Special Issue Reprint

Shadow Economy and Tax Evasion

Edited by
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About the Editor

Gaetano Lisi

Gaetano Lisi graduated in Economics and Commerce (2004) and obtained a master's degree in Economics, Institutions, and Markets (2006), both cum laude, at the University of Cassino and Southern Lazio (Italy). He is also obtained a master's degree in Saving Management (2005), cum laude, at the University of Rome "Tor Vergata". Finally, he holds a Ph.D. in Economics, Firms, and Quantitative Analysis (2010) from the University of Cassino and Southern Lazio (Italy), where he discussed a theoretical and empirical thesis on the complex and ambiguous relationship between shadow economy and unemployment in Italian regions. Since 2011, he has been a lecturer in Macroeconomics, Microeconomics, and Labor Economics (at the University of Cassino and Southern Lazio) and an official expert in statistical-economic analysis (at the Italian Revenue Agency). In August 2018, he obtained the "national scientific qualification" (ASN) for the scientific disciplinary sector SECS-P/02 (Economic Policy). Since June 2019, he has been an Associate Professor of Economic Policy at the eCampus University (Faculty of Economics), where he teaches Development Economics and Economic Policy for Economic Growth and Sustainable Development. His main research interests cover the complex relation between shadow economy, tax evasion, and fiscal policy, as well as the intricate relationship between homeownership, labour mobility, and unemployment. To date, his research is published in over ninety journals with ISSN and volumes with ISBNs.

Preface

Shadow economy and tax evasion are widely studied topics in economics and behavioural sciences. Still, determinants of the tax behaviour of individuals and firms (including psychological aspects and social and cultural norms and customs) are not fully understood. Additionally, questions related to the evolution, operation, and design of formal institutions capable of effectively counteracting these two widespread and related phenomena remain (substantially) unanswered. Finally, fiscal policies fighting against shadow economy and tax evasion could (at least in the short term and in some countries) have adverse effects on economic growth and unemployment. This Special Issue Reprint contributed to improving the understanding of several aspects of shadow economy and tax evasion. It comprises 12 papers, both theoretical and empirical, by scholars and experts in the field.

The first paper by Lisi (*Tax Audits, Tax Rewards and Labour Market Outcomes*) studies the relation between tax audits and labour market outcomes (job creation and unemployment) in an economy that contemplates penalties for firms that evade taxes and rewards for firms that comply with tax rules. The main finding of this work is that tax audit remains the best fiscal policy tool to increase tax compliance and decrease tax evasion.

The article by Gnangnon (*Effect of the Shadow Economy on Tax Reform in Developing Countries*) studies the effect of the shadow economy on tax reform in developing countries. Specifically, two types of tax reform are considered: the "structural tax reform", characterized by large episodes of tax revenue mobilization; and the "tax transition reform" that reflects the reform of the tax revenue structure that involves the reduction in its dependence on international trade tax revenue at the benefit of domestic tax revenue. The paper finds that shadow economy negatively affects tax reforms in developing countries.

The article by Orsi and Knut (*Do Increased Tax Base and Reductions in the Underground Economy Compensate for Lost Tax Revenue Following a Tax Reduction Policy? Evidence from Italy 1982 to 2006*) tests the hypothesis that an increase in the tax base and a decrease in tax evasion will compensate for a loss in tax revenues caused by a lower tax level. Using a unique data set for estimating the underground economy in Italy from 1982 to 2006, the paper finds that a loss in tax revenues can be compensated by an increase in GDP.

The article by Paleka and Vitezić (*Tax Compliance Challenge through Taxpayers' Typology*) identifies critical gaps in understanding taxpayer heterogeneity. An exploratory factor analysis of taxpayer perceptual and attitudinal elements revealed several factors influencing taxpayer compliance with the tax system. Furthermore, the cluster analysis identified four groups of taxpayers, and significant differences between the clusters and the descriptive profile of each cluster were also found. Hence, in fostering tax compliance, the tax authority has to consider the different taxpayers' typologies.

The article by Alm, Burgstaller, Domi, März, and Kasper (*Nudges, Boosts, and Sludge: Using New Behavioral Approaches to Improve Tax Compliance*) discusses the importance of using behavioural interventions in fostering tax compliance. Specifically, this paper considers "nudges" (interventions that use behavioural economics to alter the ways in which the choice architecture facing individuals is communicated to them by the tax administration), "sludge" (institutional features that complicate compliance), and "boosts" (initiatives that target individuals' competencies and thereby help them to make better decisions). All three of these behavioural interventions should be utilized in the design of tax policies.

The article by Andrejovská and Glova (*Economic Determinants Concerning Corporate Tax Revenue*) applies a panel regression analysis (with the 27 EU Member States considered for the period 2004–2020) to quantify the impact of both the nominal tax rate (which is legislatively determined based on political consensus) and the effective tax rate, which involves selected economic determinants on corporate tax revenues. The study shows that fiscal policies should be aimed at an effective tax rate or a better harmonization of the nominal tax rate toward the effective rate.

The article by Sánchez, Sastre-Hernández, Jorge-Vazquez, and Alonso (*Cryptocurrencies, Tax Ignorance and Tax Noncompliance in Direct Taxation: Spanish Empirical Evidence*) highlights the complexity of taxation surrounding cryptocurrency transactions due to the lack of uniform regulation, creating uncertainty for both taxpayers and tax authorities.

