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Is Risk Profiling in Tax Audit Case Selection Rewarded? An Analysis of Corporate Tax Avoidance

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Is Risk Profiling in Tax Audit Case Selection Rewarded? An Analysis of Corporate Tax Avoidance*

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Abstract: This study examines the relation between tax audit case selection based on risk profiling and corporate tax avoidance. We exploit the International Survey on Revenue Administration (ISORA) data on risk profiling in tax administrations from 2014 to 2017 to investigate whether the implementation of risk profiling has an incremental effect on firms' tax avoidance. Controlling for tax enforcement, firm-specific, and country-specific factors, our results suggest that the use of risk profiling is associated with lower tax avoidance. Risk profiling seems to be an effective tool to curb tax avoidance across firms of all sizes, but the effect is more pronounced for large firms. However, risk profiling seems only effective in countries where risk profiling experts support the tax administration, and where tax administrations employ a larger number of tax auditors. Additional tests with country-level data on tax administration performance imply that risk profiling improves tax administrations' performance. Overall, our findings point towards risk profiling as an audit case selection tool, appropriately staffed, incrementally attenuates firms' tax avoidance and increases tax revenues. Experts for a thorough design and execution of risk profiling and sufficient staffing of the subsequent audits of high-risk taxpayers are necessary.

Keywords: tax audits, tax avoidance, tax compliance, tax enforcement, tax risk

JEL classification: H25, H26, M41, M42, M4

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Introduction

We examine the relation between risk profiling in tax audit case selection and corporate tax avoidance. Increasingly over the past decade, and in line with their digitalization, tax administrations worldwide employ risk profiling to target high-risk taxpayers. Risk profiling describes the process of using comprehensive data on taxpayers' characteristics such as information from tax returns, historical audits, and third-party information and employing advanced analytical techniques to this data to identify high-tax risk taxpayers. As a result, risk profiling helps to conduct targeted scrutiny and improve the identification of high-risk taxpayers. Tax administrations expect higher taxpayer compliance, lower tax avoidance, and higher tax revenues with less intrusion and costs after implementing risk profiling because taxpayers anticipate higher audit effectivity.

If harnessed properly, risk profiling can help tax administrations adapt to ever-changing tax and tax risk environments, closing the tax gap¹ and increasing tax administration efficiency. Single-component selection strategies such as random audits, or selection by size only, seem less effective as they do not reflect the complexity of the drivers of taxpayers' compliance behavior and the heterogeneity across taxpayers (Jackson & Milliron, 1986; Jimenez & Iyer, 2016; Slemrod, 2019). Furthermore, as tax administration resources are limited, risk profiling improves audit-cost-effectiveness by devoting the resources with higher potential for detecting non-compliance to high-risk taxpayers.² For instance, since 2016, Canada has spent C\$1.1 billion on a risk-based audit strategy to help target non-compliance cases (Anderson et al., 2019). However, not all tax administrations employ risk profiling yet. Budgetary or political

¹ 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).

² 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, retrieved from <https://www.gov.uk/hmrc-internal-manuals/tax-compliance-risk-management>.

constraints, or algorithm aversion of individual decision-makers may deter investment in IT and risk-profiling expertise (Burton et al., 2020; Eynon & Dutton, 2007).

Risk profiling as a tax audit case selection strategy affects audit probability and audit effectiveness, not only in theory, but also as perceived and anticipated by corporate taxpayers (Fischer et al., 1992; Hashimzade & Myles, 2017). Corporations may revise their tax avoidance behavior in the face of upcoming changes in audit probability and audit 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 profiling is implemented.

However, the possible benefits from risk profiling in tax audit case selection may not materialize, or risk profiling may even incline corporations to increase their tax avoidance behavior. Although the use of risk-based audits, including risk profiling, is associated with more compliance for *individual* taxpayers, application of these results seems to be complex for *corporate* taxpayers for three reasons. First, data availability for corporate taxpayers may not be sufficient for risk profiling. The organizational form of corporations asks for multi-layer data, which often makes the employment and matching of different data resources impractical. Second, the risk profiling models used for corporations may not be sufficiently advanced, and thereby not include many aspects of tax avoidance (for example, the models do not cover transfer pricing). Lastly, the available models can potentially estimate the tax risk of corporate taxpayers at large, but not necessarily identify specifically risky areas or practices in the corporation. Firms may be aware of such restrictions in the effectiveness of risk profiling, and therefore not perceive a change in their individual audit probability.

Rather than reducing tax avoidance, risk profiling may encourage corporations to enhance their tax risk management. On this basis, corporations can opt for riskier tax avoidance strategies to maintain or extend their level of tax avoidance. Corporations or tax intermediaries

can strategically use actual or assumed audit case selection criteria to circumvent classification as ‘high-risk’ and thus avoid tax audits while continuing or extending their level of tax avoidance. Additionally, corporations that are already aware of their high risk because of their past behavior may increase tax avoidance and choose an aggressive starting point for negotiations with the tax administration to reduce their ultimate tax liability (Gleason & Mills, 2011; Hanlon et al., 2007). Thus, corporations may have incentives to decrease or increase their tax avoidance behavior. We therefore explore whether and to what extent the employment of risk profiling in tax audit case selection is associated with corporate tax avoidance.

We analyze the effect of risk profiling and examine cross-country panel data of 16,492 firms from 54 countries from 2014 to 2017 to investigate the incremental effect of risk profiling implementation on corporate tax avoidance. The data on countries’ use of risk profiling is publicly available from the ISORA portal and includes joint survey data collected from national and federal tax administrations.³ The ISORA data comprises 19 items for audit case selection in tax administrations. Two of these items refer explicitly to risk profiling (based on business rules and predictive modeling). We construct a binary measure depending on whether the tax administration explicitly reports that they employ either form of risk profiling⁴ (business rules or predictive modeling) in their audit case selection.

We follow Atwood et al. (2012) and measure corporate tax avoidance by the difference between taxes calculated at the statutory tax rate and taxes actually paid. To test the incremental effect of risk profiling, we control for the level of enforcement, measured as the

³ The ISORA is a joint survey about tax administration operations and other characteristics according to the common questions and definitions agreed by the CIAT (Inter-American Center of Tax Administrations), International Monetary Fund (IMF), Intra-European Organisation of Tax Administrations (IOTA), and OECD. Tax experts in these organizations jointly design the survey questions.

⁴ Risk profiling is the result of risk assessment for each taxpayer, which involves identifying, analyzing, and prioritizing the risk presented by taxpayers using statistics. For example, HMRC employs software that conducts a search engine and research tool, and enables analysts to trace and review complex cases (Khwaja et al., 2011).

number of employees in tax administration, and for other country-level controls and firm-specific variables that might affect tax avoidance.

Consistent with tax administrations' expectation of improving the identification of high-risk taxpayers by advanced analytical techniques,⁵ we hypothesize and find evidence that risk profiling is associated with a lower level of tax avoidance. In cross-sectional tests, we further explore under which circumstances countries that implemented risk profiling show lower levels of tax avoidance. In line with our theory, our findings suggest that the effectiveness of risk profiling to reduce tax avoidance heavily relies on the availability of specific expertise and sufficient workforce in tax administrations. Particularly, our results show that implementing risk profiling is associated with lower tax avoidance solely in countries where tax administrations have a comparatively higher number of tax auditors available to focus on audits of high-risk taxpayers. Further, risk profiling is significantly associated with lower tax avoidance only in countries where tax administrations employ data scientists, behavioral scientists, and computer systems analysts, thus maintaining a high level of expertise in data and IT needed for risk profiling.

Further, we investigate the timing of the reduction of tax avoidance behavior. We neither expect nor find an anticipatory effect in the two years prior to the implementation of risk profiling. Early announcements of later implementation do not take place, or do not induce firms to change their tax behavior. This also partially mitigates the concern of reverse causality. However, we expect and find an association in the year of implementation of risk profiling. The association persists, and becomes stronger, during the subsequent years, in line with firms needing time to adjust their tax planning strategies.

We expect that firms' tax behavior differs conditional on their perceived audit probability and specifically on firm size. We find that the deterrence effect of risk profiling holds for firms

⁵ See anecdotal evidence for selected countries in Appendix 1.

of all sizes and is more pronounced for large firms, even though they may be subject to permanent audit or scrutiny already. The stronger effect for large firms may be due to the fact that in some countries, risk profiling has been initiated for large taxpayers only. Large taxpayers likely have more sophisticated tax functions, which are more aware, and respond more effectively to, the information related to how tax administrations employ risk profiling. We thus determine that risk profiling makes it more difficult for firms to respond strategically by actively managing the key indicators that risk profiling would identify below the threshold that triggers an audit.

In supplementary analysis, we investigate the association between risk profiling and the performance of tax administrations in different countries. We use two measures from the United States Agency for International Development's (USAID) Collecting Taxes Database (CTD) to proxy performance. We use the ratio of the total annual tax administration expenditures to the net tax revenue collected by the tax administration. We also use actual tax revenue as a percent of GDP to their potential tax capacity. These measures indicate how effective a country's tax administration is in raising revenue. Our findings suggest that employing risk profiling for audit case selection reduces the cost of tax collection, increases tax revenue, and thus improves the performance of tax administrations.

We contribute to the literature in two ways. First, we examine the incremental effect of risk profiling 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) and study corporations in a cross-country setting instead. The cross-country setting helps us to alleviate generalizability concerns. As evidence for individuals may not apply to firms, it is necessary to study the latter. Not only is risk profiling for firms more complicated to implement than for individuals, but the effect of risk profiling may also be very different for

firms (Hoopes et al., 2012), which may be 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., 2007; Hanlon & Slemrod, 2009; Jacob et al., 2021), and different risk-taking patterns in their tax behavior (Armstrong et al., 2019). Additionally, firms face a 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).

