigate how audits affect reporting behavior in the years after audits. Using administrative data from the UK, they find that the effect of audits is likely sustainable, and audits increase the reported tax liabilities among self-employed UK taxpayers for at least five years after an audit. Consistent with these findings, DeBacker et al. (2018) use IRS data and provide evidence that auditing increases the reported wage income of individual taxpayers over three years following an audit.

[6] As Slemrod and Yitzhaki (1987) point out, the optimal audit strategy is not the same as the revenue-maximizing strategy, so administrative costs of tax audits should also be taken into consideration. Slemrod et al. (2001) argue that resources should be allocated differently across taxpayers with different risk levels.

While the aforementioned archival studies provide an indication for a positive effect of enforcement on tax compliance among individual taxpayers, several experimental studies find opposite results. For instance, Mittone (2006) and Guala and Mittone (2005) show in behavioral studies that individual taxpayers increase their tax evasion subsequent to a tax audit, which is referred to as the "bomb crater effect". This effect can be explained by the misperception of audit chance, in which individuals underreport income because they underestimate the risk of future examination since an audit has not happened for a while or has recently happened (Mittone et al., 2017).

Corporate tax behavior

Over several years, corporate tax avoidance has received heightened attention from tax authorities and the public. Prior research has provided mixed evidence on the relation between tax audits and firms' tax avoidance behavior. Hoopes et al. (2012), examine how IRS monitoring affects corporate tax avoidance and find that when the probability of an audit is high, public corporations in the US engage in less tax avoidance. Gupta and Lynch (2016) examine the impact of changes in state-level tax enforcement expenditure and find evidence that higher enforcement expenditure is effective at improving aggregate state-level tax collection. Nessa et al. (2020) show a positive relation between IRS enforcement resources and aggregate corporate tax collection for large businesses and international corporate taxpayers. Atwood et al. (2012) investigate the impact of home-country tax system characteristics on corporate tax avoidance and provide evidence that firms avoid more taxes when their home country's perceived enforcement is lower. These studies provide evidence that enforcement likely reduces firms' tax avoidance.

On the other hand, DeBacker et al. (2015) find evidence that tax audits may increase tax avoidance for corporate taxpayers. Using IRS data, they find that corporations in the U.S pay less taxes after an audit and increase their tax payments before they are re-audited. Their results

imply that corporations gradually become more tax aggressive following an audit and then eventually decrease their aggressiveness. This result is consistent with the bomb crater effect on individual taxpayers. Finley (2019), analyzes the effects of tax audits depending on the type of settlement the firms receive. Their findings indicate that subsequent to a favorable settlement, firms increase their tax avoidance, while firms with less favorable tax settlements stick to their prior tax avoidance strategies. Slemrod et al. (2001) argue that firms may behave like high-income individuals and engage in even more aggressive tax avoidance when audit probability is high, to have room to negotiate and minimize their post-audit tax liability, assuming that the audit will not detect and punish all the tax avoidance.

Reconciliation of individual and corporate tax behavior

Taken together, while the majority of prior studies suggest that tax audits decrease tax avoidance and increase tax compliance, some studies, especially behavioral ones, indicate an opposite impact (for an overview, see Table A1 in the Appendix). One explanation for the mixed evidence is the misperceived probability of being audited. Tax audits increase rather than decrease tax avoidance when taxpayers underestimate the risk of subsequent audits (Kastlunger et al., 2009) or when enforcement is less effective than initially expected, i.e., non-compliance was not detected (Beer et al., 2020; Gemmell & Ratto, 2012). Another explanation is the effect of the non-linear weighting of probabilities: taxpayers may overweight low audit probabilities but underweight high audit probabilities (Dhami & al-Nowaihi, 2007). To attenuate this misperception of the audit probability and to make enforcement more salient, tax authorities can announce and implement a more effective audit selection strategy such as a risk-based tax audit strategy to focus on high-tax risk firms.

Risk-based audit

The effect of audits on the behavior of taxpayers seems to be attributed to the effectiveness of audits. For example, Gemmell and Ratto (2012) and Beer et al. (2020) report evidence that audits increase the compliance of previously non-compliant taxpayers, whereas they decrease the

compliance of previously compliant taxpayers. Kasper and Alm (2020) find that audit effectiveness is an important determinant of the specific deterrent effect of audits.

Little is known about risk-based tax audit strategies, especially for firms. Alm and McKee (2004) use an experimental approach to study individual tax behavior and find that the combination of risk-based and random audits is the most effective and sustainable mechanism in deterring individual tax evasion. Using administrative tax data of self-employed US taxpayers, Beer et al. (2020) find evidence that improved targeting audits toward non-compliant individual taxpayers increases current and future compliance. Further, two studies explore the features of specific methods of risk-based tax audits (predictive modeling, risk-profiling, and data mining) and their implications for tax revenues and individual taxpayer responses. Using an agent-based model and simulation analysis for individual behavior, Hashimzade et al. (2016) suggest that risk-based audits—more specifically, predictive analytics for audit selection—yield more revenue over random audits. Loyland et al. (2019) use Norwegian administrative data and empirically explore the individual behavioral responses of high-risk wage earners to audits. They find that the compliance effect of audits based on risk scores (predicted by machine learning) increases significantly with the individual taxpayers' risk score. Noticeably, the existing evidence is on responses of individual taxpayers rather than firms. One exception studying the effect of risk-based audits on corporations is the case study by Hsu et al. (2015), who find evidence that the application of data mining in tax audits increases efficiency in the audit selection process in Minnesota. Summing up, theory and empirical evidence on the relationship between tax auditing and taxpayer behavior are mixed, and the existing evidence on the effect of risk-based audits on tax avoidance is more on individual responses. Therefore whether and how risk-based tax audits are related to firms' tax avoidance remains unexplored.

2.2 Hypothesis Development

Prior research has examined the reporting behavior of individuals who were selected based on random audits (Advani et al., 2019; DeBacker et al., 2018; Kleven et al., 2011). However, in reality, tax authorities worldwide rely increasingly on case selection systems based on risk-based tax audits, which target taxpayers with a relatively high likelihood of non-compliance (see Figure A1 in the Appendix).

Firms consider and weigh the marginal benefits of their tax planning activities against the expected cost. They anticipate a potential tax audit that might impose costs upon detection of non-compliant tax avoidance behavior in the form of adjustments, fines, penalties, and interests. For their cost-benefit analysis, firms estimate the probability of an audit using the available information set and adjust their behavior accordingly. Risk-based audit changes both the actual and perceived audit risk.

Firms can obtain information about risk-based tax audits in three ways. First, general information about audit case selection strategies is provided by tax administration to the taxpayers (especially for corporations) or the wider public. Second, in the course of a risk-based tax audit, firms may receive further information about the criteria of the administration's risk assessment and experience how they are employed. Lastly, firms could attain information regarding risk assessment criteria and how they are employed by interaction with peer firms or indirectly through tax professionals who serve as an information hub (Battaglini et al., 2019; Hoopes et al., 2012). This information can also be diffused through social networks in the business process: for example, via financial analysts, audits, board of directors, banks, or via supply chains, executives or networks.[7]

[7] Three audit effects are identified in prior literature based on taxpayers' information: induced, subsequent period, and group effects (Bloomquist, 2004). First, the induced effect explains the changes in compliance behavior as a result of changes in the enforcement level (for example, changes in audit level or audit rate) (see, e.g., Atwood et al., 2012; Mendoza et al., 2017). Second, the subsequent period effect describes behavioral changes in compliance

Tax administrations expect that the targeted focus of risk-based tax audits provides a strong deterrence effect for tax avoidance. By using risk-based tax audits, tax administrations allocate more resources to the high-risk taxpayer and thus incur lower opportunity costs. Audit effectiveness, as perceived by the firm, may increase. Thus, the likelihood of high-risk tax positions being scrutinized and, in turn, the inherent tax benefits being eliminated under risk-based tax audits might give rise to more compliance. Unaggressive taxpayers will remain at low levels of tax avoidance to avoid a higher audit probability. Aggressive taxpayers may consider a future risk-based tax audit more likely, and reduce tax avoidance accordingly.

Audit probability as estimated by firms, and the risk of detection of non-compliant positions under risk-based audits, also depends on the firm's behavior in relation to their peers' behavior. The larger the deviation of a taxpayer's behavior from the average tax behavior of its peers, the higher the probability of being subject to a targeted audit. In other words, audit probability depends on both the firm's tax strategy and its relation to the cumulative tax strategies across all firms. Thus, firms are expected to anticipate the actions of other firms to assess their own risk of being audited. This risk assessment is subject to substantial uncertainty. Hence, uncertainty-adverse firms will prefer safer choices and reduce tax avoidance. We expect herding tax avoidance behavior in order to reduce the risk of future audits (Tan & Yim, 2014). Consistently, Lediga et al. (2020) find that audits have a positive effect on tax reporting of non-audited neighbor firms. To conclude, we expect firms to gather information about audit procedures enabling them to estimate their probability of audit and respond strategically to risk-based tax audits.

due to prior tax audits. The experience of being audited provides specific information to the taxpayers about the ability of the tax administration to detect non-compliance as well as the tax administration's main focus. Lastly, the group effect refers to the changes in tax behavior of taxpayers appertaining to the communication and learning from the audit experience of other taxpayers and their peers.

Moreover, risk-based audits may also encourage other kinds of corporate responses. Some countries incorporate the existence or design of the tax control framework by firms in their risk-based audit selection criteria. Firms that expect to be subject to a risk-based audit may respond to this incentive by enhancing their tax risk management system and thereby induce both lower audit probabilities and lower tax avoidance (Chen et al., 2020). This practice may also make tax issues more salient within the firms as they learn more about tax risks and their management. Consequently, firms might anticipate tax risks and take actions to attenuate tax risks when making corporate decisions.