The article by Bolarinwa and Simatele (*Asymmetric Analysis of Causal Relations in the Informality–Globalisation Nexus in Africa*) examines the causal relationship between informality and globalization in 30 African countries. It deviates from traditional research by adopting a bi-directional framework to address reverse causality. This research finds that the causal structure is better explained within a nonlinear asymmetric context. This paper provides recommendations based on the identified causal relationships. For countries in which globalization leads to informality, the paper suggests policy measures to integrate the informal sector into the formal economy. For countries experiencing positive shocks from informality to globalization, this paper recommends targeted support programmes for entrepreneurship, initiatives to formalize the sector, the enhancement of market access, and skill development tailored to the needs of the informal sector. In the case of negative shocks in globalization leading to positive shocks in informality, the paper suggests implementing resilience-building policies for the informal sector during economic downturns, establishing social safety nets, and adopting flexible labour policies.

The article by Milosavljevic, Ignjatovic, Spasenić, Milanović, and Đoković (*Is There a Link between Tax Administration Performance and Tax Evasion?*) introduces a new approach for measuring tax administration performance using the Composite I-Distance Indicator (CIDI) based on 11 individual performance measures from 35 European tax administrations over 2 consecutive years (2018–2019). The study highlights Denmark and the Netherlands as exemplary models for tax administration, with "Revenue Collection" being identified as a crucial driver of excellence and "Operational Performance" (such as "e-filing" and "on-time filing") forming critical aspects of tax administration efficiency.

The article by Barile, Cullis, and Jones (*"Optimal Honesty" in the Context of Fiscal Crimes*) considers three "apparently falsified" empirical predictions of the standard expected utility model of individual decision-making concerning participation in fiscal crimes: tax evasion and benefit fraud can be treated identically; fiscal crimes should be endemic; and all individuals, depending on parameter values, should be either honest or dishonest. A rationalization of the predictions involves defining an individual's "optimal honesty" in the context of fiscal crimes.

The article by Barile, Grossi, Lattarulo, and Pazienza (*Earmarking Taxation and Compliance: Some Evidence from Car Ownership in Italy*) focuses on the evasion of car ownership taxes. An empirical analysis in Tuscany, Italy, reveals that the inclination to evade vehicle ownership taxes is concentrated among specific demographic categories and types of vehicles.

The article by Tonetto Pique, Fochezatto, and Rapetti (*Tax Evasion and Company Survival: A Brazilian Case Study*) examines whether companies that receive tax fines for evasion have a longer or shorter life expectancy compared to those that consistently comply with tax regulations. An empirical analysis on survival rates in Rio Grande do Sul, Brazil, shows that companies fined for tax evasion had a higher survival rate compared to those without fines. The paper suggests that fines might serve as a corrective measure, helping companies realign and improve their chances of survival.

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Article

Tax Audits, Tax Rewards and Labour Market Outcomes

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Abstract: This theoretical paper studies the relation between tax audits and labour market outcomes (job creation and unemployment) in an economy that contemplates penalties for firms that evade taxes and rewards for firms that comply with tax rules. Intuitively, the simultaneous presence of penalty and reward amplifies the role of auditing, since tax audits allow both punishing tax-evading firms and rewarding fiscally honest firms. Indeed, the presence of tax rewards can make the effect of tax audits on firms' net profits positive. However, the effect of tax audits on labour market outcomes is ambiguous. By setting the choice of optimal fiscal policy in a different and original way, this paper is able to derive a formula for the audit rate—consistent with the budget constraint—that makes the relation between tax audits and labour market outcomes positive.

Keywords: tax audits; tax evasion; tax reward; job creation; unemployment

JEL Classification: H20; H26; H32; J64; M42

1. Introduction

The literature dealing with the relation between fiscal policy and tax evasion is extremely rich (Chamley 1986; Wang and Conant 1988; Slemrod 1990, 1992; Kaplow 1990; Masatoshi 1990; Schjelderup 1993; Cremer and Gahvari 1993, 1994, 1996; Jones et al. 1997; Judd 2002; Wigger 2002; Crocker and Slemrod 2005; Chen and Chu 2005; Torgler and Schaltegger 2005; Stöwhase and Traxler 2005; Kopczuk and Slemrod 2006; Hashimzade et al. 2010; Dhami and Al-Nowaihi 2010; Liu 2013; Saez 2013).

Furthermore, in the fight against tax evasion, the role of tax rewards has also been investigated (Falkinger and Walther 1991; Feld et al. 2006; Feld and Frey 2007; Kastlunger et al. 2011; Bazart and Pickhardt 2011; Murphy 2012; Brockmann et al. 2016; Fochmann and Kroll 2016). If the penalty is an economic disincentive for tax evasion, then tax reward should be an economic incentive for tax compliance (Falkinger and Walther 1991). Actually, the simultaneous presence of penalty and reward makes the tax system fairer (Lisi 2022a, 2022b).

Tax evasion and the issue of optimal fiscal policy also appear in economic growth models. Chen (2003) includes tax evasion into a standard AK growth model with public capital and studies the effect of three tax policies (cost of tax enforcement, punishment–fines and tax auditing) on both tax evasion and economic growth. It finds that the three fiscal policies are able to discourage tax evasion, but the effect on economic growth is small. Economides et al. (2020) study the properties of the optimal tax policy in a version of the neoclassical growth model where both households and firms can choose to under-report their incomes. They find that the type of tax evasion under consideration (under-report of labour income, under-report of capital income and under-report of sales) is crucial to the properties of optimal tax policy.

This theoretical paper, instead, focuses on the effect of tax evasion and fiscal policy on labour market outcomes (i.e., job creation and unemployment) in an economy that contemplates penalties for firms that evade taxes and rewards for firms that comply with tax rules. Precisely, the paper develops a modified version of the benchmark macroeconomic

model of the labour market, i.e., the search and matching model (Pissarides 2000, 2011), where tax reward is introduced in the simplest form of a "negative penalty", namely, a monetary reward for firms that comply with tax rules.