Second, we contribute to the extant literature regarding the effect of enforcement on corporate tax behavior (Atwood et al., 2012; DeBacker et al., 2015; Gupta & Lynch, 2016) by examining the incremental effect of additional enforcement resources, namely risk-profiling. While the effect of general enforcement through adjustments of audit levels and penalties has been studied intensively, we investigate how risk profiling (e.g., one step *before* tax audit) would incrementally affect firms' tax avoidance, given the enforcement level. In addition, our study adds to prior research as it includes firms' *perception* of possible audit strategies and their specific perceived audit probability (instead of materialized audit strategies and audit probabilities as in e.g., DeBacker et al., 2015 and Finley, 2019). Moreover, we examine how the effect of risk profiling is related to country characteristics. By doing so, we aim to explore the determinants of the effectiveness of risk profiling, as suggested by Slemrod (2019).

Our findings have significant implications for the growing use of risk profiling by tax administrations. To them, understanding the prerequisites of effective risk profiling is important, because an appropriate implementation is very costly. Our results indicate that the use of risk profiling is related to lower tax avoidance. However, this relation strongly depends on the quality of risk profiling implemented by the tax administration. First, our findings

suggest that risk profiling effectively reduces tax avoidance only in countries with a high risk profiling expertise that assures an adequate design and execution. Second, consistent with anecdotal evidence, we find risk profiling is only effective in countries with sufficient employees in audits and verification. These findings imply that risk profiling is complementary to actual audits, and for an effective outcome, both expertise and sufficient staffing must be coordinated. Furthermore, we find that employing risk profiling is associated with higher performance of tax administrations, meaning that the cost of tax collection is lower, and the actual collected tax is closer to the tax potentially collectible (reduction of tax gap). Taken together and consistent with Slemrod et al. (2001), our findings suggest that risk profiling contributes to a more efficient allocation of the limited resources in tax administrations to high-risk areas with the highest potential outcome.⁶ Therefore, we also contribute to analyses on the effectiveness of intervention activities (Keen & Slemrod, 2017) and answer the call for a re-examination of tax enforcement from DeBacker et al. (2015).

Our results are also informative for other settings where regulators use risk profiling approaches to select suspicious candidates. For instance, PCAOB uses a risk-based approach to select audits for inspection,⁷ and the SEC flags firms for earnings management.⁸ Future research may study the effect of risk profiling in audits and supervision on corporate behavior.

Conceptual Framework

Prior Research: Tax Audits

The economics of crime model (Becker, 1968) argues that the deterrence effect of enforcement

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.

⁷ See <https://pcaobus.org/oversight/inspections/inspection-procedures>

⁸ In the US Securities and Exchange Commission's (SEC) quarterly earnings per share (EPS) initiative, the Division of Enforcement uses risk-based data analytics to red flag firms for investigation and "uncover accounting and disclosure violations caused by, among other things, earnings management practices to mask unexpectedly weak performance" (SEC, 2020).

is shaped by both audit probability and penalty (Allingham & Sandmo, 1972; Lee & McCrary, 2017). Accordingly, 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 taxpayer behavior has increased as enforcement is a crucial component to ensure tax compliance and combat evasion behavior (Slemrod, 2019).

Accordingly, a large part of prior research focuses on individual taxpayers' behavior after audits (e.g., Guala & Mittone, 2005; Mittone, 2006). For example, Gemmell and Ratto (2012) and Beer et al. (2020) report evidence that audits increase the compliance of previously non-compliant individual taxpayers but decrease the compliance of previously compliant taxpayers. Kasper and Alm (2022) find that audit effectiveness is an important determinant of the specific deterrent effect of audits for individual taxpayers.

For corporate taxpayers, prior research uses data on actual tax audits (e.g., Advani et al., 2021; Finley, 2019; Hoopes et al., 2012), and has demonstrated the link between the strategic behavior of taxpayers and tax administrations. However, the results are mixed. Some studies show that real tax audits lead to less tax avoidance, i.e., an increase in reported tax liabilities (Advani et al., 2021) or an increase in reported wages (DeBacker et al., 2018). Similarly, Gupta and Lynch (2016) and Nessa et al. (2020) provide evidence that increased tax enforcement resources improve tax collection. Hoopes et al. (2012) find that high audit probability leads to less tax avoidance, in line with the prior theoretical framework (Kahneman & Tversky, 1979; Von Neumann & Morgenstern, 1947). Some studies, however, point to the opposite effect. DeBacker et al. (2015) and Finley (2019) find evidence that tax audits and tax settlements, respectively, may increase tax avoidance for corporate taxpayers.

While audit probability and audit incidence are well-studied in the literature, our study focuses on the probability of being audited, as perceived by firms. This perception is

determined by a firm's self-assessment of how the tax administration or its algorithm will characterize "high-risk" tax behavior, and hence the firm's tax behavior, and is conditioned on the perception of the administration's risk profiling effectiveness. Thus, we investigate ex-ante expectations of firms on their subjective audit probability. In contrast to prior literature, which investigates ex-post reactions to tax audits that have been carried out, we take an ex-ante perspective. Further, while Atwood et al. (2012) use a country-specific tax evasion index to proxy for tax enforcement, we use data on tax administrations' risk profiling in 54 countries.

Even though risk-based audit strategies, including risk profiling, are increasingly implemented, little is known about their effects on tax avoidance, compliance, and tax revenues, especially for corporations. Prior literature indicates that the use of risk-based tax audits is associated with more compliance for individual taxpayers (Alm & McKee, 2004; Beer et al., 2020; Loyland et al., 2019). Results for individual taxpayers do not necessarily hold for corporate taxpayers. Anecdotal evidence from our informal interviews with administration officials suggests three reasons for this difference. First, risk profiling for corporations requires data from multiple sources, which – if available at all – are often hard to match due to the lack of IT interfaces or lack of data warehouses. Also, data protection concerns, even within the tax administration, or internal firewalls may hinder data matching. Second, available models can potentially estimate the tax risk of corporate taxpayers at large but may not be sufficiently granular to identify specific risky topics. Third, the data and models might not cover complex tax avoidance channels, such as transfer pricing, comprehensively. Firms might be aware of such restrictions in risk profiling, and therefore not expect a change in audit probability.

There are only a few studies on the effect of risk-based tax audits, and these all focus on individual tax avoidance. 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, Hashimzade et al. (2016) and Loyland et al. (2019) 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 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 taxpayer's risk score. To the best of our knowledge it is only Hsu et al. (2015), who study the effect of risk-based audits on corporations. They investigate corporations in Minnesota and find evidence that the application of data mining in tax audits increases efficiency in the audit selection process.

Summing up, risk profiling in tax audit case selection is used to better identify high-risk taxpayers. In this study we examine how risk profiling (a step *before* actual audits) in different countries affects the perceived audit probability and perceived audit effectiveness by corporate taxpayers and, in turn, whether and how risk profiling relates to firms' tax avoidance.

Hypothesis Development

Firms consider and weigh the marginal benefits of their tax planning activities against the expected costs. They anticipate potential tax audit costs in the form of adjustment costs, fines, penalties, and interest payments upon post-audit adjustments. For their cost-benefit analysis, firms estimate the probability of an audit based on available information and adjust their behavior accordingly. The employment of risk profiling in tax audit case selection could change corporate taxpayers' perception of audit probability and audit effectiveness. Depending

on their perception, from a theoretical point of view, both negative and positive effects of risk profiling on tax avoidance are possible.

The implementation of risk profiling could be negatively associated with tax avoidance in three ways. First, the enhanced expected audit effectiveness might lead to less tax avoidance. Equipped with risk profiling tools, tax auditors are more likely to challenge tax declarations and detect those tax avoidance activities that they consider as violating the tax code. As a consequence of this enhanced audit effectiveness and the identification of overly aggressive tax avoidance strategies, taxpayers anticipate respective tax adjustments. Consequently, taxpayers are likely to abstain from overly aggressive tax avoidance strategies. This prediction is in line with the results of Gemmell and Ratto (2012), who find that the specific deterrent effect of audits depends on the audit outcome and audit effectiveness.

Second, the uncertainty about the outcome of risk assessment via risk profiling for their corporation in relation to their peers might reduce tax avoidance. The uncertainty about their peers' tax risk increases the uncertainty about their own risk profiling outcome. Hence, uncertainty-adverse firms will prefer safer choices and reduce tax avoidance. Thus, we expect herding tax avoidance behavior to reduce tax avoidance and thus the risk of future audits (Tan & Yim, 2014). This reasoning is also consistent with Lediga et al. (2020), who find that audits have a positive effect on tax reporting of non-audited neighbor firms.

Third, the implementation of risk profiling may foster enhanced tax risk management systems and thereby indirectly reduce tax avoidance. In some countries, tax administrations incorporate the existence or design of firms' tax control framework in their risk profiling. Firms that expect to be identified as "high-risk" may respond by enhancing their tax risk management system and thereby signal lower risk, inducing both lower audit probabilities and lower tax avoidance (Chen et al., 2020). Enhanced tax risk management systems may also make tax issues more salient within the firms as they learn more about tax risks and their

management. Consequently, firms react to the additional information on risky tax issues provided by this internal system and take actions to attenuate these tax risks when making corporate decisions.