Taken all together, when corporations learn about the use of risk-based tax audits and their effectiveness, they are expected to become less tax aggressive, implement better internal tax control systems, and become more diligent in their tax assessment. Based on this rationale and prior findings, we propose the following:

H1: The employment of risk-based tax audits is associated with lower levels of tax avoidance.

Although this prediction is both intuitive and in line with the literature, we expect that some firms are insensitive to risk-based tax audits for two reasons. First, small businesses may pay limited attention to tax audit strategies and are not able to draw differentiated conclusions from information on the employment of risk-based tax audits. Moreover, large businesses that are often permanently and comprehensively audited, might not expect to experience an increase in challenging tax issues under a risk-based approach. Thus, they might not adjust their tax behavior in response to the employment of risk-based tax audits. Furthermore, some firms participate in cooperative compliance programs and enjoy the benefit of no or less comprehensive post-filing audits. In all these cases, risk-based tax audits may have no or little effect.

Second, risk-based tax audits could also relate to higher levels of tax avoidance because firms may change their cost/benefit consideration when employing (new) tax professionals in the face of risk-based tax audits. Belnap et al. (2020) find that audited firms are more likely to change tax preparers.[8] Some tax service providers, for example, the Big 4, use data analytics or artificial intelligence to assist firms in solving tax compliance problems automatedly. The service includes trend analyses and the timely detection of potential errors, risks, or abnormal conditions. Ultimately such service is expected to help firms better cope with risk-based tax audits. Consequently, firms may build on tax advisors/tax professionals' expertise in facilitating tax avoidance outside the scope of risk-based tax audits. In addition, firms in a country with more information about the key parameters or criteria in risk-based tax audits may behave strategically and use more tax avoidance techniques without triggering an audit.

3. Data and Research Methodology

3.1 Measuring Risk-based Tax Audits

Most countries worldwide use risk-based tax audit strategies to determine their tax audit cases, combined with random selection. Countries disclose general information on their risk-based tax audit strategies on their tax administrations' websites and in their report to the OECD. However, the exact details on audit case selection and risk criteria are confidential to prevent taxpayers from acting strategically (Khwaja et al., 2011).

Table A2 in the Appendix provides general information about risk-based tax audit strategies in selected OECD countries. For instance, in Canada, the Canadian Revenue Agency (CRA) connects data from several CRA systems with a comprehensive dataset of taxpayers' information (filing and assessment information, risk profiles, historical audits, collections, and appeal information) to determine high-risk taxpayers in SMEs. Then, the mining/machine learning algorithms, including cluster analysis, decision trees, neural networks, and deep

[8] The tax preparer's effect on compliance is ambiguous and fosters a median stance (Marchese & Venturini, 2020).

learning, are employed to develop predictive models and to score and identify the highest risk taxpayers (OECD, 2019).

To proxy for risk-based tax audits, we exploit information on audit case selection from the OECD database, published by *Tax Administration Comparative Information Series*, which provides internationally comparative data of fundamental elements of tax administrations in advanced and emerging countries.[9] For details on case selection methods reported by the tax authorities to the OECD, see Table 1. The OECD reports 19 items for tax audit case selection; out of these 19 items, three are the most advanced and common methods for risk-based tax audits (Khwaja et al., 2011; OECD, 2004, 2017, 2019)[10], which we use for our study: item (7) "risk profiling - business rules", item (8) "risk profiling - predictive modeling", and item (9) "internal intelligence function". We argue that these three strategies out of the 19 disclosed by OECD are also the most relevant, representative, and explicit ones for risk-based tax audit selection. Other items, if used in risk-based audits, either serve as inputs of risk-profiling or represent specific rules or procedures (see Appendix Figure A1 for details).

< Insert Table 1 about here >

Our binary measure for risk-based tax audits equals one if the tax administration explicitly reports that they employ at least one of the three, risk profiling (business rules), or predictive modeling, or internal intelligence function in their audit case selection criteria. We use a binary indicator variable because it allows clear-cut interpretations. We do not use a continuous variable to avoid double counting. Although there is no information available on which kind of taxes these reported methods are used, we assume that tax authorities at least partially use these methods for corporate income taxes. To validate this measure on the use of

[9] OECD *Tax Administration Comparative Reports Series*, https://www.oecd.org/tax/forum-on-tax-administration/publications-and-products/comparative/.

[10] There is no global definition of risk-based tax audits, and different countries may have different approaches and different understandings of the content of risk-based tax audits. In this study, we aim to find items that are generally accepted as risk-based tax audits (e.g., by OECD and World Bank) and comparable among countries.

risk-based tax audits by tax administrations, we compare our measure from the OECD reports, with tax authorities' websites, PwC summaries, and the World Bank website for all the countries. Our additional search confirms the information in the OECD database for most countries. In case of disparities, we gather more information from tax authorities' websites, check papers and reports written by employees in tax authorities or other insiders, and talk to tax officers of tax administrations and other experts such as tax advisors. After gathering the details of a country's audit case selection strategy, we modify the dataset if the OECD data is inaccurate (for four countries).[11] The map of risk-based tax audits proxied by our revised dataset by countries can be found in Figure 1.

< Insert Figure 1 about here >

3.2 Research Design

In order to explore the relation between the use of risk-based tax audits and tax avoidance, we estimate the following model using least squares pooling, where *i* denotes firm, *j* denotes country, and *t* denotes the year:

$$Tax\ Avoid_{i,j,t} = \beta_0 + \beta_1 Risk\_basedAudit_{j,t} + \beta_2\ Enforcement_{j,t} + X_{i,j,t} + \varepsilon_{i,t} \qquad (1)$$

The dependent variable is tax avoidance.[12] We use the tax avoidance measure developed by Atwood et al. (2012), which is the difference between taxes calculated at the statutory tax rate

[11] We only change the data for risk-based tax audits from the OECD database for Germany, China, Kenya, and Thailand. Risk-based audit indicators are missing for Kenya and Thailand for 2014 and 2015 in the OECD database, and we change it to 0 according to our hand-collected information. We correct the risk-based audit variable for Germany to 0 (Germany indicated as 1 for all four years in the OECD database), and China, which should be 0 for all years (China indicated 1 for 2014 and 0 for 2015, 2016, 2017 in the OECD database). In the case of Germany, audit cases are selected based on size and industry. In the case of China, early actions to categorize taxpayers are based on size and industry. In July 2015, the State Tax Authority launched the "1,000 Enterprises Initiative", focusing on identifying the tax risks, assisting the enterprises to improve their tax control systems of the largest business groups in terms of size, turnover and tax contribution in China (including private enterprise, multinationals and all state-owned enterprises), and providing better service to reduce disputes. The collected data serves as inputs for risk profiling and modelling for different industries, supporting the tax credit rating for other taxpayers and helping to generate industry benchmarks. This "1,000 Enterprises Initiative" represents the start of the risk-based audit approach, and is only available for the biggest enterprise.

[12] We follow the definition of tax avoidance behavior in prior literature (Lisowsky et al., 2013), i.e., "any activity that reduces the firm's explicit taxes in any manner, including tax positions that may or may not be challenged".

and taxes actually paid. We follow De Simone et al. (2020) and calculate it as $\frac{(\text{pre-tax income} \cdot \text{statutory tax rate}) - \text{current taxes paid}}{\text{pre-tax income}}$, where pre-tax income (PTI) equals pre-tax earnings (PI) less special items (SPI) and current taxes paid (CTP) equals total tax expense (TXT) less deferred taxes (TXDI). Hence, *Tax Avoid* increases in increasing avoidance behavior of firms. This measure takes into account different statutory tax rates between countries over time and thus is suitable for cross-country samples.

The variable of interest in our analysis is *Risk-based Audit* at the country-year level. As explained above, this binary indicator variable equals one if a risk-based tax audit strategy is employed and zero otherwise. As outlined in our hypothesis, we expect a negative relation between risk-based tax audits and tax avoidance. That is, we predict that the coefficient of *Risk-based Audit*, β_1, is negative for *Tax Avoid.* We also control for the enforcement level. We follow Alexander et al. (2020)[13] and measure *Enforcement* as the total number of employees in tax administrations divided by the number of active firms (corporate income taxpayers) per country per year.[14] To facilitate interpretation, the enforcement measure is multiplied by 100 so that it can be interpreted as the total number of employees in tax administrations per 100 firms. We replace the missing data for enforcement with the nearest observation following Alexander et al. (2020). Thus, we capture differences in human resources to perform tax audits at the country level, with higher scores of *enforcement* indicating stronger tax enforcement. Thereby, we are able to explore whether the employment of risk-based tax audits has an incremental effect on firms' tax behavior, given the level of enforcement. Similar to our main variable of interest, and in line with previous studies, we expect a negative relation between this enforcement proxy and *Tax Avoid*.

[13] They measured enforcement as the ratio of citizens to tax staff at the central government tax agency and convert this ratio into tax staff per 1,000 inhabitants.
[14] If the number of active taxpayers is missing, we replace it with the number of total taxpayers.

We include a set of time-varying control variables ($X_{i,j,t}$), both at the country level and at the firm level, to alleviate the concern that the result is driven by other factors. The country's GDP per capita and GDP growth as indices for market size and overall economic activity are used in the model. Furthermore, we include a set of control variables for firm characteristics. We control for firm profitability (measured by pre-tax ROA, prior loss, sales growth), leverage (measured by the sum of long-term and short-term debt), R&D (measured by R&D expense), cash holding (measured by cash and equivalents), all scaled over total assets. *Pre-tax ROA* equals pre-tax income divided by lagged total assets. We use firms' size (Ln assets) to control for differences in tax planning related to scale. These variables affect tax avoidance, according to prior literature (Edwards et al., 2016; Law & Mills, 2017). In addition, *PP&E* also indicates tax avoidance opportunities (Chen et al., 2010; De Simone et al., 2020). Furthermore, the Worldwide Governance Indicators (WGI) are added into our regression. Lastly, we account for industry and year fixed effects in all regressions to control for unobservable tax-related differences across time and industry affecting our results. All variables are defined in Table A3 in the Appendix.