The simultaneous presence of penalty and reward amplifies the role of tax audits, since tax audits allow both punishing tax-evading firms and rewarding fiscally honest firms. Indeed, an increase in tax auditing increases firms' net profits if tax rewards are high enough. In Chen (2003), an increase in tax auditing reduces tax evasion only if the cost of tax enforcement is not too high.

However, the effect of tax audits on labour market outcomes is, a priori, ambiguous. In order to clarify that relation, the role of the tax authority is also introduced into the model. The term 'tax authority' should be understood in a broad sense, namely, the authority that decides, enforces and audits tax rules (the 'fiscal policy maker'). Thus, it also includes the key role of the government that decides the tax rules. Hence, the tax authority cares (must care) about job creation and unemployment.

By setting the tax authority's problem in a different and original way—namely, the function to be maximised is the evolution of (un)employment instead of social welfare—this paper is able to derive the level of tax audits that maximises job creation and is consistent with the budget constraint.

The rest of this theoretical paper is organised as follows. Section 2 reviews the literature on tax evasion and fiscal policy and shows the connection with the labour market. Section 3 presents the theoretical model and describes the equilibrium in the labour market. Section 4 studies the tax authority's problem and derives the optimal level of tax audits. Finally, Section 5 concludes the work and summarises the main fiscal policy implications.

2. Literature Review

The relationship between tax evasion/tax compliance and (optimal) fiscal policy is at once complex, challenging and fascinating (Torgler 2008).

The theory of tax evasion started with the seminal works by Allingham and Sandmo (1972), Srinivasan (1973) and Yitzhaki (1974), whereas the theory of optimal tax policy started with the seminal work by Sandmo (1981). Basically, the theory of optimal tax policy aims at giving suggestions on how to plan an efficient tax system such that the cost of taxation is reduced in the best possible way (see, e.g., Slemrod 1990).

The influential works by Allingham and Sandmo (1972), Srinivasan (1973) and Yitzhaki (1974), however, do not discuss the theory of optimal tax policy (Mirrlees 1971; Diamond and Mirrlees 1971a, 1971b; Jones et al. 1997; Chamley 1986; Judd 2002; Kopczuk and Slemrod 2006; Saez 2013).

Starting from the seminal work by Sandmo (1981), instead, several papers have introduced the social welfare objective of governments and tax administrations in models of tax evasion (see, e.g., Kaplow 1990; Masatoshi 1990; Cremer and Gahvari 1993, 1994, 1996; Schjelderup 1993; Wigger 2002; Dhami and Al-Nowaihi 2010; Liu 2013; Lisi 2015).

Of course, different types of taxes can be evaded. For example, Gordon and Nielsen (1997) allow for evasion of both value-added tax (VAT) and cash-flow income tax. Without tax evasion, taxes should have similar behavioural and distributional consequences, while the available means of evasion can be very different among taxes. In general, in planning an efficient tax system, a government should use different types of taxes, relying more on whichever tax is harder to evade. In a model calibrated to Denmark, Gordon and Nielsen (1997) find that value-added taxes are harder to evade than cash-flow income taxes.

However, when tax evasion is feasible, the normative policy implications (namely, "what should the tax authority do?"), derived from the optimal fiscal policy may be misleading (Cremer and Gahvari 1993, 1996; Boadway et al. 1994; Gueth and Sausgruber 2004; Richter and Boadway 2005). According to Gueth and Sausgruber (2004), in particular, such distortions can be avoided if the optimal taxation theory accounts for basic insights from behavioural economics.

For this reason, another important strand of literature focused on the effect of the intrinsic motivation to pay taxes (the so-called "tax morale") on tax compliance (see, e.g., Slemrod 1992; Feld and Frey 2002; Torgler 2007; Frey and Torgler 2007; Torgler and Schneider 2009; Cummings et al. 2009; Kirchler et al. 2010; Alm and Torgler 2011; Halla 2012; Molero and Pujol 2012; Castañeda 2019). The general conclusion of this stream of literature is the usefulness of going beyond a deterrence approach.

Moreover, the role of a further component of fiscal policies for increasing tax compliance, namely tax reward, has been investigated (see, e.g., Feld et al. 2006; Feld and Frey 2007; Kastlunger et al. 2011; Bazart and Pickhardt 2011; Murphy 2012; Brockmann et al. 2016; Fochmann and Kroll 2016; Lisi 2022a, 2022b).

Within this evergreen literature, the theoretical contribution of this paper is anything but trivial. Tax evasion, of course, is closely related to the phenomenon of shadow economy (an increase in the shadow income increases tax evasion). In turn, shadow economy is closely related to the phenomenon of unemployment (undeclared work often concerns unemployed workers). Hence, the use of the benchmark macroeconomic model of the labour market becomes very useful. Additionally, this work considers all the main benefits and costs of tax evasion/tax compliance, including tax rewards. Indeed, tax audits and tax rewards can contribute to building a "fiscal culture" (tax morale) in an economy where unemployment is very high and tax evasion (shadow economy) is widespread (and often tolerated). Rewarding honest taxpayers and punishing tax evaders, in fact, should be a basic principle of any democratic and modern society.

Finally, there are studies on the relationship between fiscal policy and labour market outcomes (Gomes 2010; Bova et al. 2014; Stepanyan and Leigh 2015). However, as far as we are aware, this is the first work that addresses the interplay between all fiscal policy variables (including tax rewards) and the two main indicators of labour market performance (job creation and unemployment).