By contrast, risk profiling might exert no or a positive effect on tax avoidance for reasons at the tax administration or firm level. For tax administrations, risk profiling relies heavily on quality data on both previous and current taxpayer attributes and on IT systems, including hardware, software, and training, to process the data and provide reliable risk scores (Khwaja et al., 2011). As a result, risk profiling may lead to false positives that occupy the auditors' time and attention if not designed and used appropriately. Second, the use of risk profiling changes the way in which audits are conducted, and auditors may be tempted to over-rely on automated risk profiling. They may compromise professional judgment (Dowling & Leech, 2014) or reduce audit quality (Austin et al., 2021). Auditors may rely on the results mechanically and neglect to develop their own experience-based expertise. Consequently, they might fail to consider factors and detect risks not explicitly identified with data analytics in case selection. Conversely, auditors may be "algorithm averse", and not attribute sufficient weight to the risk-based audit case selection (Koreff et al., 2021). In both cases, distrust in the tax auditors and tax administration may arise, which may cause a backfiring effect from enforcement (Mendoza et al., 2017). Third, tax administrations may face weaknesses or shortages in staff skills. This could seriously impede the tax administration's ability to deal with high-risk taxpayers even if risk profiling could effectively recognize risky taxpayers. Hence, the employment of risk profiling may not necessarily lead to the expected enhanced audit outcome.

Firms may not change their level of tax avoidance, or even avoid more tax, when informed about the implementation of risk profiling. They may anticipate key parameters of risk profiling, based on their own, their peers' or tax experts' experience. Firms might infer that they individually are unlikely to be targeted and thus maintain their level of tax avoidance, or

even feel sufficiently safe to increase their level of tax avoidance. Firms might further be able to strategically circumvent targeted tax avoidance strategies and use other non-targeted tax avoidance strategies. For example, they could employ experienced tax professionals (Daoust & Malsch, 2020) and take advantage of their data analytics skills, including artificial intelligence-based analyses with trend analyses and the timely detection of potential errors, risks, or abnormal conditions.⁹

Tax enforcement may also increase the likelihood of firms changing tax preparers (Belnap et al., 2022). Some firms may switch to more aggressive tax preparers in the face of risk profiling. Additionally, tax avoidance might not decrease, or may even increase, because firms intentionally file very risky tax positions to create mass for future negotiations with the tax auditor. Despite the role of risk profiling to identify high-risk firms and predict non-compliance, firms may not perceive the tax audit as sufficiently costly, because the negotiation process between the taxpayers and tax administration is assumed (Beck & Jung, 1989; Dyck et al., 2022; Eberhartinger et al., 2022; Gleason & Mills, 2011; Slemrod et al., 2001). Thus, for some taxpayers, it may be beneficial to choose an aggressive starting point for negotiations with the tax administration, which creates leeway to give up some positions and still ultimately reduce their tax liability. Consistently, there is evidence that the US. Internal Revenue Service often settles for less than the initially proposed deficiency after the negotiation with firms (Gleason & Mills, 2011; Hanlon et al., 2007).

This discussion on the association of risk profiling and the level of tax avoidance by firms being likely, but not necessarily, negative is consistent with prior literature on individual

⁹ Firms can obtain information about the risk assessment criteria and how they are employed in general. information provided by tax administrations to the taxpayers, their own experience, and their interaction with peer firms. This information can also be diffused through social networks in the business process: for example, via financial analysts, auditors (Lim et al., 2018), boards of directors, banks (Gallemore et al., 2019), or via supply chains (Cen et al., 2017, 2022), labor markets (Barrios & Gallemore, 2021), or networks. The behavior of taxpayers may change appertaining to the communication and learning from the audit experience of other taxpayers and their peers.

taxpayers. Thus, it is an empirical question whether, how, and to what extent risk profiling affects tax avoidance. We expect that the use of risk profiling has a strong deterrent effect on corporate taxpayers by signaling the specific ability of tax administration to identify risky taxpayers and devote the resource more efficiently. Therefore, we test:

H1: The employment of risk profiling in tax audit case selection is associated with a decrease in tax avoidance.

Next, we explore the heterogeneity in the effect of risk profiling on tax avoidance. It is often stated in the prior literature that tax audit case selection is based on the size and complexity of the firms (Ayers et al., 2019; Bachas et al., 2019). Risk profiling uses various factors from diversified data sources beyond size and complexity and is thus often assumed to be more effective. However, it is unclear whether the deterrence effect of risk profiling on tax avoidance will hold for firms of all sizes.

Even though size has played a major role in risk profiling case selection, it is unclear whether larger firms assume a higher audit probability under risk profiling. On the one hand, large corporations are under permanent audit in many countries, so risk profiling could barely have a deterrence effect for large firms, which might imply no adjustments in tax avoidance activities. Relatedly, Ayers et al. (2019) investigate the reporting behavior of the largest firms in the USA, which are assigned to the IRS Coordinated Industry Case (CIC) program with an audit probability of 100 percent. They find that the tax payments of firms do not change after entering the CIC program. On the other hand, the majority of tax administrations in advanced economies manage their largest taxpayers in Large Taxpayer Units (LTUs) (OECD, 2017), and risk profiling has been initiated in many tax administrations by large taxpayers (IOTA, 2012).¹⁰ Therefore, risk profiling might have a stronger deterrence effect for larger firms as the risk profiling model could be more advanced for large taxpayers (more data is available for large

¹⁰ For more information see: https://www.iota-tax.org/system/files/risk_analysis_0.pdf.

taxpayers). Additionally, large taxpayers have more sophisticated tax functions that are more aware and respond more effectively to the information related to employing risk profiling by tax administrations. To avoid the costs related to tax audits, larger firms try to avoid tax audits; thereby, the effect might be more pronounced for larger taxpayers.

In contrast, small businesses may pay limited attention to tax audit strategies, may not perceive or ill-perceive information on risk profiling, and may not be able to draw differentiated conclusions from this information. Further, some firms might also increase the tax avoidance level to have more positions for negotiations with tax administrations. This effect may be particularly pronounced for large firms, as they use professional tax assistance for negotiation. This argument is in line with Slemrod et al. (2001), finding that high-income taxpayers claimed more tax benefits to create a more aggressive starting point for negotiation with tax administrations.

Ultimately, we conjecture that employing risk profiling is more promising to attenuate tax avoidance in larger firms.

H2: The association between risk profiling in tax audit case selection and tax avoidance is stronger for larger firms.

Data and Research Methodology

Measuring Risk Profiling

Most tax administrations worldwide use advanced analytics as a means of risk profiling to determine their tax audit cases, combined with random selection.¹¹ In a separate study in 2017, one-half of 53¹² tax administrations reported the use of advanced analytics in risk profiling, to improve the match of audits and taxpayers' specific risks (OECD, 2017). Countries disclose general information on their risk-based tax audit strategies on their tax administrations'

¹¹ See selected anecdotal evidence on tax administrations' incentive to implement risk profiling in Appendix 1.

¹² This study is distinct from our sample size of 54.

websites. However, the exact details on their audit case selection strategy and the risk criteria are often confidential to prevent taxpayers from acting strategically (Khwaja et al., 2011).

To identify countries that apply risk profiling, we exploit information on audit case selection from the ISORA database, which collects tax administration data from national and federal administrations. ISORA is a joint survey about tax administration operations and other characteristics according to the common questions and definitions agreed by the CIAT (Inter-American Center of Tax Administrations), International Monetary Fund (IMF), Intra-European Organisation of Tax Administrations (IOTA), and OECD.¹³ Survey questions are designed jointly by tax experts in these organizations. Before answering the survey, respondents from tax administrations all over the world had the opportunity to ask questions and provide comments.

ISORA reports 19 items for tax audit case selection, from which we choose two items that represent the risk evaluation procedure using rule-based data analytics, or automated machine-learning techniques for risk profiling (Khwaja et al., 2011; OECD, 2004, 2017, 2019). For details on case selection methods reported by the tax administrations, see Table 1.

< Insert Table 1 about here >

Our binary measure for risk profiling equals one if the respective tax administration explicitly reports that they employ at least one of the two, ‘risk profiling – business rules’ (item 7) or ‘risk profiling – predictive modeling’ (item 8), in their audit case selection criteria. Other items from ISORA data either serve as inputs for risk profiling (such as data) or represent specific rules or procedures (see Figure 1 for details). We use a binary indicator variable because it allows clear-cut interpretations, and we avoid double counting. Although there is no information available on which kind of taxes these reported methods are used, we assume that tax administrations at least partially use these methods for corporate income taxes.

¹³ For details, see <https://data.rafit.org>.

< Insert Figure 1 about here >

To validate our measure on risk profiling, we compare our measure from the ISORA data with tax administrations' websites, PwC summaries, and the World Bank website. Our additional search confirms the information in the ISORA database for most countries. In the few cases with disparities, we gathered more information from tax administrations' websites, checked studies and reports written by officials from tax administrations or other insiders, and talked to tax officers and other experts such as tax advisors. After gathering the details of a country's audit case selection strategy, we modify the ISORA data for six countries.¹⁴

The country of Ireland provides an ideal example of what 'risk profiling – business rules' entails. Ireland uses an intelligent system applying rules of analysis against customer data held in the Tax Administration Data Warehouse and scoring taxpayers according to the rules they break (IOTA, 2012). As an example of 'risk profiling – predictive modeling', 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 data mining and machine learning algorithms, including cluster analysis, decision trees,

¹⁴ We changed the data for risk profiling from the ISORA database for Germany, China, Kenya, Thailand, Greece, and Portugal. Risk-profiling indicators are missing for Kenya and Thailand for 2014 and 2015 in the ISORA database, and we change it to 0 according to our hand-collected information. We correct the risk profiling variable for Germany to 0 (Germany indicated as 1 for all four years in the ISORA database), and China, which should be 0 for all years (China indicated 1 for 2014 and 0 for 2015, 2016, 2017 in the ISORA database). In the case of Germany, audit cases are selected based on size and industry (although Germany will adopt it out of our sample period). 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 (tax) risks, assisting enterprises to improve their tax control systems of the largest business groups in terms of size, turnover and tax contribution in China (including private enterprises, multinationals, and all state-owned enterprises), and providing better service to reduce disputes. The collected data serves as input 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 enterprises. Greece implemented risk-profiling in 2016, which was 0 in the ISORA dataset; therefore, we changed it to 1. We changed Portugal from 0 to 1 for all the years, as Portugal has started using risk profiling for large taxpayers before 2014 (IOTA, 2012).

neural networks, and deep learning, are employed to develop predictive models and score and identify the highest-risk taxpayers (OECD, 2019). Appendix 1 provides general information about risk-profiling in selected OECD countries.¹⁵

Research Design

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

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

The dependent variable is tax avoidance.¹⁶ We use the tax avoidance measure developed by Atwood et al. (2012), which is the difference between taxes calculated at the statutory tax rate and taxes actually paid. We follow De Simone et al. (2020) and calculate tax avoidance 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 firms' tax avoidance. This measure accounts for different statutory tax rates across countries over time and thus is suitable for cross-country samples.¹⁷

The variable of interest in our analysis is *Risk Profiling* at the country-year level, a binary indicator variable, which equals one if risk profiling is employed and zero otherwise. We expect a negative relation between risk profiling and tax avoidance and predict the coefficient

¹⁵ For more detail about the ISORA survey questions on audit case selection and description of results, see Appendix 2 and 3.