3.3 Sample and Data

We obtain the audit case selection and enforcement data from the *OECD's Tax Administration Comparative Series* from 2014 to 2017 to construct our variable of interest, *Risk-based Audit*, and key control variable *Enforcement*. Furthermore, the statutory tax rate data is taken from KPMG Corporate Tax Rates Table[15], which provides information on all corporate income taxes and related taxes on corporate profits across countries. We use other country-level control variables such as the annual level of GDP per capita and GDP growth from the World Bank.

Our primary analysis from equation (1) is at the firm level. We start from all the firm-year observations in Compustat North America and Compustat Global from 2014 to 2017 for

[15] See KPMG Corporate Tax Rates Table, https://home.kpmg/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/corporate-tax-rates-table.html.

those countries with sufficient audit selection and enforcement data in the OECD series. Financial reporting data from Compustat Global are translated into US dollars using yearly exchange rates from the World Bank. We exclude firms with negative pre-tax income from our sample, following prior literature (Atwood et al., 2012). We drop all observations that do not have sufficient data to construct variables in equation (1). After our screening procedure, the final sample includes 45,762 firm-year observations across 54 countries between 2014 and 2017 for firm-level regressions. Table A4 in the Appendix presents the sample selection.

We add country characteristics representing the quality of governance from the WGI. The indicators consist of six dimensions: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, the rule of law, and control of corruption. Furthermore, we use tax administration and tax performance data from USAID's CTD, which provides comparable information relating to tax administration systems in an internationally comparative context.[16] The data is publicly available from the USAID DRM website.

3.4 Descriptive Statistics

Our sample comprises both developed and developing countries. Table 2 reports descriptive statistics for *Tax Avoid* and *STR* by country. Countries with the most observations in our sample are from China (3,458 firms), followed by the United States (3,436 firms), Canada (827 firms), United Kingdom (760 firms). Firms from the United States and Malta show the highest tax avoidance, 0.176 and 0.115, respectively. In Comparison, Hungary and Portugal report the lowest level of tax avoidance. Table 2 reports considerable variation in the corporate tax rate in our sample, with the highest rate for the USA (40 percent) and the lowest rate for Bulgaria (10 percent).

[16] USAID CTD was launched to promote tax system assessment and measurement as a means to promote improvements in tax policy and tax administration. See USAID COLLECTING TAXES FULL DATABASE 2019, https://www.usaid.gov/documents/1865/collecting-taxes-full-database.

< Insert Table 2 about here >

Table 3 reports summary statistics for firm-level variables. We winsorize all firm-level variables at the 1 percent and 99 percent levels. The mean (median) of tax avoidance is 0.032 (0.063), indicating some level of tax avoidance in our sample consistent with prior research (e.g., Atwood et al., 2012). Sample firms report average (median) *Pre-tax ROA* of 8.9 (6.5) percent and *Sales growth* of 14.4 (6.8) percent. Around 10.7 percent of the firm-year observations show a prior year accounting loss.

< Insert Table 3 about here >

Table 4 displays the Pearson correlations for our variables used to test our hypothesis. We observe a negative correlation between *Tax Avoid* and *Enforcement*. We note a positive correlation between *Tax Avoid* and *Pre-tax ROA*. We also observe a small but significant positive correlation between *Tax Avoid* and Sales growth, *PP&E*, *R&D*. Consistent with De Simone et al. (2020), the correlation between *Tax Avoid* and *Statutory corporate tax rate (STR)* is positive and significant, indicating that firms are more likely to avoid when the economic benefit is high.

< Insert Table 4 about here >

4. Results

4.1 Main Result: Tax Avoidance

We investigate whether and how the employment of risk-based tax audits is associated with tax avoidance at the firm level. Table 5 displays the results of our estimate of equation (1). Column (1) reports the results of our baseline model. We observe a negative and significant coefficient estimate for *Tax Avoid*, suggesting that the employment of risk-based tax audit strategies is associated with a lower level of tax avoidance. The coefficient -0.047 indicates that the employment of risk-based tax audits is associated with a 4.7 percentage point reduction in tax avoidance

Relatedly, we also observe a negative and significant coefficient estimate on *Ln(Enforcement)* in both columns, which suggests that firms engage in less tax avoidance when tax enforcement is stronger. This is consistent with prior literature (Atwood et al., 2012; Hoopes et al., 2012), which finds evidence of the effectiveness of enforcement to curb tax avoidance. With regard to other control variables, *R&D* is positively related to tax avoidance, consistent with Dyreng et al. (2017), and De Simone et al. (2020). This indicates that firms use R&D accounts for tax avoidance.

In column (2), we add additional control variables at the country level to control for the effect of a country's governance level: *Voice and Accountability*, *Government Effectiveness*, *Political Stability*, *Rule of Law*, and *Regulatory Quality*. These variables reflect the citizen's perception of participating in selecting the government, the quality of public services, the risk of political instability, the extent to which agents have confidence in and abide by the rules of society respectively, and the ability of the government to formulate and implement policies and regulations. A higher score indicates better governance of the country. We continue to observe a significant relation between *Risk-based Audit* and *Tax Avoid* after adding additional controls, which suggests that our results are consistent.

To address potential concerns about the impact of the denominator in measuring tax planning for the dependent variable, column (3) additionally employs the variable *One over Pre-tax Profit* (Edwards et al., 2020). We find consistent results when controlling for trends in tax avoidance by *One over Pre-tax Profit.*

< Insert Table 5 about here >

4.2 Cross-sectional Tests

Firm characteristics

While the negative association mentioned above addresses the average effect of risk-based tax audits, the effect might vary across heterogeneous firms. In this section, we analyze the potential

heterogeneous effect of risk-based tax audits depending on the firm size, which usually is one of the audit selection criteria. The majority of tax administrations in advanced economies manage their largest taxpayers in Large Taxpayer Units (LTUs) (OECD, 2017). Firms are selected for LTUs based on specific size thresholds, including sales, income, total assets, taxable profit, or the number of employees (OECD, 2017). These size classes and thresholds differ significantly across countries.[17]

It is unclear how large firms specifically react to risk-based audits. On the one hand, some countries employ risk-based audits in LTUs first and have a stronger focus on large taxpayers. In this case, large firms are expected to respond to risk-based audits more strongly than other firms. On the other hand, for those large corporations that are constantly audited, the use of risk-based tax audits should affect their behavior to a lower extent than others because under de facto audit certainty, targeted audits barely are expected to have an incremental deterrence effect (Ayers et al., 2019), or may even increase the incentives for uncertain tax avoidance (Mills & Sansing, 2000).[18] However, large firms use complex financial instruments and arrangements that could be hard to detect under random audits, even with 100% audit probability. But under risk-based tax audits, not only is audit probability different, but audit intensity also differs. Tax administrations could improve the identification of high-risk taxpayers, high-risk cases, and non-compliance by the use of risk-based tax audit strategies.

The effect of risk-based tax audits on small firms is similarly ambiguous. Bachas et al. (2019) find evidence that audit probability increases with the firm size. In addition, the audit intensity across different size classes also varies in terms of audit depth. Given that tax audits

[17] For instance, the German tax authority divides firms into four size classes, i.e., very small, small, medium and large based on revenue and taxable profit, while other tax administrations might differentiate between two size-classes.

[18] Mills & Sansing (2000) argue that taxpayers are expected to claim more tax benefits under a permanent tax audit to create aggressive issues for negotiations with the tax administrations. These taxpayers assume that the tax administration in such a setting will not detect and punish all tax avoidance (Slemrod et al., 2001), which leads to higher levels of tax avoidance.

incur administrative costs for firms and could further lead to additional tax expenses or fines, firms strategically try to avoid tax audits. For instance, Almunia and Lopez-Rodriguez (2018) find significant evidence on downward size management by Spanish firms and show that firms strategically bunch below a certain threshold to avoid stricter tax audits. Under risk-based tax audits, the probability and intensity of audits not only depends on size but on the combination of non-compliance factors such as complexity, business model, and firms' prior compliance behavior. Therefore, we expect that risk-based tax audits have a deterrence effect on firms of all sizes.

However, small firms may pay limited attention and are not able to draw differentiated conclusions from information on the implementation of risk-based tax audits. Conversely, it is also possible that they change their cost/benefit consideration in employing tax intermediaries under risk-based tax audits. These tax intermediaries provide technical expertise to implement tax avoidance schemes, which offset the deterrent effect of risk-based audits. Taken together, ex-ante it is unclear how the effect of risk-based audit differs across different size groups. In order to test the potential heterogeneous effects of different firm size groups, we split the sample into three size groups (*Ln Assets*) within country-year.

Table 6 Panel A presents the regression results of equation (1) for the dependent variable *Tax Avoid* based on different sizes: small, medium, large. Interestingly, the results suggest that risk-based tax audits have a deterrence effect on all firms, irrespective of size. Moreover, the effect is more pronounced for medium and large firms, suggesting that risk-based tax audits increase control over the large taxpayers and improve the compliance of these groups. Note that Compustat only covers public firms, and thus small firms in our sample may already have a relatively larger size than private firms. As such, our result should be interpreted with caution.

Country characteristics

This section examines how heterogeneity across countries could affect the association of risk-based tax audits and tax avoidance. We first focus on countries' governance quality. *High Governance* indicates that the government is performing well in providing accessible and high quality public goods and implementation of policies. Countries with high governance might be more effective in employing policies and regulations and have better socioeconomic conditions, which do not necessitate using risk-based tax audits to curb tax avoidance. However, these are mostly the developed countries with a higher level of tax rates, which might incentivize firms to avoid taxes. Hence, risk-based tax audits might be effective in improving targeting audits toward non-compliant firms. Countries with a lower level of governance suffer from inadequate socioeconomic conditions, affecting citizens' willingness to pay taxes. In addition, these countries might be less effective in implementing the regulations and policies. Therefore, risk-based tax audits could coordinate to target and identify the non-compliance cases.