3. The Theoretical Model

This section combines the benchmark model of the labour market (Pissarides 2000, 2011) with the core of tax evasion analysis (Sandmo 2005). Furthermore, in the spirit of Falkinger and Walther (1991), the tax evasion analysis also includes a monetary reward for tax compliance.

3.1. A Basic Search and Matching Model of the Labour Market

The key feature of a basic search and matching model (Pissarides 2000) is the "matching function", which expresses the number of jobs (m) as a function of firms' job vacancies (v) and unemployed workers (u). In this model, the matching function takes the usual form of a Cobb–Douglas function with constant returns to scale, viz.:

$$m = m(v, u) = v^{1-\alpha} \cdot u^{\alpha}$$

where $0 < \alpha < 1$ is the unemployment elasticity. From the matching function, it is straightforward to find:

- the probability of filling a job vacancy, viz.: $\left(\frac{m}{v}\right) = v^{-\alpha} \cdot u^{\alpha} \equiv \theta^{-\alpha}$, with $\frac{\partial(\theta^{-\alpha})}{\partial\theta} < 0$;
- the probability of finding a job: $\left(\frac{m}{u}\right) = v^{1-\alpha} \cdot u^{\alpha-1} \equiv \theta^{1-\alpha}$, with $\frac{\partial(\theta^{1-\alpha})}{\partial\theta} > 0$;

where $\theta \equiv \frac{v}{u}$ represents the so-called "labour market tightness or frictions". Intuitively, the probability of filling a job vacancy decreases in the ratio between job vacancies and unemployment; whereas, the probability of finding a job increases in the ratio between job vacancies and unemployment.

In order to find the equilibrium value of θ, it needs to introduce the present value of an operative one-job firm ($r \cdot J$) and the present value of a firm' job vacancy ($r \cdot V$):

$$r \cdot J = \pi + \delta \cdot [V - J] \tag{1}$$

$$r \cdot V = -\psi + \theta^{-\alpha} \cdot [J - V] \tag{2}$$

where r is the real interest rate, π is the firm's net profit, ψ is the cost of opening (and maintaining) a job vacancy and δ is the exogenous job destruction rate (the firm's dismissal rate and/or the worker's resignation rate). Equations (1) and (2) state that an operative firm (J) becomes a job vacancy (V) at the job destruction rate δ, whereas a job vacancy becomes an operative firm at the matching rate $\theta^{-\alpha}$ (the probability of filling a job vacancy). By combining Equations (1) and (2) under the so-called *Job Creation condition*, namely the condition $V = 0$, it is straightforward to obtain the equilibrium value of labour market tightness ($\theta = \theta^*$):

$$\frac{\pi}{(r + \delta)} = \theta^{\alpha} \cdot \psi$$

$$\stackrel{yields}{\rightarrow} \theta^* = \left[\frac{\pi}{\psi \cdot (r + \delta)} \right]^{\frac{1}{\alpha}} \tag{3}$$

Basically, the condition $V = 0$ implies that, in equilibrium, all the profit opportunities have been exploited and, thus, it is no longer convenient for a firm to open a further job vacancy.

Since θ^* derives from the job creation condition, we refer to it as "job creation". Intuitively, job creation is a positive function of the firm's net profit (π), while it is a negative function of both the cost of opening (and maintaining) a job vacancy (ψ) and the "total" discount rate ($r + \delta$).

3.2. Firm's Net Profit, Penalty, Tax Reward and Tax Audits

The net profit (π) of a firm that can evade taxes or comply with tax rules is the following:

$$\pi = y - \tau \cdot y^D - \rho \cdot \left(\gamma^{-1} \cdot \tau \cdot s \right) + \rho \cdot (b \cdot \gamma) - \varphi \tag{4}$$

where y is the exogenous (true) net income (revenues net of wages); y^D is the declared income (the firm's tax base); τ is the tax rate (a "linear income tax", for the sake of simplicity); ρ is the audit rate; $s \equiv (y - y^D) \geq 0$ is the evaded income; $b > 0$ is the monetary tax reward; $\gamma \equiv \frac{y^D}{y}$ is the reward rate; $\gamma^{-1} \equiv \frac{y}{y^D}$ is the multiplier of taxation (the weight of penalty); and φ the concealment cost of the evaded income.[1]

Note that $s \equiv (y - y^D)$ is the shadow economy (income), while $\tau \cdot s$ is tax evasion.

Regarding γ^{-1} and γ, a fair penalty should be assessed on the level of tax evasion (and it should be always higher than taxation); additionally, a right reward should be assessed on the level of declared income. Hence, the higher the declared income, the higher the γ and the lower the γ^{-1}, and vice versa. At the limit, when $y = y^D$ (and thus $s = 0$), the full monetary reward is received; on the other hand, when $y^D \to 0$, the penalty becomes very high, thus cancelling out profits entirely, i.e., $\lim_{y^D \to 0} \pi \to 0$.

The firm chooses the level of declared income, $y^D = (y^D)^*$, that maximises the net profit (for mathematical details, see Appendix A):

$$(y^D)^* = \frac{y}{\left(\frac{1}{\rho} - \frac{b}{y \cdot \tau} \right)^{\frac{1}{2}}} \tag{5}$$

where $(y^D)^*$ is positive for $y > \frac{b \cdot \rho}{\tau}$. From Equation (5), the shadow income (s) is also obtained. Intuitively, $\frac{\partial (y^D)^*}{\partial b} > 0$, $\frac{\partial (y^D)^*}{\partial \tau} < 0$ and $\frac{\partial (y^D)^*}{\partial \rho} > 0$.