¹⁶ From a conceptual point of view, we follow prior literature (Lisowsky et al., 2013), which defines tax avoidance behavior as 'any activity that reduces the firm's explicit taxes in any manner, including tax positions that may or may not be challenged'.

¹⁷ When using ETR and cash ETR as dependent variables, results for the variable of interest, *Risk Profiling*, are not significant. However, the Atwood et al. measure for tax avoidance is particularly adequate for cross-country comparisons, and for our research question. The results using the Atwood et al. measure are robust across several specifications.

of *Risk Profiling*, β_1 , is negative for *Tax Avoid*. We control for the natural logarithm of enforcement. We follow Alexander et al. (2020)¹⁸ 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.¹⁹ 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 missing data for enforcement with the nearest observation for the respective country. Thus, we capture differences in human resources employed in tax administrations to perform tax audits at the country level, with our scores of *Enforcement*. Thereby, we are able to explore whether the employment of risk profiling has an incremental effect on firms' tax behavior. Similar to our main variable, and in line with previous studies, we expect a negative relation between this enforcement proxy and *Tax Avoid*.

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 year 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. All these variables, following empirical evidence, are related to tax avoidance (Edwards et al., 2016; Law & Mills, 2017). In addition, we control for *PP&E*, which also indicates tax avoidance opportunities (Chen et al., 2010; De Simone et al., 2020). Furthermore, we add the Worldwide Governance Indicators (WGI) to our

¹⁸ They measured enforcement as the ratio of citizens to tax staff at the central government tax agency and converted this ratio into tax staff per 1,000 inhabitants.

¹⁹ If the number of active taxpayers is missing, we replace it with the number of total taxpayers.

regression to control for country characteristics (Isidro et al., 2020; Kaufmann et al., 2011; Osswald & Sureth-Sloane, 2020). 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. 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. To account for the potential correlation of standard errors at the country level, we cluster standard errors at the country level.²⁰ All variables are defined in Appendix 4.

Sample and Data

We obtain the audit case selection and enforcement data from the ISORA database from 2014 to 2017 to construct our variable of interest, Risk profiling, and key control variable Enforcement. Furthermore, the statutory tax rate data is taken from the KPMG Corporate Tax Rates Table²¹, 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 those countries with sufficient audit selection and enforcement data in the ISORA database. We translate financial reporting data from Compustat Global 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

²⁰ We note that our results are robust to variation of clustering (firm, industry, and country_industry).

²¹ 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>.

final sample includes 46,908 firm-year observations across 54 countries between 2014 and 2017. Appendix 5 presents the sample selection. 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.²²

Descriptive Statistics

Our sample comprises both developed and developing countries. Table 2 reports descriptive statistics for *Tax Avoid* and the statutory tax rate (STR) by country. Countries with the most observations in our sample are China (12,770 observations), followed by the United States (10,326 observations), Canada (2,135 observations), and the United Kingdom (2,055 observations). Firms from the United States and Malta show the highest tax avoidance, 0.176 and 0.121, 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). The variation regarding the implementation of risk profiling across countries is provided in Table 2. China, the Czech Republic, Germany, Japan, and Korea do not use risk profiling between 2014 to 2017. Greece, Kenya, Thailand, and Turkey started to employ risk profiling in 2016. The US and Morocco employed risk profiling in 2015.

< 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 0.033 (0.064), indicating some level of tax avoidance in our sample consistent with prior research (e.g., Atwood et al., 2012). The sample firms report a mean (median) *Pre-tax ROA* of 9.2 (6.6)

²² 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>. The data is publicly available from the USAID DRM website.

percent and *Sales growth* of 14.9 (7.1) percent. Around 10.5 percent of the firm-year observations show an accounting loss in the previous year.

< Insert Table 3 about here >

Table 4 displays the Pearson correlations for the variables used to test our hypothesis H1. 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*.

< Insert Table 4 about here >

Results

Main Result: Tax Avoidance

We investigate whether and how the employment of risk profiling 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 profiling is associated with a lower level of tax avoidance. The coefficient -0.046 indicates that the employment of risk profiling is associated with a 4.6 percentage point reduction in tax avoidance. The effect is therefore substantial in magnitude, given that our measure of tax avoidance (i.e. Atwood et al., 2012); the difference between the cash effective tax rate and the statutory tax rate per country), is, on average, 3.3 percentage points across all countries and firms (cf. Table 3). On average therefore, firms' cash effective tax rate increases above the statutory tax rate. A possible explanation for the large effect size would be that those firms with high tax avoidance in prior years (for P75, for instance, tax avoidance amounts to 16.4 percentage points, cf. Table 3), have a particular reduction in their tax avoidance.

Relatedly, we also observe a negative and significant coefficient estimate on *Ln (Enforcement)* in all 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 provides 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), which indicate 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 structures: *Voice and Accountability*, *Government Effectiveness*, *Political Stability*, *Rule of Law*, and *Regulatory Quality*. These variables reflect the citizens' 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 Profiling* and *Tax Avoid* after adding these controls, which suggests that our results are consistent.²³

To address potential concerns about the impact of the denominator (pre-tax income) in measuring tax avoidance for the dependent variable, column (3) additionally employs the variable *One over Pre-tax Profit* (Edwards et al., 2021) to control for trends in tax avoidance. We find consistent results. Column (4) includes additional control variables (*Transfer Pricing Rules*, *CFC Rules*, *Thin Capitalization Rules*, *R&D Tax Incentives*, *Anti Avoidance Rules*) from the Tax Attractiveness Index²⁴ to capture possible changes in the tax base as a result of the implementation of anti-avoidance measures. We continue to find consistent results.

²³ Since these additional control variables are correlated, we repeated the regression with only *Regulatory Quality* as an additional control variable (untabulated) and find that our results hold.

²⁴ The Tax Attractiveness Index includes 20 different equally weighted tax components and provides a comprehensive picture of countries' tax environment. We selected the parameters related to firms' tax avoidance strategies. Data of the Tax Attractiveness Index including its components is available on <https://www.tax-index.org/>.

To mitigate concerns on whether differences in the number of observations across countries bias our results, we repeat our main regression using weighted least squares (WLS, based on Guenther, 2018) in column (5), with weights being the number of firms in each country. Consistent with our baseline regression, we continue to find a negative association between the implementation of risk profiling and tax avoidance. Imbalances in the distribution of firms across countries do not affect our results.

< Insert Table 5 about here >

We further investigate when the association between implementing risk profiling and reduced tax avoidance starts and how long this association last. We do not expect tax avoidance in t to respond to risk profiling in future years (e.g., $t+1$ and $t+2$), meaning that we do not expect anticipatory tax avoidance effects. Instead, we expect the tax avoidance effect to appear in the year when firms face the implementation of risk profiling (year t). In addition, we expect to find delayed tax avoidance effects, which implies that tax avoidance in t responds to the implementation of risk profiling in past years (e.g., $t-1$ and $t-2$). The results in Table 6 support our assumption and reveal that there are no significant effects of the future implementation of risk profiling on current tax avoidance (anticipatory effect). Instead, firms will reduce their tax avoidance more significantly in years after the implementation of risk profiling, which suggests that changing the tax avoidance plan may take some time.

< Insert Table 6 about here >

Cross-sectional Tests

Firm Size and Industry

While the negative association estimated in Table 5 addresses the average effect of risk profiling, the effect might vary across heterogeneous firms. In this section, we analyze the potential heterogeneous effect of risk profiling depending on the firm size, which usually is one

of the audit selection criteria.²⁵ To test the potential heterogeneous effects of firm size, and especially whether the association of risk profiling and tax avoidance is stronger for larger firms (H2), we split the sample into three size groups (*Ln Assets*) within country-year.

Table 7 Panel A presents the regression results of equation (1) for the dependent variable *Tax Avoid* based on different firm sizes, measured as total assets, split in thirds: small, medium, and large. Interestingly, the results suggest that risk profiling has a deterrence effect on all firms, irrespective of size. However, the effect is more pronounced for large firms, suggesting that risk profiling increases control over the large taxpayers, in spite of possibly frequent audits, 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.

Untabulated results of our main regression per industry show that the negative association between risk profiling and tax avoidance persists across most industries.²⁶ We believe that industry, similar to size, is not a new indicator for tax avoidance for the tax administrations because already before implementing risk profiling, tax administrations assume that specific industries have higher tax risk and already conducted the focused audits (e.g., in the intangible-intensive pharmaceutical industry²⁷). Our results on industry, therefore, aligns well with our result on size, which similarly does not seem to be a novel criterion for tax case selection. We accordingly find an effect for small, medium, and large firms.