To analyze the effect of governance quality, we split the sample based on countries' level of governance provided by the six dimensions of the WGI (voice and accountability, political stability and absence of violence/terrorism; government effectiveness; regulatory quality; rule of law; and control of corruption). The results (Panel B of Table 6) are generally consistent with the idea that risk-based tax audits are more effective in curbing tax avoidance in countries with a low level of governance quality, which might offset the poor quality of governance in these countries.

The effect of risk-based audits may differ across countries with different development levels. We split up the sample by GDP per capita, which represents the wealth effect. On the one hand, countries that are more economically developed might also have more developed risk-based audit routines and, in turn, more effective procedures. On the other hand, these countries

might not suffer as much from budget constraints, and hence the pressure on tax administration to collect taxes might be less pronounced.

Panel B of Table 6 represents the result of two subgroups: countries with high and low GDP per capita. Results indicate that the deterrence risk of risk-based audits on tax avoidance is more pronounced in countries with higher GDP levels. In columns (5) and (6), we split the sample according to countries' level of trust in government. As indicated from prior literature, frequent auditing could be perceived as excessively and unnecessarily costly and may signal distrust, particularly for the honest taxpayers (Kirchler et al., 2008). We analyze how risk-based tax audits as a well-targeted procedure to capture tax-evaders will affect tax avoidance considering the level of trust in the government. We measure trust in government as the average score of perceptions of effectiveness and transparency of government policy indicators, following Mendoza et al. (2017). The results indicate that risk-based tax audits are more effective in subsiding tax avoidance in countries with lower trust levels in government.

< Insert Table 6 about here >

4.3 Supplementary Analysis

Disaggregation of risk-based audit measure

To further explore our measure of risk-based audit, we disaggregate and create a separate dummy variable for each component of our measure: risk profiling (business rules), predictive modeling, and internal intelligence function. This test partially alleviates the concern about our measure for risk-based audits.

Results are shown in Table 7. Column (1) displays the results for the analysis of all three components, of which only predictive modeling shows a negative and significant coefficient. However, when analyzing each component separately in Columns (2), (3) and (4), each component variable is negative and significant ($p<0.01$). Our results show that the use of each of the three components is negatively associated with tax avoidance. We are thus confident that

our combined measure of risk-based audits in the main analysis is unbiased. These findings are intuitive and consistent with Hashimzade and Myles (2017) results, which show that predictive analytics are successful in raising compliance.

< Insert Table 7 about here >

Effect of implementation of risk-based audits on tax avoidance

To alleviate the potential concern that the result is driven by confounding factors, we use a different identification strategy and focus on countries that implement a risk-based tax audit in our sample period. Using a difference-in-difference design, we compare the changes in tax avoidance for firms in countries that switched to risk-based tax audits (treatment group) with changes for firms in countries that never implemented risk-based audits (control group).

China, Czech Republic, Germany, Japan, and Korea do not use risk-based audits between 2014 to 2017. Georgia, Greece, Kenya, Thailand, and Turkey start to employ risk-based audits in 2016. The US started a risk-based audit in 2015; however, because tax avoidance of US firms is too different from that of other countries in our sample and may affect the parallel trend assumption, we exclude the US from the difference-in-difference test. Untabulated tests show that our result is robust when including US firms. Accordingly, 2014 and 2015 serve as the pre-treatment years, while 2016 and 2017 serve as the post-treatment years.

The model is as follows:

$$TaxAvoid_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt} \quad (2)$$

Our dependant variable is *Tax Avoid* and our coefficient of interest is the interaction term $Treat_{ij} * Post_t$, representing the relative change in tax avoidance between treated and control firms. We include firm- and country-specific characteristics from our main tests. Our models also include indicator variables for firm fixed effects to absorb unobservable time-invariant firm characteristics and year fixed effects to control for common time trends.

Figure 2 indicates that before 2016—the year in which treated countries switch to risk-based audit—there is a parallel trend in *Tax Avoid* between the treatment group and the control group.

< Insert Figure 2 about here >

Table 8 shows the results of our difference-in-difference specification. The negative and significant coefficient of *Treat*Post* suggests that relative to firms in the control group, firms reduce tax avoidance after a risk-based audit approach is introduced in the respective country. Our analysis confirms that the introduction of risk-based audits reduces tax avoidance.

< Insert Table 8 about here >

4.4 Tax Administration Performance

Next, we use country-level analysis to examine the association of risk-based tax audits and the performance of tax administrations in different countries. We employ the data from USAID CTD, which compares the administrative frameworks, functions, and performance of different tax administrations.[19] To test for the association between risk-based tax audits and tax administration performance, we estimate the following regression at the country level, where *j* is the country identifier, and *t* is the year identifier:

$$Tax\ Admin\ Performance_{j,t} = \beta_0 + \beta_1 Risk\_basedAudit_{j,t} + \beta_2\ Enforcement_{j,t} + \delta\ X_{j,t} + \varepsilon_{j,t} \quad (3)$$

Tax Admin Performance is one of three indicators: cost of collection, tax effort, and tax buoyancy which is described in detail below. All three indicators are collected and calculated by USAID's CTD. Find descriptives of these indicators in Table A5 in the Appendix. Similar to our main

[19] For an overview of CTD comparable data on taxation, see https://www.usaid.gov

tests, we control for enforcement level and country characteristics, and we include year fixed effects.

First, we use the cost of tax collection as the dependent variable to capture the effectiveness of tax authorities, as given by CTD. The measure for the cost of collection (*Cost*) is given by the ratio of the total annual tax administration expenditures (budget) to the net tax revenue collected by the tax administration (in percent). The lower this indicator is, the more efficient the tax system is in collecting all taxes. The cost indicator is affected by the revenue productivity of taxes.[20] The data is available for two points in time over the sample period (in 2015 and 2017). Therefore, we replace the missing cost of collection data for 2014 with 2015 value and for 2016 with 2017 value.

On the one hand, the employment of risk-based tax audits may increase effectiveness by devoting the resources to high-risk taxpayers. On the other hand, the employment of risk-based tax audits may trigger substantial costs in terms of data and IT systems at first, but the cost may outweigh the reduction in enforcement costs. Hence, the association between risk-based audits and the cost of tax collection is ambiguous.

The results in column (1) of Table 9 indicate a lower cost of collection (-0.243) associated with the use of risk-based tax audits. The positive coefficient estimate for *Enforcement* suggests that the cost of collection increases with higher enforcement levels, i.e., more tax administration employees per 100 firms. This result is consistent with the OECD (2019), which shows that automated risk management informed by advanced analytics reduces the cost per audit substantially.

Our second dependent variable *Tax Effort*, derived from CTD, is attributed to the performance of tax administrations and estimates the taxes a country could potentially collect

[20] Note, that this indicator does not take into account that some tax administrations rent the building or use government buildings and nationwide Information Technology (IT) hardware, or similar costs.

based on its macroeconomic, demographic, and institutional features. The *Tax Effort* indicator equals the actual value of tax as a percent of GDP to tax capacity (the potential tax to the GDP ratio). In other words, it indicates how much tax revenue a country collects relative to its tax capacity (predicted value of tax as a percent of GDP regarding several factors such as macroeconomic, demographic, and institutional characteristics of a country). For example, a tax effort of 1.0 shows that a country is collecting exactly its predicted capacity. A low tax effort (tax effort below one) indicates the opposite. We replace the missing data for *Tax Effort* with the nearest observation. We expect that the employment of risk-based tax audits will increase the extent that a country could collect tax revenue to its full capacity with respect to its characteristics. Results reported in columns (2) and (3) of Table 9 also show that the use of risk-based tax audits by tax administrations positively affects the *Tax Effort* in a country and could facilitate the tax collection of a country to reach its full potential.

The third dependent variable, *Tax Buoyancy*, again from CTD, provides insight on the extent to which tax collection responds to changes in the tax base measured by GDP. *Tax Buoyancy* is measured by the percent change of tax revenue (VAT, CIT, and PIT) divided by the percent change of the tax base or GDP. It is calculated based on 10-year rolling averages of the country's tax performance and economic growth. Therefore, we examine whether the employment of risk-based tax audits is associated with higher tax buoyancy. We expect that the employment of risk-based tax audits by tax administration could increase the tax revenue in proportion to an increase in GDP. Column (4) of Table 9 presents the results of the effect of risk-based audits on *Tax Buoyancy*. Specifically, the coefficient estimate on *Tax Buoyancy* is significantly positive. Hence, the employment of risk-based tax audits is associated with an increase in tax revenue at a faster rate relative to the growth in GDP.

Overall, we provide evidence that the employment of risk-based tax audits for selecting the firms reduces the cost of enforcement and improves the performance of tax authorities.

< Insert Table 9 about here >

5. Conclusion

We conduct a cross-country study to explore whether and to what extent risk-based tax audits strategies are associated with firms' tax avoidance after controlling for enforcement and other country characteristics. We use annual country-level OECD data on audit case selection strategies across 54 countries from 2014 to 2017. We measure risk-based tax audit strategies by the reported employment of risk profiling (business rules), predictive modeling, and internal intelligence function in tax administrations' audit case selection criteria.