Furthermore, note that the effect of tax audits on firms' net profits can be positive, viz.:

$$\frac{\partial \pi}{\partial \rho} = -\left(\gamma^{-1} \cdot \tau \cdot s \right) + (b \cdot \gamma) > 0$$

if $b > \left[\left(\gamma^{-1}\right)^2 \cdot \tau \cdot s\right]$. As a result,

Proposition 1. *Tax reward increases the declared income by firms and amplifies the role of tax audits. Precisely, a high tax reward can make the effect of tax audits on firms' net profits positive.*

Looking at Equation (3), therefore, the presence of taw rewards could trigger a virtuous circle, i.e., the higher the tax reward, the higher the declared income by firms, the higher the firms' net profits and the higher job creation. In turn, an increase in the declared income by firms increases tax rewards and, thus, the virtuous circle starts again.

3.3. Labour Market Outcomes and Fiscal Policies

By normalising the labour force to the unit, the evolution of unemployment over time (t) is given by:

$$\dot{u} \equiv \frac{du}{dt} = [\delta \cdot (1 - u)] - \left[\theta^{1-\alpha} \cdot u\right] \tag{6}$$

where $[\delta \cdot (1 - u)]$ is the inflows into unemployment, i.e., the employed workers $(1 - u)$ who lose their jobs at the job destruction rate (δ), whereas $\left[\theta^{1-\alpha} \cdot u\right]$ is the unemployment outflows, namely, the unemployed workers (u) who find a job at the probability of finding a job ($\theta^{1-\alpha}$).

Thus, in the steady state (with $\dot{u} = 0$), the equilibrium unemployment (u^*) is given by:

$$u^* = \frac{\delta}{\delta + \theta^{1-\alpha}} \tag{7}$$

From Equation (7), the negative relation between unemployment and job creation clearly emerges, since the probability of finding a job ($\theta^{1-\alpha}$) positively depends on job creation (θ).

However, the effect of tax audits on job creation and unemployment is, a priori, ambiguous (for mathematical details, see Appendix B). Precisely,

Proposition 2. *The effect of tax audits on job creation and unemployment depends on penalty and reward that, in turn, depend on the budget constraint, viz.:*

$$\underbrace{\left(\tau \cdot y^D\right) + \rho \cdot \left(\gamma^{-1} \cdot \tau \cdot s\right)}_{revenue} - \underbrace{c(\rho) - \rho \cdot b \cdot \gamma - g}_{expenditure} \geq 0 \tag{8}$$

where g is the public spending per capita (the needs of the public sector) and $c(\rho)$, with $\frac{dc(\rho)}{d\rho} > 0$, is the auditing cost, namely, the administrative cost to the tax authority to increase tax audits.

Actually, an increase in tax audit rate (ρ) increases both the penalty component $\left(\gamma^{-1} \cdot \tau \cdot s\right)$, which increases state revenues, and the reward component ($b \cdot \gamma$), which increases public spending. As a result, its net effect is, a priori, ambiguous.

4. Fiscal Policy

In order to define the rate of tax audits that is harmless for labour market outcomes and consistent with the budget constraint, it is needed to introduce the tax authority's problem.

Precisely, this section assumes that the (benevolent and forward-looking) tax authority maximises labour market performance, i.e., the evolution of employment:

$$\epsilon = 1 - u$$

under the (balanced) budget constraint:[2]

$$\begin{cases} max \left[\int_0^\infty \left[\theta^{1-\alpha} \cdot (1 - \epsilon) - \delta \cdot \epsilon\right] \cdot e^{-r \cdot t} dt\right] \\ s.t. \ g = \left(\tau \cdot y^D\right) + \rho \cdot \left(\gamma^{-1} \cdot \tau \cdot s\right) - c(\rho) - \rho \cdot b \cdot \gamma \end{cases} \tag{9}$$

the fiscal policy variables (τ, ρ and b) are the 'control variables' while the public spending (g) is the 'state variable'.

The tax authority's problem (9) is specified in a different and somehow original way with respect to the standard social planner problem, where some version of social welfare is maximised.[3] As analysed in Section 3.3., fiscal policy variables directly affect job creation and, thus, unemployment. Furthermore, an increase in unemployment could rise shadow income and tax evasion, since unemployed workers can find a job in the shadow economy. Hence, it makes sense for the tax authority or the government (the 'fiscal policy maker') to aim for the maximisation of employment (the minimisation of unemployment).

The solution to the dynamic optimisation problem gives the rate of tax audits ($\bar{\rho}$) that makes $\frac{\partial\left(\theta^{1-\alpha}\right)}{\partial\rho} = 0$ (for mathematical details, see Appendix C):

$$\bar{\rho} = \left[\frac{\left(\gamma^{-1}\cdot\tau\cdot s\right) - b\cdot\gamma}{\omega}\right]^{\frac{1}{\omega-1}} \tag{10}$$

where $\omega > 0$ is the elasticity of the auditing cost function (see again Appendix C).

Consequently, the "optimal" level of tax audits (ρ^*) should be always higher than ρ^*:

$$\rho^* > \bar{\rho}$$

since the "optimal" level of tax audits (ρ^*) is the level that makes the relation between tax audits and labour market outcomes positive, i.e., $\frac{\partial\theta^*}{\partial\rho} > 0$ and, thus, $\frac{\partial u^*}{\partial\rho} < 0$.

Note that this also implies an increase in official employment and a decrease in shadow employment, since $\frac{\partial\left(y^D\right)^*}{\partial\rho} > 0$ in Equation (5) and, thus, $\frac{\partial s^*}{\partial\rho} < 0$. In short, a high tax audit decreases both unemployment and shadow income. It follows that official employment should increase more than the decrease in shadow employment. Employment, therefore, will migrate from "the grey zone into daylight". Unfortunately, job migration is a very 'complex' socioeconomic dynamic that this simple model is not able to directly catch.