²⁵ For instance, the German tax administration divides firms into four size classes (very small, small, medium and large) based on revenue and taxable profit, while other tax administrations might differentiate between two size-classes.

²⁶ Results display significance at the $p < .1$ level for Construction, Food/Agriculture, Pharmaceuticals, Textiles/Printing/Publishing, Extractive/Mining, Manf: Chemicals/Glass/Metals, Manf: Electrical Equipment, Utilities/Cable/Broadcasting, and Services. Results are not significant, but negative as expected for Manf: Machinery, Manf: Transportation Equipment, Computers/Semiconductors, Transportation, Retailers, Financial/Insurance/Real Estate. Results are not significant and positive for Manf: Instruments and Wholesalers.

²⁷ See TRAC, https://trac.syr.edu/tracirs/trends/v10/industry_4_retail.html; (Neuman et al., 2020).

Thus, risk profiling promises to detect those firms with yet undetected tax risk. Our results across size and industry emphasize that the association with tax avoidance is firm-specific rather than industry-specific.

Tax Administration Effectiveness

Firms' adaptation in their levels of tax avoidance associated with risk profiling for tax audit case selection may depend on firms' perception of tax administrations' effectiveness in designing and executing risk profiling and subsequent audits. We use two specific characteristics as proxies for tax administrations' effectiveness, both from ISORA data. First, we use the employment of risk profiling experts, namely data scientists, behavioral researchers, and computer systems analysts. Continuous in-house availability of risk profiling expertise likely improves the design, and execution of risk profiling. Second, we use the number of tax auditors, measured as the number of full-time equivalents (FTE) employed in audit, investigation, and other verification. In the presence of risk profiling, tax auditors are needed to effectively target high-risk taxpayers. Otherwise, the identification of high-risk taxpayers is of little consequence.

Table 7 Panel B presents the regression results of equation (1) for the dependent variable *Tax Avoided*, again including all control variables, notably *Enforcement* level among others. We distinguish in columns (1) and (2) between firms in countries without and with risk profiling experts. Columns (3) and (4) display firms in countries with a low number of tax auditors (first quartile) and firms in countries with a high number of tax auditors (fourth quartile). Results show that indeed, risk profiling is associated with less tax avoidance only when firms have reasons to assume that risk profiling is based on high expertise and well-staffed tax audits. In other words, risk profiling must be equipped with both expertise and workforce. Only then do firms perceive risk profiling as effective and adapt their tax behavior. Therefore, in line with

our theory, we find evidence that the effectiveness of risk profiling in reducing tax avoidance heavily relies on its execution in tax administrations.

< Insert Table 7 about here >

Supplementary Analysis

Tax Administration Performance

We use country-level analysis to examine the association of risk profiling 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.²⁸ To test for the association between the use of risk profiling 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:

$$\begin{aligned} \text{Tax Admin Performance}_{j,t} \\ = \beta_0 + \beta_1 \text{RiskProfiling}_{j,t} + \beta_2 \text{Enforcement}_{j,t} + \delta X_{j,t} + \varepsilon_{j,t} \end{aligned} \quad (2)$$

Tax Admin Performance is one of two variables: Cost of Collection, or Tax Effort.

Both indicators are collected and calculated by USAID's CTD. Similar to our main 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 efficiency of tax administrations, as given by CTD. The measure for the *Cost of Collection* is calculated as the ratio of the total annual tax administration expenditures (budget) to the net tax revenue collected by the tax administration (in percent). The lower the *Cost of Collection*, the more efficient the tax system is in collecting all taxes.²⁹ The data is available for two points in time

²⁸ For an overview of CTD comparable data on taxation, see USAID COLLECTING TAXES 2017/ 2018, https://www.usaid.gov/sites/default/files/documents/1865/CTD_Program_Document_-_2017-18_-_FINAL.pdf.

²⁹ 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.

over the sample period (2015 and 2017). We replace the missing data for 2014 with 2015 values and for 2016 with 2017 values.

While the employment of risk profiling may increase efficiency by devoting the resources to high-risk taxpayers it may also trigger substantial costs in terms of data and IT systems, which may outweigh the reduction in enforcement costs. Hence, the association between risk profiling and the cost of tax collection is ambiguous. The results in column (1) of Table 8 suggest that the use of risk profiling is associated with lower *Cost of Collection*. The positive coefficient estimate for *Enforcement* suggests that the cost of collection also increases in higher enforcement levels, i.e., more tax administration employees per 100 firms.

Our second dependent variable for tax administrations' performance, *Tax Effort*, estimates the taxes a country could potentially collect based on its macroeconomic, demographic, and institutional features. *Tax Effort* equals the actual amount of tax revenue as a percent of GDP related to the potential tax to the GDP ratio (tax capacity). In other words, *Tax Effort* indicates how much tax revenue a country collects relative to how much it could collect, predicted on the basis of 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 country collects less. In years, where data for *Tax Effort* are missing, we use the nearest observation instead.³⁰ We expect and find that the employment of risk profiling is associated with higher tax revenues and brings a country closer to its full capacity, i.e., closer to a tax effort of 1.0. Results reported in column (2) of Table 8 show that the use of risk profiling could facilitate the tax collection of a country to reach its full potential.

³⁰ Results hold and are even more pronounced ($p < .05$) when not imputing missing data and reducing the sample to observations where *Tax Effort* is available in all years (untabulated).

Overall, we provide evidence that the employment of risk profiling for tax audit case selection reduces the cost of enforcement and improves the performance of tax administrations, specifically the cost of tax collection, and tax effort.

< Insert Table 8 about here >

Conclusion

We conduct a cross-country study to explore whether and to what extent risk profiling is associated with firms' tax avoidance after controlling for the level of enforcement and other country characteristics. We use annual country-level data on audit case selection (ISORA) across 54 countries from 2014 to 2017 to measure risk profiling.

Our results indicate that the employment of risk profiling is on average negatively associated with corporate tax avoidance, irrespective of firm size. That is, risk profiling could potentially deter the strategic responses to audits and enhance the effectivity of audits by attenuating bunching below a certain threshold of revenue to avoid an audit. We find no anticipatory effect of tax avoidance, and firms will significantly reduce their tax avoidance in the year of implementation of risk profiling, with an even larger effect in subsequent years. The results hint at reaction time for firms to adapt their perception of tax administrations' effectiveness after the implementation of risk profiling, and to adapt their tax behavior. However, we find the negative association only for countries that employ risk profiling experts, and for countries with a high number of tax auditors. In other words, the implementation of risk profiling affects firms' tax behavior only when design and execution assure a high quality, and when sufficient workforce can focus on high-risk taxpayers.

In additional tests, we analyze whether risk profiling is associated with tax administrations' performance and focus on two measures, cost of tax collection, and tax effort. We find that risk profiling significantly reduces the cost of tax collection, i.e. the ratio between tax administration's budget and its tax revenue. Also, risk profiling increases the tax effort, i.e.

the difference between the amount of tax actually collected and potentially collected is reduced. Broadly speaking, our results confirm the connection between the high performance of tax administration and their use of risk profiling.

To the best of our knowledge, this is the first cross-country study to examine the association between risk profiling in tax audit case selection and corporate tax avoidance. We do not infer causality between the employment of risk profiling and corporate tax avoidance behavior. Instead, we paint a consistent picture of the association between the use of risk profiling and tax avoidance, which tax administrations actively seek to combat.

We acknowledge that our analysis is subject to some limitations. We can only refer to data on risk profiling included in the ISORA questionnaire and as self-reported by tax administrations. We mitigate this limitation by validating our measure with other available resources such as tax administrations' websites, PwC summaries, World Bank reports, and contacting tax experts in different countries. In addition, we acknowledge that during our observation period from 2014 to 2017 only a few countries implement risk profiling, which reduces variation in our data. Further, countries' decision to implement risk profiling may be a function of the overall level of tax avoidance. Our country-specific control variables may capture some of these concerns. Finally, unobserved events concurrent with implementing risk profiling may bias our results. Despite these limitations, 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 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 dedicate resources or overcome legal or political obstacles. Our results indicate that the use of risk profiling is related to lower tax avoidance, whereas this relation strongly relies on the execution of risk profiling by tax

administrations. More broadly, our results indicate that risk profiling not only relates to less tax-avoiding firm behavior but also a better performance of tax administrations.

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Appendix 1. Risk profiling in selected countries

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.
Ireland	An intelligent system applying rules of analysis against customer data held in the Tax Administration data warehouse and scoring taxpayers according to the rules they break.
Italy	Big data and data mining analysis is another area where the Italian Revenue Agency has started adopting and exploring new approaches: hiring skilled data scientists and developing Advanced Analytics tools is part of this strategy that aims at fostering tax compliance while creating better risk profiles of clusters of taxpayers. The use of data analytics and the related activities aim at mining data to help increase tax collection, target compliance initiatives and improve efficiency. The application of data mining techniques is part of a risk-analysis strategy, focusing on: estimates of individual income (74.6% positivity rate versus 33.9% using traditional techniques); identification of VAT fraud profiles (80% positivity rate); definition of taxpayer profiles based on the financial reports archive.
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), IOTA (2012, 2018), OECD (2004, 2017, 2019), Tax administrations' websites

Further details and anecdotes about country experiences and how tax administrations developed and use risk profiling are provided in Khwaja et al. (2011).

We collect additional anecdotal evidence and provide a selection of excerpts to illustrate tax administrations' motivation to implement risk profiling.