Our results indicate that the employment of risk-based tax audits is on average negatively associated with corporate tax avoidance. We further exploit a difference-in-difference design and compare the tax behavior of firms in countries that switch to risk-based audits and firms in countries that never used risk-based audits (first difference) before and after the introduction of risk-based audits (second difference). The results are consistent with our main analysis and indicate that the implementation of risk-based audit strategies in a country affects firms' tax behavior, i.e., reducing tax avoidance. In cross-sectional tests, we analyze firm and country heterogeneity. We show that risk-based tax audit strategies are associated with lower tax avoidance for firms of all sizes. That is, risk-based audits could potentially deter the strategic responses to audits, such as bunching below a certain threshold of revenue to avoid an audit. In addition, we show that the effect of risk-based tax audits is more pronounced in countries with poor governance quality, and low level of trust, and good economic conditions.

In additional tests, we analyze whether risk-based tax audit strategies are associated with three specific qualities of tax administrations and find that the use of risk-based tax audits relates to lower cost of tax collection, to tax collection reaching its full potential, and to a disproportionately high increase in tax revenue as compared to GDP growth. Broadly speaking,

our results confirm the connection between the high performance of tax administration and their use of risk-based tax audit strategies.

To the best of our knowledge, this is the first cross-country study to examine the association between risk-based tax audits and corporate tax avoidance. However, it is important to emphasize that we do not infer causality between the employment of risk-based tax audits and corporate tax avoidance behavior for most of the tests. Instead, we paint a consistent picture of the association between the use of risk-based tax audit strategies and tax avoidance, which tax administrations actively seek to combat. Note that we use cross-country data on risk-based tax audits. However, we can only refer to data on case selection strategies included in the OECD questionnaire and as self-reported by tax administrations. We mitigate this limitation by validating our measure with other available resources such as tax authorities' websites, PwC summaries, World Bank reports, and contacting tax experts in different countries. Despite this limitation, we believe that our findings provide insights to researchers, policymakers, and tax administrations globally.

Our findings enrich the debate on tax enforcement design. They underline the importance of investing in the analytical techniques of tax administrations to support advanced risk-based audit selection mechanisms. While several countries are well advanced in implementing such strategies, others seem to be rather reluctant to either free resources or overcome legal or political obstacles. Hence, our results provide important policy input for tax enforcement considerations in developed as well as less developed countries. Our results indicate that the employment of risk-based tax audits is also likely to deter tax avoidance in countries with poor governance indicators. More broadly, our results indicate that risk-based tax audits not only relate to less tax-avoiding firm behavior but also to better performance of tax administrations.

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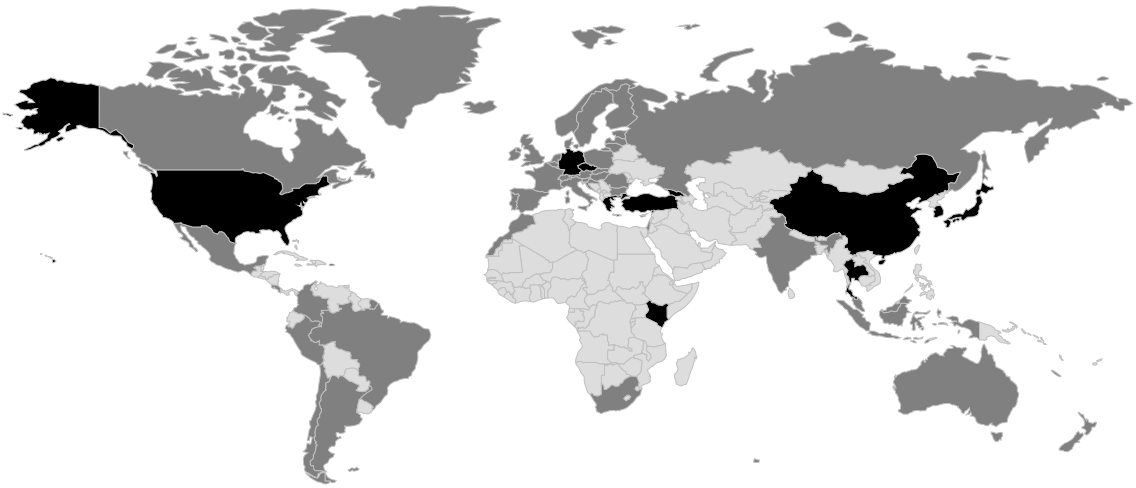
Figure 1

Risk-based Tax Audit across Countries and over Time

Notes: This figure indicates the employment of risk-based tax audits across our sample countries between 2014 and 2017. Countries highlighted in black employ no risk-based tax audit strategy, and countries shaded in grey employ risk-based tax audits.

Risk-based Tax Audit across Countries 2014



Risk-based Tax Audit across Countries 2017

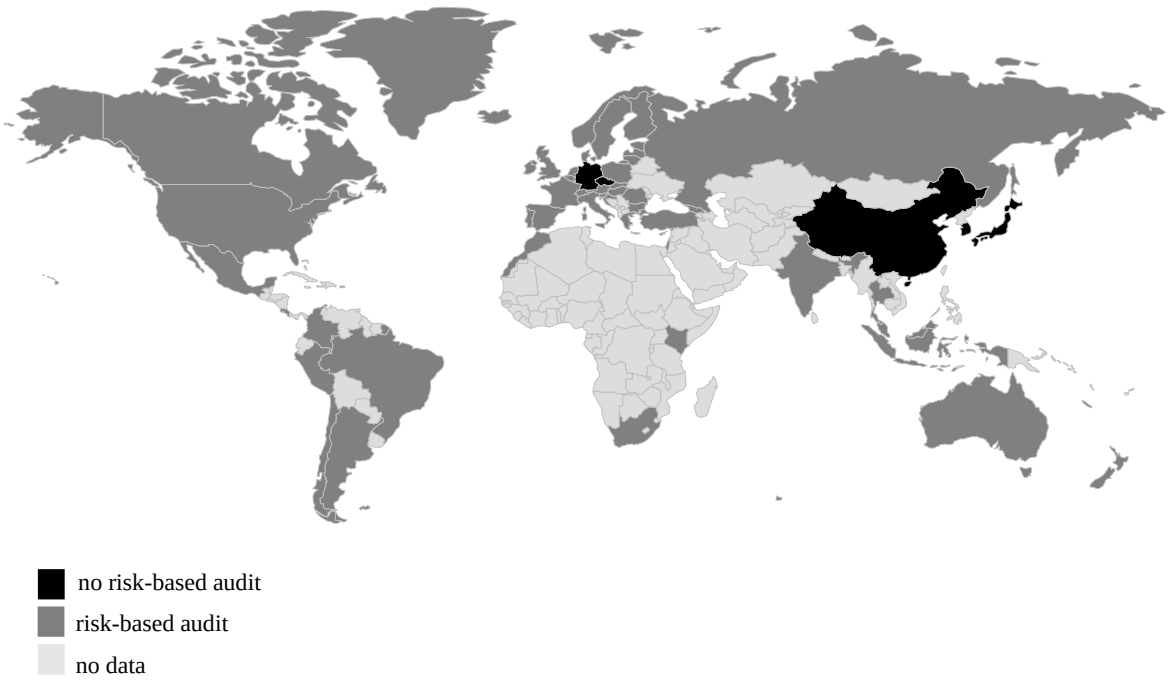


Figure 2

Difference-in-difference

Notes: This figure plots the difference in tax avoidance between treated and control firms. 2014 and 2015 serve as the pre-treatment years, whereas 2016 and 2017 serve as the post-treatment years. Treated firms are those whose countries switched to risk-based tax audits in 2016. Control firms are those whose countries do not use risk-based tax audits between 2014-2017—the parallel trend between the treated and control groups before 2016, supporting our identification assumption.

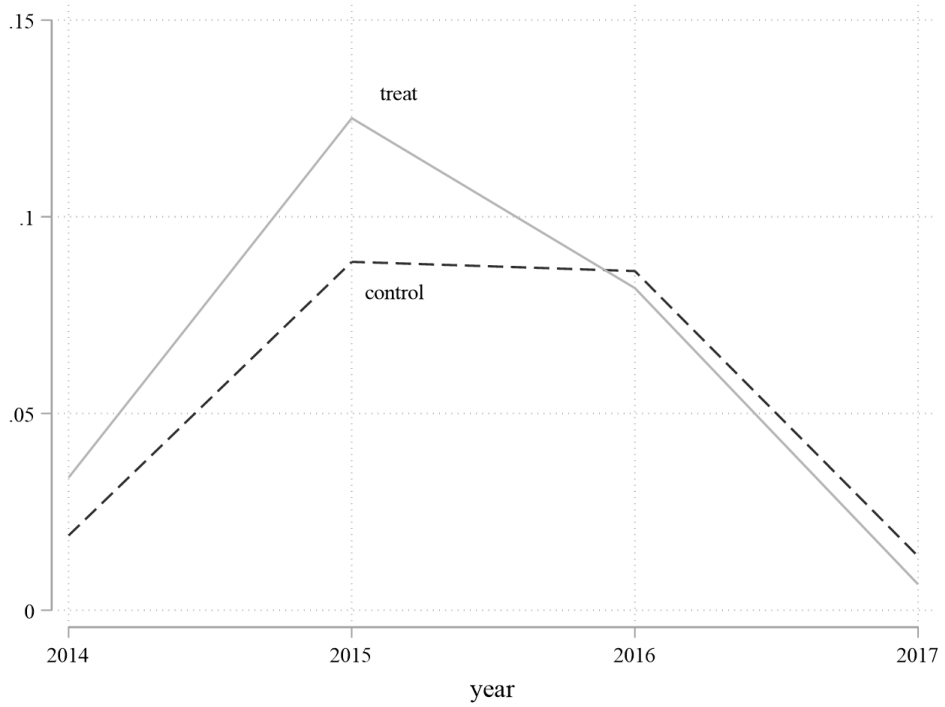


Table 1: Audit Case Selection Criteria Reported to the OECD

Notes: This table describes the audit case selection criteria as reported by the countries' tax administrations to the OECD. Our measure of risk-based audits includes: (7) risk profiling - business rules, (8) risk profiling - predictive modeling, and (9) internal intelligence function.