Therefore, once the tax authority detects tax compliance (y^D), the rates/weights γ^{-1} and γ are obtained. Given s, γ^{-1} and γ, the ratio between taxation (τ) and tax reward (b) consistent with Equation (10) is given by:

$$\frac{\tau}{b} \geq \frac{\gamma}{\gamma^{-1}\cdot s}$$

Finally, the tax authority should fix $\rho^* > \bar{\rho}$. Accordingly,

Proposition 3. *Once a benchmark level of auditing is identified, optimal tax audits should be fixed at a higher level rather than at a lower level.*

A high tax audit rate, indeed, could be the best fiscal policy in "bad" scenarios. First of all, when tax evasion is a widespread phenomenon, penalty, reward and tax audits can contribute to build a "fiscal culture", since rewarding honesty (in a broad sense) and punishing corrupt and criminal behaviour should be a basic principle of any democratic and modern society. Furthermore, in an "abnormal" situation (where there are too many tax evaders), tax audits should be high, and "normality" (complying with the tax rules) should be rewarded.

5. Conclusions

The literature on the optimal fiscal policy in the presence of tax evasion is rich and important. However, as far as we are aware, there are no studies that address, at the same time, the interplay between fiscal policy, tax evasion and labour market outcomes (job creation and unemployment) in the presence of tax rewards.

Therefore, this theoretical paper introduces into the benchmark model of the labour market, i.e., the search and matching model, the core of tax evasion analysis and the possibility of a monetary reward for firms that comply with tax rules.

The presence of tax rewards amplifies the role of auditing. Precisely, tax audits increase the declared income by firms and, when tax rewards are high, tax auditing also increases firms' net profits.

Meanwhile, at the macroeconomic level, the effect of tax audits on job creation and unemployment is, a priori, ambiguous and depends on both penalty and reward.

In order to clarify that relation, the choice of optimal fiscal policy is fixed in a different and original way. Precisely, the tax authority (the 'fiscal policy maker') maximises labour market performance, i.e., the evolution of employment, under the balanced budget constraint. Unemployment, indeed, is closely related to shadow economy, which, in turn, is closely related to tax evasion.

Eventually, the model is able to derive a formula for the audit rate—consistent with the budget constraint—that makes the relation between tax audits and labour market outcomes positive. From an economic policy point of view, once a benchmark level of auditing is identified, the tax authority should fix the audit rate at a higher level rather than at a lower level.

Concisely, there could be a positive relation between tax audits, tax compliance and labour market outcomes. In countries (like Italy)—where unemployment is very high, shadow economy is widespread and often tolerated—tax audits and tax rewards can contribute to building a "fiscal culture", since rewarding honest taxpayers and punishing tax evaders should be a basic principle of any democratic and modern society. Unfortunately, however, tax rewards are poorly considered, and tax audits are either too low or ineffective. This theoretical paper, indeed, shows that high tax audits, in the presence of tax rewards, can reduce both tax evasion and unemployment. Of course, in the short run, this policy increases public expenditure, but in the long run, the increase in declared income will increase state revenues and the increase in the net profit of firms will increase job creation. Without forgetting that, when a "fiscal culture" is realised, a virtuous circle can arise.

Appendix A

The solution to the maximisation problem of a firm requires the usual first-order-condition:

$$\frac{d\pi}{dy^D} = \frac{d\left\{ y - \tau \cdot y^D - \rho \cdot \left[\frac{y \cdot \tau \cdot (y - y^D)}{y^D} \right] + \rho \cdot \left(b \cdot \frac{y^D}{y} \right) - \varphi \right\}}{dy^D} = 0$$

thus obtaining, after some algebraic steps, Equation (5):

$$- \tau - \rho \cdot \tau \cdot \left(-\frac{y}{y^D} \right)^2 + \frac{\rho \cdot b}{y} = 0$$

$$\rho \cdot \tau \cdot \left(\frac{y}{y^D} \right)^2 + \frac{\rho \cdot b}{y} = \tau$$

$$\left(\frac{y}{y^D}\right)^2 = \frac{\left(\tau - \rho \cdot \frac{b}{y}\right)}{\rho \cdot \tau}$$

$$\left(\frac{y}{y^D}\right)^2 = \frac{1}{\rho} - \frac{b}{y \cdot \tau}$$

$$\frac{y}{y^D} = \left(\frac{1}{\rho} - \frac{b}{y \cdot \tau}\right)^{\frac{1}{2}}$$

$$\left(y^D\right)^* = \frac{y}{\left(\frac{1}{\rho} - \frac{b}{y \cdot \tau}\right)^{\frac{1}{2}}}$$