Finland, Pekka Ruuhonen, Director General, Finnish Tax Administration, IOTA (2017)

We strongly believe that investing in analytics is valuable and benefits the administration immensely. We will, in the near future, invest in Big Data know-how, Big Data environment, robotics and utilizing the data available on the internet. Seize the moment, as it might be too late tomorrow - Digital economy offers challenges and opportunities to all tax administrations.

Hungary, Csilla Tamásné Czinege, Director General for Taxation Issues, Hungarian Tax and Customs Administration, IOTA (2016)

As a summary, it can be stated that the tools applied and introduced by the National Tax and Customs Administration of Hungary in order to whiten further the economy as well as to repel tax frauds have reached their impacts: amounts of tax revenues have increased, more targeted tax audits have become more effective and, because of preventive effects of measures and their effects deterring from further infringements, level of taxpayers' voluntary compliance has risen. On the basis of all these, we are entitled to say that the measures described above have enhanced the professional reputation of Hungary's state tax and customs authority not only in our closer region but also in a wider area: throughout the European Union.

Spain, José Borja Tomé, Deputy Director, IT Department, Spanish Tax Agency, IOTA (2016)

Data analytics offers uncountable opportunities for tax administrations, and poses new challenges in order to leverage efforts and investments. A winning strategy will be to combine simple technologies which can be used by anyone keeping governance of information under control, with deploying advanced analytic projects which will need careful selection and a tailored organization. Integrating the results of the analysis into the operational systems can ease user adoption.

European Commission, Caroline Edery, Head of Unit, European Commission, Directorate-General for Taxation and Customs Union, IOTA (2016)

With the increased use of data analytics tax administrations are moving towards a more risk based tax compliance strategy. Data analytics allow for developing sophisticated risk profiles, analysing trends, flagging potential audit issues and identifying higher-risk cases for deeper investigation and cutting off avenues for fraud before they even occur.

Appendix 2. Survey questions

International Survey on Revenue Administration (ISORA) 2018³¹

Case Selection	
5 Does the administration make use of any of the selection processes /criteria listed below to formally initiate a verification / audit intervention?	☐ Yes ☐ No
If “YES“, check all appropriate boxes	☐ Economic sector (e.g. Financial, Banking, Industrial etc.) ☐ Location ☐ Taxpayer category (e.g. self-employed, professionals etc.) ☐ Ownership in a corporate entity ☐ Taxpayer behavior ☐ Frequency (time between audits) ☐ Risk profiling – business rules ☐ Risk profiling – predictive modelling ☐ Third party information ☐ Internal intelligence function ☐ Commercial register ☐ Collected tax ☐ Significant changes to taxpayer ☐ Audits as a result of Base Erosion and Profiting Shifting (BEPS) or aggressive tax planning issues ☐ Audits as a result of international exchange of information ☐ Tax control framework based “audits“ ☐ Compliance checks (e.g. payroll checks) ☐ Information cross checking ☐ Selected by auditors based on their judgement and experience ☐ Other, briefly describe in the space provided...

³¹ See <https://data.rafit.org/?sk=3dba84d7-1dd8-4533-b682-c0dfcb1d7f13&sId=1637514078838>.

Case Selection	
6 Does the administration make use of any of the selection processes / Criteria listed below to formally initiate a verification / audit intervention	☐ Yes ☐ No
If “Yes“, check all appropriate boxes below	☐ Economic sector (e.g. Financial, Banking, Industrial etc.) ☐ Location ☐ Taxpayer category (e.g. self-employed, professionals etc.) ☐ Ownership in a corporate entity ☐ Taxpayer behavior ☐ Frequency (time between audits) ☐ Random ☐ Risk profiling – business rules ☐ Risk profiling – predictive modelling ☐ Third party information ☐ Internal intelligence function ☐ Commercial register ☐ Collected tax ☐ Significant changes to taxpayer ☐ Audits as a result of Base Erosion and Profiting Shifting (BEPS) or aggressive tax planning issues ☐ Audits as a result of international exchange of information ☐ Tax control framework based “audits“ ☐ Compliance checks (E.g. payroll checks) ☐ Information cross checking ☐ Selected by auditors based on their judgement and experience ☐ Other, briefly describe in the space provided...

³² See <https://data.rafit.org/?sk=3dba84d7-1dd8-4533-b682-c0dfcb1d7f13&sId=1637514126154>.

Appendix 3. Descriptions of the ISORA results

The IMF ISORA 2016 Understanding Revenue Administration Report³³ provides explanations on and descriptives about their survey on audit case selection. The subsequent table from their report, provides the percentage of administrations indicating the use of a specific process or criterion in different groups of countries.

**Table 40. Administrations Using Specified Case Selection Criteria, 2015
(Percent)**

Group	Small States (31)	Lower Income (44)	Higher Income (60)	All (135)
Economic Sector	81	95	88	89
Third-Party Information	77	91	92	88
Taxpayer Behavior	77	84	88	84
Taxpayer Category (for example, self-employed)	71	77	88	81
Information Cross-Checking	61	84	87	80
Significant Changes to Taxpayer	65	77	87	79
Selected Based on Judgment	77	70	73	73
Internal Intelligence Function	61	80	73	73
Risk Profiling—Business Rules	42	70	82	69
Compliance Checks (for example, payroll checks)	71	64	70	68
Collected Tax	55	66	68	64
Frequency (time between audits)	42	75	62	61
BEPS or Aggressive Tax Planning Issues	23	57	67	53
Random	58	50	52	53
Location	39	48	62	52
International Exchange of Information	26	39	75	52
Tax Control Framework-based “Audits”	23	61	52	48
Ownership in a Corporate Entity	39	41	52	45
Risk Profiling—Predictive Modeling	19	45	50	41
Commercial Register	19	25	42	31
Other	6	7	10	8

Note: Numbers in parentheses equal the sample size for data supplied in each column. BEPS = base erosion and profit shifting.

³³ See <https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2019/03/07/ISORA-2016-Understanding-Revenue-Administration-46337>, p. 80.

Appendix 4. Variable definition

Panel A: Firm-level variables		
Variable	Definitions	Source
<i>Tax Avoid</i>	$[(PTI * \text{Statutory Tax Rate}) - CTP] / PTI$, 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
<i>Pre-Tax ROA</i>	Pre-tax Income (PI) scaled by lagged total assets (AT).	Compustat
<i>Prior Loss</i>	A dummy variable, equal to 1 if the firm had negative <i>Pre-Tax ROA</i> in the previous year and 0 otherwise.	
<i>Sales Growth</i>	Percentage change in Sales (SALE) from year $t-1$ to year t .	Compustat
<i>PP&E</i>	Net property, plant, and equipment (PP&ENT) scaled by lagged total assets (AT).	Compustat
<i>Leverage</i>	Sum of long-term and short-term debt, scaled by lagged total assets, set to 0 if missing.	Compustat
<i>R&D</i>	R&D Expense in year t scaled by lagged total assets, set to zero if missing.	Compustat
<i>Cash</i>	Cash and equivalents scaled by lagged total assets, set to zero if missing.	Compustat
<i>Ln Assets</i>	Natural log of total assets.	Compustat
Panel B: Country-level variables		
<i>Risk Profiling</i>	An indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling equal to one from ISORA audit case selection data.	ISORA
<i>Enforcement</i>	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.	ISORA
<i>STR</i>	Statutory tax rate, the average statutory corporate income tax rate in the country at year t .	KPMG
<i>Ln (GDP per capita)</i>	Natural logarithm of per-capita GDP.	World Bank
<i>GDP Growth</i>	The percentage change in GDP in a country from year $t-1$ to t .	World Bank
<i>Corruption</i>	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)
<i>Voice and Accountability</i>	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)
<i>Political Stability</i>	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)
<i>Government Effectiveness</i>	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	World Bank Worldwide

	pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Governance Indicators (WGI)
<i>Regulatory Quality</i>	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)
<i>Rule of Law</i>	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)
<i>Transfer Pricing Rules</i>	An indicator variable equal to one if there are no specific rules concerning transfer pricing in law and 0 otherwise.	The Tax Attractiveness Index
<i>CFC Rules</i>	An indicator variable equal to one if a country has not implemented controlled-foreign corporation rules and 0 otherwise.	The Tax Attractiveness Index
<i>Thin Capitalization Rules</i>	A categorical variable equals one if the deductibility of interests is not limited in the country, equals 0.5 if the deduction of interests is limited in the country, and equals 0 if thin capitalization rules are clearly defined in the country.	The Tax Attractiveness Index
<i>R&D Tax Incentives</i>	A categorical variable equals one if a country's R&D tax credits or deductions in relation to R&D costs are among the top 25% most attractive incentives worldwide in the year, equals 0.5 if a country offers tax incentives that are not among the 25% most attractive, R&D Tax Incentives receives, and equals 0 if no R&D Tax Incentives are offered in a country.	The Tax Attractiveness Index
<i>Anti-Avoidance Rules</i>	A categorical variable equals one if a country has no anti-avoidance rules, equals 0.5 if a country has a general anti-avoidance rule in the national tax law, and equals 0 if a general rule plus special anti-abuse clauses are applied in a country.	The Tax Attractiveness Index
<i>FTE Tax Audit</i>	Number of full-time employees in audit, investigation, and other verification.	ISORA
<i>Risk Profiling Experts</i>	An indicator variable equals one if tax administrations employ data scientists, behavioral researcher scientists, and computer systems analysts, and equals 0 if the tax administrations do not employ any of these three experts.	ISORA
<i>Cost of Collection</i>	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)
<i>Tax Effort</i>	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)

Appendix 5. Sample selection

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	174,293
2	Merge with country level data	147,792
3	Less duplicate observations	140,982
3	Less firm observations without positive pre-tax income	106,329
4	Less firm observations without sufficient data for variables	46,908

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.