Item	Rating
(1) Economic sector	1 – Yes | 0 – No
(2) Location	1 – Yes | 0 – No
(3) Taxpayer category	1 – Yes | 0 – No
(4) Ownership in a corporate entity	1 – Yes | 0 – No
(5) Taxpayer behavior	1 – Yes | 0 – No
(6) Frequency (time between audits)	1 – Yes | 0 – No
(7) Risk profiling - business rules	1 – Yes | 0 – No
(8) Risk profiling - predictive modeling	1 – Yes | 0 – No
(9) Internal intelligence function	1 – Yes | 0 – No
(10)Third party information	1 – Yes | 0 – No
(11)Commercial register	1 – Yes | 0 – No
(12) Collected tax	1 – Yes | 0 – No
(13) Significant changes to taxpayer	1 – Yes | 0 – No
(14) Audits as a result of BEPS or ATP issues	1 – Yes | 0 – No
(15) Audits as a result of international EOI	1 – Yes | 0 – No
(16) Tax control framework based "audits"	1 – Yes | 0 – No
(17) Compliance checks	1 – Yes | 0 – No
(18) Information cross-checking	1 – Yes | 0 – No
(19) Random Audit	1 – Yes | 0 – No

Source: The OECD's *Tax Administration Comparative Information Series*, 2014 -2019.

Table 2: Mean of Selected Variables by Country

Country	Tax Avoid	STR	No. of Firms
Argentina	0.013	0.35	55
Australia	0.053	0.30	505
Austria	0.010	0.25	59
Belgium	0.049	0.34	79
Brazil	0.057	0.34	191
Bulgaria	-0.063	0.10	37
Canada	0.068	0.27	827
Chile	-0.057	0.23	108
China	-0.001	0.25	3,458
Colombia	-0.079	0.27	30
Croatia	0.052	0.20	49
Cyprus	-0.075	0.13	39
Czech Republic	-0.002	0.19	10
Denmark	-0.064	0.23	81
Estonia	0.004	0.20	13
Finland	-0.069	0.20	112
France	0.041	0.33	462
Germany	-0.019	0.30	418
Greece	-0.060	0.28	101
Hong Kong	-0.070	0.17	190
Hungary	-0.144	0.16	19
Iceland	0.015	0.20	9
Indonesia	-0.080	0.25	297
Ireland	-0.088	0.13	58
Israel	-0.022	0.25	239
Italy	-0.115	0.30	236
Japan	0.000	0.33	588
Kenya	-0.079	0.30	23
Korea	-0.006	0.24	8
Latvia	0.042	0.15	18
Lithuania	0.003	0.15	30
Luxembourg	-0.016	0.29	44
Malaysia	-0.068	0.24	457
Malta	0.115	0.35	11
Mexico	-0.113	0.30	74
Morocco	-0.012	0.31	48
Netherlands	0.004	0.25	114
New Zealand	0.011	0.28	89
Norway	-0.033	0.26	102
Peru	-0.081	0.29	66
Poland	-0.010	0.19	520
Portugal	-0.130	0.21	38
Romania	-0.082	0.16	56
Russia	-0.059	0.20	177
Singapore	-0.083	0.17	447
Slovak Republic	0.017	0.22	5
Slovenia	-0.007	0.18	22
South Africa	-0.021	0.28	166
Spain	-0.045	0.27	114
Sweden	0.004	0.22	271
Thailand	0.016	0.20	339
Turkey	0.009	0.20	215
United Kingdom	-0.011	0.20	760
United States	0.176	0.40	3,436

Table 3: Descriptive Statistics

Notes: This table describes the sample and summary statistics for the cross-country sample of our main variables for 15,920 firms and 45,762 firm-year observations from 2014 to 2017 used in the empirical tests. All continuous variables are winsorized at the 1st and 99th percentiles.

Variable	Obs.	Mean	Std. Dev.	P25	P50	P75
Tax Avoid	45762	0.032	0.318	-0.023	0.063	0.166
Pre-tax ROA	45762	0.089	0.095	0.031	0.065	0.118
Prior loss	45762	0.107	0.309	0.000	0.000	0.000
Sales growth	45762	0.144	0.392	-0.011	0.068	0.189
PP&E	45762	0.303	0.266	0.085	0.235	0.454
Leverage	45762	0.253	0.238	0.057	0.210	0.374
R&D	45762	0.016	0.033	0.000	0.000	0.019
Cash	45762	0.191	0.212	0.049	0.122	0.254
Ln (Assets)	45762	6.266	2.183	4.902	6.193	7.639
Risk-based Audit	45762	0.615	0.487	0.000	1.000	1.000
Ln (Enforcement)	45762	0.505	0.826	-0.298	0.725	0.956
STR	45762	0.283	0.075	0.250	0.250	0.340
Ln (GDP per capita)	45762	9.982	0.951	8.897	10.544	10.861
GDP Growth	45762	3.658	2.400	2.193	2.881	6.737
Corruption	45762	0.790	0.946	-0.270	1.315	1.525
Voice and Accountability	45762	0.241	1.213	-1.505	1.034	1.110
Political Stability	45762	0.216	0.668	-0.499	0.336	0.678
Government Effectiveness	45762	1.043	0.654	0.408	1.403	1.554
Regulatory Quality	45762	0.869	0.852	-0.148	1.216	1.628
Rule of Law	45762	0.842	0.952	-0.263	1.413	1.645

Table 4: Correlations

Notes: This table provides Pearson correlations for the sample. * denotes significance at the .05 level.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1)Tax Avoid	1.000													
2)Risk-based Audit	0.019*	1.000												
3)Ln (Enforcement)	-0.133*	-0.279*	1.000											
4)Pre-tax ROA	0.115*	-0.039*	0.002	1.000										
5)Prior loss	-0.029*	0.105*	-0.052*	-0.121*	1.000									
6)Sales growth	0.037*	-0.065*	0.023*	0.271*	0.092*	1.000								
7)PP&E	0.021*	-0.003	0.030*	0.002	0.008	0.101*	1.000							
8)Leverage	0.027*	0.113*	-0.110*	-0.107*	0.070*	0.196*	0.245*	1.000						
9)R&D	0.037*	-0.166*	0.048*	0.186*	0.004	0.118*	-0.174*	-0.153*	1.000					
10)Cash	0.005	-0.225*	0.048*	0.408*	-0.025*	0.246*	-0.173*	-0.200*	0.331*	1.000				
11)Ln (Assets)	0.044*	-0.030*	-0.204*	-0.171*	-0.104*	-0.033*	0.098*	0.273*	-0.087*	-0.192*	1.000			
12)STR	0.230*	0.045*	-0.526*	-0.007	0.024*	-0.042*	-0.086*	0.131*	0.068*	-0.072*	0.289*	1.000		
13)Ln (GDP per capita)	0.133*	0.509*	-0.376*	-0.066*	0.105*	-0.075*	-0.113*	0.130*	-0.023*	-0.183*	0.183*	0.454*	1.000	
14)GDP Growth	-0.077*	-0.580*	0.359*	0.059*	-0.108*	0.092*	0.040*	-0.127*	0.111*	0.232*	-0.094*	-0.378*	-0.676*	1.000

Table 5: Risk-based Tax Audits and Tax Avoidance

Notes: This table presents the results of equation (1). The dependent variable is *Tax Avoid*, measured as the difference between taxes calculated at the statutory tax rate and taxes that are actually paid, based on De Simone et al. (2020) and Atwood et al. (2012). Our main variable of interest, *Risk-based Audit*, is an indicator variable equal to one if risk profiling - business rules, risk profiling - predictive modeling, or internal intelligence function equal to one from OECD audit case selection data. All continuous variables are winsorized at the 1% and 99% levels. Variables are defined in Table A3. Industry and year fixed effects are included in all regressions. We report robust standard errors clustered at the country level in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	**Tax Avoid**	**Tax Avoid**	**Tax Avoid**
Risk-based Audit	-0.047***	-0.040***	-0.040***
	(0.016)	(0.012)	(0.012)
Ln (Enforcement)	-0.032**	-0.026**	-0.026**
	(0.015)	(0.010)	(0.010)
Pre-tax ROA	0.427***	0.412***	0.402***
	(0.083)	(0.090)	(0.090)
Prior loss	-0.025**	-0.028**	-0.027**
	(0.011)	(0.011)	(0.011)
Sales growth	0.011**	0.014**	0.014**
	(0.005)	(0.006)	(0.006)
PP&E	0.065***	0.074***	0.074***
	(0.021)	(0.018)	(0.018)
Leverage	-0.028	-0.039	-0.037
	(0.035)	(0.033)	(0.033)
R&D	0.350***	0.222***	0.225***
	(0.095)	(0.081)	(0.079)
Cash	-0.060**	-0.051**	-0.050**
	(0.026)	(0.021)	(0.021)
Ln (Assets)	-0.002	-0.004**	-0.005***
	(0.002)	(0.002)	(0.002)
Ln (GDP per capita)	0.044***	0.037*	0.038*
	(0.016)	(0.020)	(0.021)
GDP Growth	0.002	0.006	0.006
	(0.005)	(0.004)	(0.004)
Corruption		-0.085*	-0.085**
		(0.042)	(0.042)
Voice and Accountability		-0.015	-0.015
		(0.014)	(0.013)
Government Effectiveness		-0.083*	-0.085*
		(0.047)	(0.047)
Political Stability		-0.041*	-0.041*
		(0.022)	(0.022)
Rule of Law		0.302***	0.303***
		(0.058)	(0.059)
Regulatory Quality		-0.124***	-0.123***
		(0.029)	(0.029)
One over Pre-tax Profit			-0.002**
			(0.001)
Constant	-0.485***	-0.397*	-0.401*
	(0.178)	(0.199)	(0.201)
Observations	45,762	45,762	45,762
R-squared	0.077	0.093	0.097
Industry FE	yes	yes	yes
Year FE	yes	yes	yes