Appendix B

The labour market equilibrium is characterised by the job creation Equation (3) and the unemployment Equation (7):

$$\theta^* = \left[\frac{\pi}{\psi \cdot (r + \delta)}\right]^{\frac{1}{\alpha}}$$

$$u^* = \frac{\delta}{\delta + \theta^{1-\alpha}}$$

with

$$\frac{\partial u^*}{\partial \theta^*} = (-1) \cdot \frac{\delta}{[\delta + \theta^{1-\alpha}]^2} \cdot (1 - \alpha) \cdot \theta^{-\alpha} < 0$$

since $0 < \alpha < 1$. It follows that:

$$\frac{\partial \theta^*}{\partial \tau} = \frac{1}{\alpha} \cdot \left(\frac{\pi}{\psi \cdot (r + \delta)}\right)^{\frac{1}{\alpha}-1} \cdot \left(-y^D - \gamma^{-1} \cdot s\right) < 0$$

thus,

$$\frac{\partial u^*}{\partial \tau} > 0$$

and,

$$\frac{\partial \theta^*}{\partial b} = \frac{1}{\alpha} \cdot \left(\frac{\pi}{\psi \cdot (r + \delta)}\right)^{\frac{1}{\alpha}-1} \cdot \rho \cdot \gamma > 0$$

thus,

$$\frac{\partial u^*}{\partial b} < 0$$

Meanwhile, the effect of tax audits on job creation and unemployment is, a priori, ambiguous:

$$\frac{\partial \theta^*}{\partial \rho} = \frac{1}{\alpha} \cdot \left(\frac{\pi}{\psi \cdot (r + \delta)}\right)^{\frac{1}{\alpha}-1} \cdot \left(-\gamma^{-1} \cdot \tau \cdot s + b \cdot \gamma\right)$$

Precisely, it depends on the sign of $\left(-\gamma^{-1} \cdot \tau \cdot s + b \cdot \gamma\right)$.

Appendix C

Let λ be the costate variable, i.e., the shadow value of a marginal decrease in the public spending at time t, so that the Hamiltonian (H) is:

$$H = \left\{\left[\theta^{1-\alpha} \cdot (1 - \epsilon) - \delta \cdot \epsilon\right] + \lambda \cdot \left[\left(\tau \cdot y^D\right) + \rho \cdot \left(\gamma^{-1} \cdot \tau \cdot s\right) - c(\rho) - \rho \cdot b \cdot \gamma\right]\right\} \cdot e^{-r \cdot t}$$

The solution to this dynamic optimisation problem requires that:[4]

$$\frac{\partial H}{\partial \tau} = 0 \overset{yields}{\rightarrow} \frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \tau} \cdot (1 - \epsilon) + \lambda \cdot \left[y^D + \rho \cdot \left(\gamma^{-1} \cdot s\right)\right] = 0$$

$$\overset{yields}{\rightarrow} \left(-\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \tau}\right) \cdot (1 - \epsilon) = \lambda \cdot \left[y^D + \rho \cdot \left(\gamma^{-1} \cdot s\right)\right] \tag{A1}$$

$$\frac{\partial H}{\partial b} = 0 \overset{yields}{\rightarrow} \frac{\partial \partial \left(\theta^{1-\alpha}\right)}{\partial b} \cdot (1 - \epsilon) - \lambda \cdot \rho \cdot \gamma = 0$$

$$\overset{yields}{\rightarrow} \frac{\partial \left(\theta^{1-\alpha}\right)}{\partial b} \cdot (1 - \epsilon) = \lambda \cdot \rho \cdot \gamma \tag{A2}$$

$$\frac{\partial H}{\partial \rho} = 0 \overset{yields}{\rightarrow} \frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho} \cdot (1 - \epsilon) + \lambda \cdot \left[\left(\gamma^{-1} \cdot \tau \cdot s\right) - \frac{dc(\rho)}{d\rho} - b \cdot \gamma\right] = 0$$

$$\overset{yields}{\rightarrow} \frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho} \cdot (1 - \epsilon) = \lambda \cdot \left[\frac{dc(\rho)}{d\rho} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right)\right] \tag{A3}$$

By using the optimality conditions (A3) and (A2), we obtain:

$$\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho} = \frac{\left[\frac{dc(\rho)}{d\rho} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right)\right]}{\rho \cdot \gamma} \cdot \frac{\partial \left(\theta^{1-\alpha}\right)}{\partial b}$$

Note that now the sign of $\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho}$ also depends on the marginal effect of the auditing cost, viz.:

$$\frac{dc(\rho)}{d\rho} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right)$$

This finding is robust, since it does not change when the optimality conditions (A3) and (A1) are used:[5]

$$\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho} = \frac{\left[\frac{dc(\rho)}{d\rho} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right)\right]}{\left[y^D + \rho \cdot (\gamma^{-1} \cdot s)\right]} \cdot \left(-\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \tau}\right)$$

with $\left(-\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \tau}\right) > 0$, since $\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \tau} < 0$.

By assuming that $c(\rho) = \rho^\omega$, with a positive elasticity $\omega > 0$, we obtain the value of tax audits that makes $\frac{dc(\rho)}{d\rho} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right) = 0$ and, thus, $\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho} = 0$, viz.:

$$\omega \cdot \rho^{\omega - 1} + b \cdot \gamma - \left(\gamma^{-1} \cdot \tau \cdot s\right) = 0$$

$$\overset{yields}{\rightarrow} \overline{\rho} = \left[\frac{\left(\gamma^{-1} \cdot \tau \cdot s\right) - b \cdot \gamma}{\omega}\right]^{\frac{1}{\omega - 1}}$$

with $\lim_{y^D \to 0} \overline{\rho} \to \infty$ and $\lim_{y^D \to y} \overline{\rho} \to 0$.

Recall that $\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \theta} > 0$; thus, the sign of $\frac{\partial \theta}{\partial \rho}$ is equal to the sign of $\frac{\partial \left(\theta^{1-\alpha}\right)}{\partial \rho}$.

Notes

[1]   As in Kolm and Larsen (2019), the concealment cost of tax evasion is just a parameter. Chen (2003) and Economides et al. (2020) assume that this cost depends on the level of income and the degree of tax evasion. However, that assumption would only complicate the mathematics, but it would not change the key result of the following Proposition 1.

[2]   For the sake of clarity, we neglect the time reference of the variables. Of course, with respect to Equation (6), the inflows into unemployment become the employment outflows and the unemployment outflows become the inflows into employment.