Table 1. Audit case selection criteria reported to the ISORA

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

Notes: This table describes the audit case selection criteria as reported by the countries’ tax administrations to the ISORA. Our measure of risk profiling includes: (7) business rules, (8) predictive modelling.

Table 2. Mean of selected variables by country

Country	<i>Tax Avoid</i>	STR	Risk profiling 2014	Risk profiling 2017	Number of firm-year observations
Argentina	0.019	0.35	1	1	166
Australia	0.053	0.30	1	1	1,173
Austria	0.010	0.25	1	1	185
Belgium	0.050	0.34	1	1	247
Brazil	0.063	0.34	1	1	536
Bulgaria	-0.061	0.10	1	1	115
Canada	0.068	0.27	1	1	2,135
Chile	-0.054	0.23	1	1	319
China	0.006	0.25	0	0	12,770
Colombia	-0.077	0.27	1	1	107
Croatia	0.049	0.20	1	1	146
Cyprus	-0.074	0.13	1	1	91
Czech Republic	0.001	0.19	0	0	37
Denmark	-0.065	0.23	1	1	225
Estonia	-0.001	0.20	1	1	49
Finland	-0.071	0.20	1	1	336
France	0.042	0.33	1	1	1,417
Germany	-0.021	0.30	0	0	1,205
Greece	-0.053	0.28	0	1	249
Hong Kong	-0.068	0.17	1	1	475
Hungary	-0.143	0.16	1	1	53
Iceland	0.015	0.20	1	1	25
Indonesia	-0.081	0.25	1	1	784
Ireland	-0.091	0.13	1	1	181
Israel	-0.019	0.25	1	1	691
Italy	-0.114	0.30	1	1	689
Japan	-0.001	0.33	0	0	859
Kenya	-0.070	0.30	0	1	72
Korea	-0.097	0.24	0	0	18
Latvia	0.042	0.15	1	1	52
Lithuania	0.006	0.15	1	1	94
Luxembourg	-0.015	0.29	1	1	134
Malaysia	-0.066	0.24	1	1	1,152
Malta	0.121	0.35	1	1	30
Mexico	-0.116	0.30	1	1	221
Morocco	-0.009	0.31	0	1	165
Netherlands	-0.011	0.25	1	1	337
New Zealand	0.011	0.28	1	1	252
Norway	-0.040	0.26	1	1	249
Peru	-0.068	0.29	1	1	194
Poland	-0.009	0.19	1	1	1,467
Portugal	-0.129	0.21	1	1	113
Romania	-0.081	0.16	1	1	144
Russia	-0.058	0.20	1	1	521
Singapore	-0.082	0.17	1	1	1,144
Slovak Republic	0.017	0.22	1	1	13
Slovenia	-0.003	0.18	1	1	67
South Africa	-0.020	0.28	1	1	469
Spain	-0.042	0.27	1	1	337
Sweden	0.002	0.22	1	1	683
Thailand	0.017	0.20	0	1	781
Turkey	0.009	0.20	0	1	553
United Kingdom	-0.012	0.20	1	1	2,055
United States	0.176	0.40	0	1	10,326

Table 3. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	P25	P50	P75
<i>Tax Avoid</i>	46908	0.033	0.313	-0.022	0.064	0.164
<i>Pre-tax ROA</i>	46908	0.092	0.098	0.032	0.066	0.121
<i>Prior loss</i>	46908	0.105	0.307	0.000	0.000	0.000
<i>Sales growth</i>	46908	0.149	0.399	-0.009	0.071	0.195
<i>PP&E</i>	46908	0.303	0.266	0.085	0.237	0.454
<i>Leverage</i>	46908	0.251	0.238	0.055	0.208	0.373
<i>R&D</i>	46908	0.016	0.034	0.000	0.000	0.019
<i>Cash</i>	46908	0.194	0.214	0.050	0.123	0.257
<i>Ln (Assets)</i>	46908	6.218	2.186	4.833	6.143	7.602
<i>Risk Profiling</i>	46908	0.605	0.489	0.000	1.000	1.000
<i>Ln (Enforcement)</i>	46908	0.510	0.823	-0.298	0.730	0.956
<i>STR</i>	46908	0.282	0.074	0.250	0.250	0.333
<i>Ln (GDP per capita)</i>	46908	9.962	0.953	8.902	10.498	10.843
<i>GDP Growth</i>	46908	3.063	2.512	1.229	2.077	6.272
<i>Corruption</i>	46908	0.770	0.946	-0.271	1.280	1.514
<i>Voice and Accountability</i>	46908	0.208	1.223	-1.504	1.000	1.110
<i>Political Stability</i>	46908	0.202	0.667	-0.499	0.292	0.678
<i>Government Effectiveness</i>	46908	1.028	0.654	0.408	1.387	1.557
<i>Regulatory Quality</i>	46908	0.849	0.857	-0.147	1.159	1.631
<i>Rule of Law</i>	46908	0.820	0.955	-0.267	1.387	1.649
<i>Transfer Pricing Rules</i>	46908	0.004	0.065	0.000	0.000	0.000
<i>CFC Rules</i>	46908	0.134	0.341	0.000	0.000	0.000
<i>Thin Capitalization Rules</i>	46908	0.092	0.263	0.000	0.000	0.000
<i>R&D Tax Incentives</i>	46908	0.510	0.256	0.500	0.500	0.500
<i>Anti Avoidance Rules</i>	46908	0.062	0.193	0.000	0.000	0.000

Notes: This table describes the sample and summary statistics for the cross-country sample of our main variables for 16,492 firms and 46,908 firm-year observations from 2014 to 2017 used in the empirical tests. All continuous variables are winsorized at the 1st and 99th percentiles.

Table 4. Correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1) <i>Tax Avoid</i>	1.000												
2) <i>Risk profiling</i>	0.016*	1.000											
3) <i>Ln (Enforcement)</i>	-0.132*	-0.285*	1.000										
4) <i>Pre-tax ROA</i>	0.114*	-0.053*	0.010*	1.000									
5) <i>Prior loss</i>	-0.029*	0.110*	-0.053*	-0.123*	1.000								
6) <i>Sales growth</i>	0.040*	-0.068*	0.026*	0.285*	0.091*	1.000							
7) <i>PP&E</i>	0.022*	-0.000	0.029*	0.001	0.009	0.102*	1.000						
8) <i>Leverage</i>	0.027*	0.119*	-0.112*	-0.110*	0.073*	0.193*	0.248*	1.000					
9) <i>R&D</i>	0.038*	-0.174*	0.052*	0.195*	0.002	0.127*	-0.174*	-0.155*	1.000				
10) <i>Cash</i>	0.008	-0.225*	0.052*	0.419*	-0.026*	0.254*	-0.173*	-0.200*	0.334*	1.000			
11) <i>Ln (Assets)</i>	0.042*	-0.012*	-0.207*	-0.184*	-0.097*	-0.043*	0.097*	0.275*	-0.099*	-0.197*	1.000		
12) <i>Ln (GDP per capita)</i>	0.127*	0.521*	-0.377*	-0.084*	0.109*	-0.083*	-0.113*	0.135*	-0.038*	-0.186*	0.197*	1.000	
13) <i>GDP Growth</i>	-0.069*	-0.622*	0.403*	0.067*	-0.116*	0.093*	0.034*	-0.138*	0.133*	0.238*	-0.103*	-0.685*	1.000

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

Table 5. Risk profiling and tax avoidance

VARIABLES	(1) <i>Tax Avoid</i>	(2) <i>Tax Avoid</i>	(3) <i>Tax Avoid</i>	(4) <i>Tax Avoid</i>	(5) <i>Tax Avoid</i>
<i>Risk Profiling</i>	-0.046*** (0.017)	-0.037*** (0.011)	-0.037*** (0.011)	-0.036** (0.017)	-0.017** (0.007)
<i>Ln (Enforcement)</i>	-0.034** (0.016)	-0.029*** (0.010)	-0.029*** (0.010)	-0.035*** (0.012)	-0.043*** (0.003)
<i>Pre-tax ROA</i>	0.410*** (0.072)	0.395*** (0.079)	0.386*** (0.079)	0.404*** (0.076)	0.332*** (0.024)
<i>Prior loss</i>	-0.026** (0.012)	-0.029** (0.011)	-0.027** (0.012)	-0.028** (0.011)	-0.037*** (0.010)
<i>Sales growth</i>	0.010** (0.005)	0.014** (0.006)	0.014** (0.006)	0.011** (0.005)	0.014*** (0.005)
<i>PP&E</i>	0.065*** (0.020)	0.075*** (0.017)	0.075*** (0.017)	0.068*** (0.019)	0.079*** (0.009)
<i>Leverage</i>	-0.028 (0.033)	-0.039 (0.032)	-0.037 (0.032)	-0.034 (0.032)	-0.039*** (0.009)
<i>R&D</i>	0.325*** (0.087)	0.200*** (0.064)	0.203*** (0.062)	0.279*** (0.075)	0.203*** (0.063)
<i>Cash</i>	-0.061** (0.027)	-0.050** (0.023)	-0.048** (0.023)	-0.055** (0.024)	-0.014* (0.008)
<i>Ln (Assets)</i>	-0.002 (0.002)	-0.004** (0.002)	-0.005*** (0.002)	-0.003 (0.002)	-0.007*** (0.001)
<i>Ln (GDP per capita)</i>	0.045** (0.017)	0.042* (0.021)	0.043** (0.021)	0.085** (0.039)	0.059*** (0.008)
<i>GDP Growth</i>	0.003 (0.005)	0.008 (0.005)	0.008 (0.005)	0.007 (0.005)	0.020*** (0.002)
<i>Corruption</i>		-0.063 (0.039)	-0.064 (0.040)	-0.035 (0.033)	-0.111*** (0.014)
<i>Voice and Accountability</i>		-0.014 (0.014)	-0.014 (0.014)		0.016** (0.008)
<i>Government Effectiveness</i>		-0.099* (0.050)	-0.101* (0.050)		-0.072*** (0.021)
<i>Political Stability</i>		-0.048** (0.021)	-0.048** (0.021)		-0.066*** (0.007)
<i>Rule of Law</i>		0.286*** (0.060)	0.286*** (0.060)		0.255*** (0.021)
<i>Regulatory Quality</i>		-0.118*** (0.029)	-0.117*** (0.029)		-0.070*** (0.014)
<i>One over Pre-tax Profit</i>			-0.002** (0.001)		
<i>Transfer Pricing Rules</i>				-0.012 (0.053)	
<i>CFC Rules</i>				-0.037* (0.021)	
<i>Thin Capitalization Rules</i>				-0.038 (0.037)	
<i>R&D Tax Incentives</i>				-0.000 (0.011)	
<i>Anti-Avoidance Rules</i>				0.066 (0.041)	
<i>Constant</i>	-0.488** (0.187)	-0.426** (0.204)	-0.431** (0.206)	-0.869** (0.380)	
Observations	46,908	46,908	46,908	46,908	46,908
R-squared	0.077	0.093	0.097	0.083	0.131
Industry FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes

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 Profiling*, is an indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling equal to one according to ISORA audit case selection data. Additional control variables are included in Columns (2), (3), and (4). In Column (5), baseline regression is estimated using weighted least squares. All continuous variables are winsorized at the 1% and 99% levels. Variables are defined in Appendix 4. 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.

Table 6. Timing of tax avoidance around the implementation of risk profiling

	Implementation of Risk Profiling	Tax Avoid in t
Anticipatory Response	<i>Risk Profiling in $t + 2$</i>	-0.005 (0.021)
	<i>Risk Profiling in $t + 1$</i>	-0.015 (0.018)
	<i>Risk Profiling in t</i>	-0.046*** (0.017)
Immediate Response	<i>Risk Profiling in $t - 1$</i>	-0.061*** (0.017)
	<i>Risk Profiling in $t - 2$</i>	-0.076*** (0.015)
Controls & FE		yes

Notes: This table presents the results of the main regression, including lead and lagged values for our variable of interest *Risk Profiling*. t denotes the year in which we observe *TaxAvoid*. *Risk Profiling in $t - 2$* , for instance, denotes the implementation of risk profiling two years before we observe *TaxAvoid*. Controls and fixed effects from the main regression 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.

Table 7. Cross-sectional tests

Panel A: Risk Profiling and Firm Size			
VARIABLES	(1) Small firms	(2) Medium firms	(3) Large firms
<i>Risk Profiling</i>	-0.049*** (0.017)	-0.040** (0.016)	-0.062*** (0.019)
<i>Ln (Enforcement)</i>	-0.014 (0.014)	-0.033** (0.015)	-0.056*** (0.016)
Observations	15,636	15,636	15,636
R-squared	0.055	0.071	0.146
Industry FE	yes	yes	yes
Year FE	yes	yes	yes

Panel B: Implementation of Risk Profiling in Tax Administrations				
VARIABLES	(1) No Risk Profiling Experts	(2) Risk Profiling Experts	(3) Low FTE Tax Audit	(4) High FTE Tax Audit
<i>Risk Profiling</i>	-0.036 (0.031)	-0.069*** (0.019)	-0.023 (0.023)	-0.023*** (0.003)
<i>Ln (Enforcement)</i>	0.014 (0.015)	-0.047** (0.017)	0.000 (0.012)	-0.072*** (0.004)
Observations	3,914	17,846	8,249	7,571
R-squared	0.046	0.098	0.042	0.145
industry FE	yes	yes	yes	yes
year FE	yes	yes	yes	yes

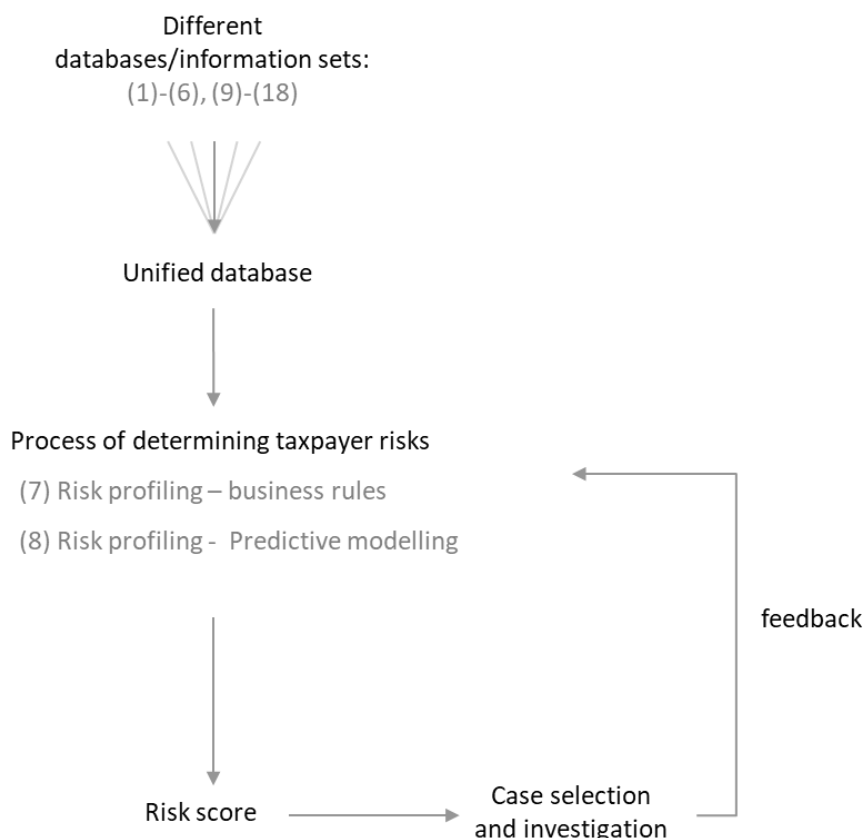
Notes: This table presents the cross-sectional results of estimating the baseline regression (Table 5). The dependent variable is *Tax Avoid*, measured as the difference between taxes calculated at the statutory tax rate and taxes that are actually paid, based on De Simone et al. (2020) and Atwood et al. (2012). Our main variable of interest, *Risk profiling*, is an indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling equal to one according to ISORA audit case selection data. In Panel A, the results of equation (1) are split by size (total asset) thirds per country and year. In Panel B, Columns (1) and (2) present the result of equation (1) split by risk profiling expertise in tax administrations. *(No) Risk Profiling Experts* represents tax administrations that (do not) employ data scientists, behavioral researcher scientists, and computer systems analysts according to ISORA data. Columns (3) and (4) present the results using a subsample of corporations located in countries with a low and high number of full-time employees in audit, investigation, and other verification. Low (high) full-time employees denote corporations in countries with 25th (75th) percentiles in full-time employees in audit, investigation, and other verification. All continuous variables are winsorized at the 1% and 99% levels. Variables are defined in Appendix 4. 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.

Table 8. Risk profiling and tax administration performance

Variables	(1) Cost of Collection	(2) Tax Effort
<i>Risk Profiling</i>	-0.255** (0.105)	0.058* (0.031)
<i>Ln (Enforcement)</i>	0.113*** (0.036)	0.031 (0.020)
<i>Voice and Accountability</i>	0.328*** (0.111)	0.033 (0.038)
<i>Political Stability</i>	0.170* (0.087)	-0.033 (0.028)
<i>Government Effectiveness</i>	0.893*** (0.284)	-0.183** (0.084)
<i>Regulatory Quality</i>	-0.106 (0.204)	-0.151*** (0.052)
<i>Rule of Law</i>	-0.618* (0.317)	0.059 (0.074)
<i>Corruption</i>	0.002 (0.188)	0.148** (0.064)
<i>Ln (GDP per capita)</i>	-0.416*** (0.124)	0.090** (0.035)
<i>GDP Growth</i>	-0.013 (0.016)	-0.009** (0.004)
<i>Constant</i>	4.689*** (1.146)	-0.214 (0.317)
Observations	196	200
R-squared	0.424	0.496
Year FE	yes	yes

Notes: This table presents the results of equation (2). In column (1), the dependent variable is *Cost of Collection*, which equals the ratio of the cost of administering the tax system to the total revenues collected by the tax administration. In column (2), the dependent variable is *Tax Effort*, which compares the actual value of tax as a percent of GDP to tax capacity. Our main variable of interest, *Risk Profiling*, is an indicator variable equal to one if risk profiling - business rules or risk profiling - predictive modeling equal to one from ISORA audit case selection data. Variables are defined in Appendix 4. 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.

Figure 1. Risk profiling and other items in ISORA on tax audit case selection



Notes: This figure exemplifies how both data from different databases (e.g., data from tax returns and third-party information) available in tax administrations and advanced analytical techniques are used for risk profiling. Numbers represent ISORA audit case selection items (1) to (18) as available in the ISORA questionnaire. Overall, the ISORA 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), (9) to (18) from the ISORA case selection data describe taxpayers' characteristics or information sources. Rule based or advanced analytical techniques (such as clustering and association analysis, risk profiling, decision trees, regressions, and predictive models) are employed to analyze the data from different databases to trace and identify risky cases and to evaluate probability of non-compliance. Our measure of risk profiling includes (7) Risk profiling - business rules, (8) Risk profiling - predictive modelling.