Table 6: Cross-sectional Tests

Notes: This table presents the cross-sectional results of estimating the baseline regression (Table 5). The dependent variable is *Tax Avoid*, measured as the difference between taxes calculated at the statutory tax rate and taxes that are actually paid, based on De Simone et al. (2020) and Atwood et al. (2012). Our main variable of interest, *Risk-based Audit*, is an indicator variable equal to one if risk profiling - business rules, risk profiling - predictive modeling, or internal intelligence function equal to one from OECD audit case selection data. In Panel A, the results of equation (1) are split by size quantile per country and year. In Panel B, Columns (1) and (2) present the results using a subsample of companies that are located in countries with low and high Governance indicators (voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, control of corruption). Columns (3) and (4) present the result of equation (1) split by GDP per capita. Columns (5) and (6) present results using a subsample of firms in countries with low and high trust in government. All continuous variables are winsorized at the 1% and 99% levels. Variables are defined in Table A3. Industry and year fixed effects are included in all regressions. We report robust standard errors clustered at the country level in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Risk-based Tax Audit and Firm Size

	(1)	(2)	(3)
Variables	**Small Firms Tax Avoid**	**Medium Firms Tax Avoid**	**Large Firms Tax Avoid**
Risk-based Audit	-0.031**	-0.046***	-0.040***
	(0.015)	(0.013)	(0.012)
Ln (Enforcement)	-0.022**	-0.021**	-0.028**
	(0.009)	(0.010)	(0.012)
Observations	15,320	15,260	15,182
R-squared	0.078	0.100	0.143
Controls	yes	yes	Yes
Industry FE	yes	yes	Yes
Year FE	yes	yes	Yes

Panel B: Risk-based Tax Audit and Country Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**low Governance**	**high Governance**	**Low GDP**	**High GDP**	**Low Trust**	**High Trust**
Risk-based Audit	-0.050***	-0.038	-0.046**	-0.053***	-0.050**	-0.025*
	(0.012)	(0.023)	(0.017)	(0.012)	(0.023)	(0.014)
Ln (Enforcement)	-0.024**	-0.031***	-0.001	-0.046***	-0.008	-0.021**
	(0.010)	(0.010)	(0.009)	(0.008)	(0.012)	(0.008)
Observations	29,079	16,683	20,166	25,596	10,945	34,817
R-squared	0.088	0.109	0.061	0.120	0.055	0.112
Controls	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes

Table 7: Supplementary Analysis - Alternative Measure of Risk-based Tax Audit

Notes: This table presents the results of equation (1) with alternative measures of risk-based tax audits. The dependent variable is *Tax Avoid*, measured as the difference between taxes calculated at the statutory tax rate and taxes that are actually paid, based on De Simone et al. (2020) and Atwood et al. (2012). The variables of interest are the components of risk-based tax audits: risk profiling (business rules), predictive modeling, and internal intelligence function. Risk profiling (business rules), predictive modeling, and internal intelligence function are dummy variables from OECD audit case selection data. All continuous variables are winsorized at the 1% and 99% levels. Variables are defined in Table A3. Industry and year fixed effects are included in all regressions. We report robust standard errors clustered at the country level in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	**Tax Avoid**	**Tax Avoid**	**Tax Avoid**	**Tax Avoid**
Risk profiling-business rules	-0.001	-0.031**		
	(0.023)	(0.012)		
Risk profiling-predictive modeling	-0.038**		-0.041***	
	(0.019)		(0.014)	
Internal intelligence	-0.006			-0.031***
	(0.023)			(0.011)
Ln (Enforcement)	-0.021**	-0.026**	-0.020**	-0.025**
	(0.010)	(0.010)	(0.010)	(0.010)
Observations	45,762	45,762	45,762	45,762
R-squared	0.094	0.092	0.094	0.092
Controls	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Table 8: Difference-in-difference

Notes: This table presents regression results for the difference-in-differences test, which compares the countries that switch to a risk-based audit in our sample with countries that do not employ risk-based tax audits. The dependent variable is *Tax Avoid*, and the coefficient of interest is the interaction term *Treat*Post*, representing the relative change in tax avoidance between treated and control firms. We include firm- and country-specific characteristics that are used in our primary tests. Our models also include indicator variables for firm fixed effects to absorb unobservable time-invariant firm characteristics and year fixed effects to control for common time trends. We report robust standard errors clustered at the country level in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	(1)
Variables	**Tax Avoid**
*Treat*Post*	-0.030**
	(0.015)
Ln (Enforcement)	-3.278
	(2.503)
Pretax ROA	0.525***
	(0.061)
Prior loss	0.001
	(0.017)
Sales growth	0.017**
	(0.008)
PP&E	-0.053**
	(0.027)
leverage	-0.031
	(0.025)
R&D	-0.190
	(0.198)
Cash	-0.037***
	(0.013)
Ln (Assets)	-0.004
	(0.010)
Ln (GDP per capita)	0.039
	(0.149)
GDP Growth	0.010*
	(0.005)
Corruption	-0.068
	(0.107)
Constant	-0.286
	(1.347)
Observations	15,521
R-squared	0.046
Number of firm	5,131
Firm FE	yes
Year FE	yes

Table 9: Risk-based Tax Audit and Tax Administration Performance

Notes: This table presents the results of equation (3). In column (1), the dependent variable is *Cost*, which equals the ratio of the cost of administering the tax system to the total revenues collected by the tax administration. In columns (2) and (3), the dependent variable is *Tax Effort*, which compares the actual value of tax as a percent of GDP to tax capacity. In column (4), the dependent variable is *Tax Buoyancy*, which equals the percent change of tax revenue divided by the percent change of the tax base or GDP. Our main variable of interest, *Risk-based Audit*, is an indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling or internal intelligence function equal to one from OECD audit case selection data. Variables are defined in Table A3. Year fixed effects are included in all regressions. We report robust standard errors clustered at the country level in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Variables	(1) Cost	(2) Tax Effort with Imputation	(3) Tax Effort without Imputation	(4) Tax Buoyancy
Risk-based Audit	-0.243**	0.051*	0.075**	0.075*
	(0.108)	(0.029)	(0.033)	(0.040)
Ln (Enforcement)	0.108***	0.030	0.026	0.010
	(0.036)	(0.020)	(0.021)	(0.015)
Voice and Accountability	0.316***	0.035	0.020	0.106*
	(0.109)	(0.037)	(0.040)	(0.053)
Political Stability	0.158*	-0.037	-0.092***	0.026
	(0.089)	(0.028)	(0.024)	(0.041)
Government Effectiveness	0.852***	-0.185**	-0.178*	0.213
	(0.275)	(0.082)	(0.105)	(0.164)
Regulatory Quality	-0.134	-0.147***	-0.140***	-0.010
	(0.215)	(0.051)	(0.051)	(0.113)
Rule of Law	-0.577*	0.049	0.152	-0.138
	(0.313)	(0.072)	(0.099)	(0.136)
Corruption	0.022	0.159**	0.096	-0.092
	(0.190)	(0.060)	(0.075)	(0.089)
Ln (GDP per capita)	-0.409***	0.089**	0.079**	0.006
	(0.125)	(0.035)	(0.036)	(0.046)
GDP Growth	-0.007	-0.009**	-0.015**	-0.003
	(0.013)	(0.004)	(0.008)	(0.004)
Constant	4.623***	-0.190	-0.118	-0.132
	(1.151)	(0.308)	(0.311)	(0.405)
Observations	196	200	68	216
R-squared	0.412	0.498	0.559	0.099
Year FE	yes	yes	yes	yes

Appendix

Table A1: Association between Tax Audits and Individual or Corporate Tax Compliance in Prior Literature

	Individual tax behavior	**Corporate tax behavior**
Positive association between tax audits and compliance	Kleven et al. (2011) Advani et al. (2019) DeBacker et al. (2018)	Hoopes et al. (2012) Gupta and Lynch (2016) Atwood et al. (2012)
Negative association between tax audits and compliance	Mittone (2006) Guala & Mittone (2005)	DeBacker et al. (2015) Finley (2019)
Negative association between risk-based tax audits and compliance	Alm and McKee (2004) Beer et al. (2020) Hashimzade et al. (2016) Loyland et al. (2019)	Hsu et al. (2015)

Table A2: Risk-based Tax Audit Strategies across Selected OECD Countries

Country	Risk-based tax audits
Australia	The Australian Tax Office uses a risk-based approach to increase the detection capability of the revenue authority. It employs a range of activities aimed at preventing, deterring, detecting, and dealing with the risks of non-compliance. This risk-based approach includes techniques such as qualitative, quantitative assessment and probability forecasts using predictive techniques.
Austria	Austria uses risk analysis systems using tax returns and case history information and evaluates/compares this information to assign risk levels to each taxpayer.
Bulgaria	Risk analysis and risk criteria at the national level. In Bulgaria, past taxpayer data, supplemented with external data, are gathered to create risk scores and categories. The risk assessment employs the point systems, which generate points based on different criteria and determines the taxpayers' total risk score.
Canada	Audit selection based on data-mining techniques (neural networks, decision trees). In Canada, data is extracted from several systems to identify the high-risk taxpayers in the Small and Medium Enterprises (SME) population. Data mining/machine learning algorithms, including cluster analysis, decision trees, neural networks, and deep learning, are used in developing SME predictive models for income.
France	Audit selection is based on data mining and other statistical tools.
Malaysia	Data-driven audit case selection (automated audit selection). The risk-based audit techniques also include advanced analytics using statistical models.
Netherlands	Dutch Tax and Customs Administration gathers and analyzes many types of information at the central level, including the industry sector-related information, information from tax returns, compliance surveys, risk database, third-party information, and information from other authorities. It employs risk-based approaches, such as data-matching and advanced analytics.
Sweden	In Sweden, risk-based tax audits are employed using data at both central and regional levels. The risk-based tax audit techniques include data-matching and predictive techniques such as predictive models to identify unreported income.
Turkey	Risk-based audits are centralized at the national level. Risk-based audit techniques are based on data mining.
United Kingdom	HM Revenue and Customs employ extensive data-matching and data-mining techniques (including decision trees and neural networks), score-based risk assessment using statistical tools.

Source: Khwaja et al. (2011), (OECD, 2004, 2017, 2019), Tax administrations websites

Table A3: Variable Definition

Panel A: Firm-level variables		
Variable	Definitions	Source
Tax Avoid	[(PTI * Statutory Tax Rate) - CTP] / PTI, where PTI = pre-tax earnings (PI) less special items (SPI), STR is the combined average statutory corporate income tax rate at all layers of government in the country during the year *t*, obtained from KPMG, and CTP = current taxes paid, measured as total tax expense (TXT) less deferred taxes (TXDI). Based on De Simone et al. (2020) and Atwood et al. (2012).	Compustat
Pre-Tax ROA	Pre-tax Income (PI) scaled by lagged total assets (AT).	Compustat
Prior Loss	A dummy variable, equal to 1 if the firm had negative *Pre-Tax ROA* in the previous year and 0 otherwise.	
Sales Growth	Percentage change in Sales (SALE) from year *t-1* to year *t*.	Compustat
PP&E	Net property, plant, and equipment (PP&ENT) scaled by lagged total assets (AT).	Compustat
Leverage	Sum of long-term and short-term debt, scaled by lagged total assets, set to 0 if missing.	Compustat
R&D	R&D Expense in year t scaled by lagged total assets, set to zero if missing.	Compustat
Cash	Cash and equivalents scaled by lagged total assets, set to zero if missing.	Compustat
Ln Assets	Natural log of total assets.	Compustat
Panel B: Country-level variables		
Variable	Definitions	Source
Risk-based Audit	An indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling or Internal intelligence function equal to one from OECD audit case selection data.	OECD's Tax Administration Comparative Information Series
Enforcement	The number of full-time employees in tax administration/total number of active firms (corporate income taxpayers) multiplied by 100. If the number of active taxpayers is missing, we replace it with the number of total taxpayers.	OECD's Tax Administration Comparative Information Series
Statutory tax rate	The average statutory corporate income tax rate in the country at year *t*.	KPMG
Ln (GDP per capita)	Natural logarithm of per-capita GDP.	World Bank
GDP Growth	The percentage change in GDP in a country from year *t-1* to *t*.	World Bank
Corruption	A yearly estimate of perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption.	World Bank Worldwide Governance Indicators (WGI)

Voice and Accountability	A yearly estimate of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	World Bank Worldwide Governance Indicators (WGI)
Political Stability	A yearly estimate of citizens perception of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism.	World Bank Worldwide Governance Indicators (WGI)
Government Effectiveness	A yearly estimate which captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	World Bank Worldwide Governance Indicators (WGI)
Regulatory Quality	Yearly estimate which captures the perception of the ability of the government to formulate and implement policies and regulations.	World Bank Worldwide Governance Indicators (WGI)
Rule of Law	Yearly estimate which captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	World Bank Worldwide Governance Indicators (WGI)
Trust	The average score of "government decisions are effectively implemented" measure and "transparency of government policy", following Mendoza et al. (2017).	World Bank Worldwide Governance Indicators (WGI)
Governance	Composite governance index of country's combined WGI measures: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, control of corruption	World Bank Worldwide Governance Indicators (WGI)
Cost	The ratio of the cost of administering the tax system to the total revenues collected by the tax administration. It is expressed as a percentage or as the cost of collecting 100 currency units of tax revenue.	USAID's Collecting Taxes Database (CTD)
Tax Effort	Yearly estimate compares the actual value of tax as a percent of GDP to tax capacity (predicted value of tax as a percent of GDP considering macroeconomic, demographic, and institutional characteristics of a country).	USAID's Collecting Taxes Database (CTD)
Tax Buoyancy	The percent change of tax revenue divided by the percent change of the tax base or GDP.	USAID's Collecting Taxes Database (CTD)

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Table A4: Sample Selection

Notes: This table describes the sample selection. Panel A presents the sample selection at the country level over the period from 2014 to 2017. Panel B presents the sample selection at the firm level.

Panel A: Country level

Step	Description	No. of Observation
1	Countries with OECD data	58
2	Less country observations without sufficient data for variables	54

Panel B: Firm level

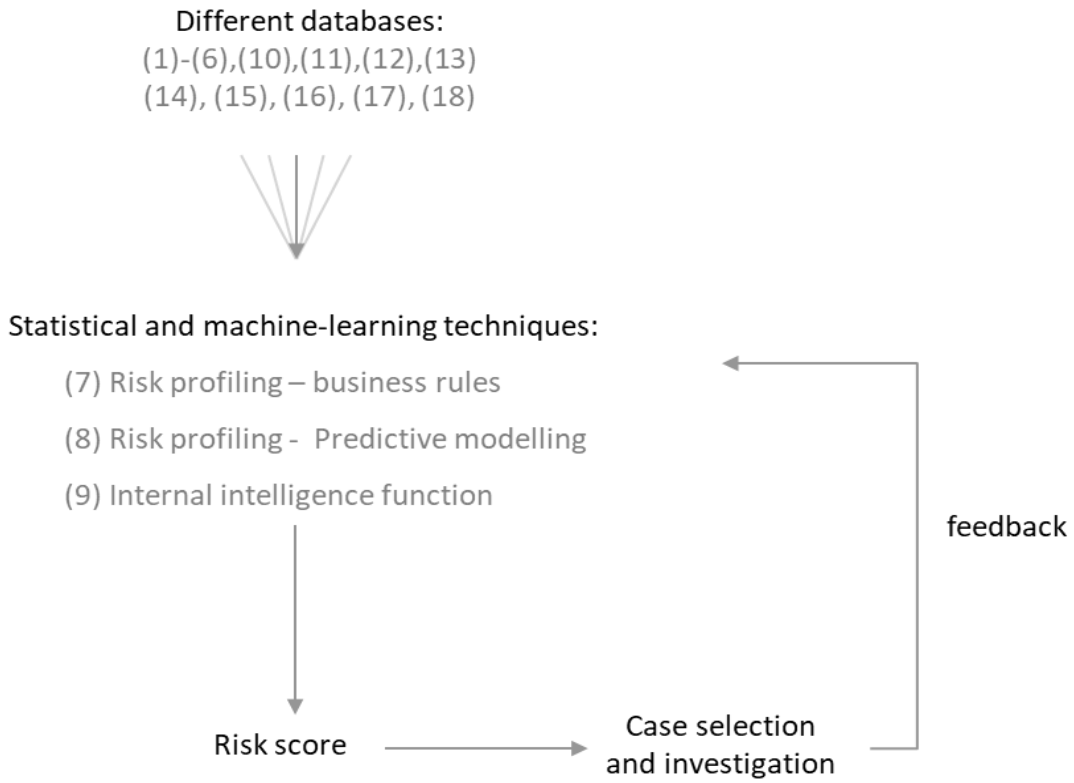
Step	Description	No. of Observation
1	Compustat 2014-2017	192,171
2	Merge with country level data	184,984
3	Less firm observations without positive pre-tax income	145,837
4	Less firm observations without sufficient data for variables	45,762

Table A5: Descriptive Statistics - Tax Administration Performance

Variable	Obs.	Mean	Std. Dev.	P25	P50	P75
Cost	204	0.865	0.507	0.567	0.711	1.068
Tax Effort without Imputation	70	0.556	0.143	0.471	0.559	0.656
Tax Effort with Imputation	208	0.577	0.140	0.485	0.567	0.659
Tax Buoyancy	224	0.077	0.197	0.000	0.002	0.026

Figure A1: Example of the Risk-based Audit Measure and other Items in OECD Audit Case Selection Strategies

Notes: This figure exemplifies how both data from different databases (e.g., data from tax returns and third party information) available in tax authorities and advanced analytical techniques are used for risk-based tax audits. Numbers represent OECD audit case selection items (1) to (18) as available in the OECD's *Tax Administration Comparative Information Series* 2014 to 2019. Overall, the OECD data covers 19 items on audit case selection strategies: (1) Economic sector, (2) Location, (3) Taxpayer category, (4) Ownership in a corporate entity, (5) Taxpayer behavior, (6) Frequency (time between audits), (7) Risk profiling - business rules, (8) Risk profiling - predictive modeling, (9) Internal intelligence function, (10) Third party information, (11) Commercial register, (12) Collected tax, (13) Significant changes to taxpayer, (14) Audits as a result of BEPS or ATP issues, (15) Audits as a result of international EOI, (16) Tax control framework based "audits", (17) Compliance checks, (18) Information cross-checking, and (19) Random Audit. The items (1) to (6), (10), (11), (12), (13), (14), (15), (16), (17), (18) from the OECD case selection data describe taxpayers' characteristics. Statistical and machine-learning techniques are used to analyze the data from different databases. Advanced analytical techniques such as clustering and association analysis, risk profiling, decision trees, regressions, and predictive models are employed to trace and identify risky cases and to evaluate non-compliance. Our measure of risk-based audits builds on a selection of these items and includes (7) Risk profiling - business rules, (8) Risk profiling - predictive modeling, and (9) Internal intelligence function, which are the most relevant, representative, and explicit ones for the process of applying the statistical and automated machine-learning technique that are generally accepted as risk-based tax audits (e.g., by OECD and World Bank) and comparable among countries.



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