[3]   For example, in the standard search and matching model (Pissarides 2000), the tax authority maximises the social welfare function (which, for an infinitely lived economy, is equal to the total net profits minus vacancy costs and plus the benefit of being unemployed) under the constraint represented by the evolution of unemployment.

[4]   There is also the optimality condition with respect to the state variable, namely $-\frac{\partial H}{\partial g} = \frac{d[\lambda(t) \cdot e^{-r \cdot t}]}{dt} = \dot{\lambda} - \lambda \cdot r$.

[5]   We need to always use condition (C3) because the ambiguous relation concerns the sign of $\frac{\partial (\theta^{1-\alpha})}{\partial \rho}$.

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Article

Effect of the Shadow Economy on Tax Reform in Developing Countries

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Abstract: The present analysis has examined the effect of the shadow economy on tax reform in developing countries. The first type of tax reform is the "structural tax reform" (STR) characterized by large episodes of tax revenue mobilization, identified by Akitoby et al. (2020) [Tax revenue mobilization episodes in developing countries, *Policy Design and Practice* 3: 1–29] using the narrative approach that allows obtaining the precise nature and exact timing of major tax actions in several areas of tax policy and revenue administration that truly led to increases in tax revenue. The second type of tax reform is referred to as "tax transition reform" (TTR) and reflects the reform of the tax revenue structure that involves the reduction of its dependence on international trade tax revenue at the benefit of domestic tax revenue. The analysis has used various estimators and shown that the shadow economy reduces the likelihood of STR (notably in low-income countries), including in several tax policy areas and in the revenue administration area. The shadow economy also undermines the TTR process in countries whose tax revenue structure is strongly dependent on international trade tax revenue. Finally, it fosters the TTR process in countries that enjoy greater trade openness.

Keywords: tax reform; international trade tax revenue; trade openness

JEL Classification: F10; H20

1. Introduction

To achieve their development goals, policymakers in developing countries need to ensure a sustainable stream of financial resources, including public revenue. Policymakers in developing countries face many challenges for mobilizing public revenue and, in particular, tax revenue. At the heart of tax revenue mobilization in developing countries is the need to strengthen the tax system, including through tax reforms. Nevertheless, several challenges constrain the ability of policymakers in developing countries to effectively implement tax reforms (e.g., Aizenman and Jimjarak 2009; Carnahan 2015; Fjeldstad 2014). These challenges include, for example, the insufficient accountability in relationships between the state and citizens around taxation, the limited administrative infrastructure to design tax policy (including expanding the domestic tax base) and effectively administer the 'hard to collect' domestic taxes[1], and the existence of a large informal sector (e.g., Bastiaens and Rudra 2016; Bilal et al. 2012; Fjeldstad 2014; IMF 2011; Tanzi and Zee 2001). While few studies have examined the effect of the shadow economy on countries' tax revenue performance (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015), to the best of our knowledge, the issue concerning the effect of the shadow economy on tax reform, notably in developing countries, has not been explored in the literature.

The relationship between the latter (i.e., the informal sector, which we also refer to as the shadow economy) and tax reform in developing countries is at the heart of the present analysis.

According to Schneider and Buehn (2018), shadow activities can be considered in a broad sense as those economic activities and income earned that circumvent government regulation, taxation, or observation. In a narrower sense, the shadow economy focuses on

productive economic activities that would normally be included in the national accounts but which remain underground due to tax or regulatory burdens (see Schneider and Buehn 2018, p. 3). According to Medina and Schneider (2018), the average size of the shadow economy of 158 countries around the world over the period from 1991 to 2015 was 31.9 percent of the official GDP, with developing countries[2] recording high levels of the shadow economy, while developed countries[3] enjoyed relatively far lower levels of the shadow economy.

Few studies have explored the tax revenue effect of the shadow economy and documented the negative effect of the shadow economy on tax revenue in developed and developing countries (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015). However, the effect of the shadow economy on tax reform in developing countries has received less attention in the literature. The present paper empirically addresses this question by considering two major types of tax reform. The first type of tax reform concerns large episodes of tax revenue mobilization (i.e., episodes of sustained tax increases) in developing countries identified by Akitoby et al. (2020) using the narrative-based approach. This type of tax reform is referred to by Gupta and Jalles (2022a) as "structural tax reform". As Akitoby et al. (2020) have selected only episodes of sustained tax revenue increases, we consider this type of tax reform as "revenue-enhancing structural tax reform". This type of tax reform covers several tax policy and revenue administration areas and hence provides an opportunity for exploring how the shadow economy influences tax policy and revenue administration reforms.

The second type of tax reform concerns the reform of the structure of tax revenue so as to reduce its dependence on international trade tax revenue. In fact, international trade taxes represent an important tax handle in many developing countries. Trade tax revenue is 'easy to collect' because it requires low administration and capacity demands, is administered at the border locations, and is easy to monitor (e.g., Aizenman and Jimjarak 2009; Carstens 2005; Greenaway and Milner 1991; Kubota 2005). In the meantime, a large number of studies have pointed to the adverse effects of trade liberalization (or the resulting trade openness) on trade tax revenue (e.g., Arezki et al. 2021; Khattry and Rao 2002; Cagé and Gadenne 2018). Given the pressure for greater trade liberalization[4] by countries around the world (e.g., Bastiaens and Rudra 2016) and the resulting higher trade openness, and in light of the importance of international trade tax revenue in the total tax revenue in many developing countries[5], international financial institutions (including the IMF and the World Bank) have recommended that developing countries should reform their tax revenue structure in favor of domestic tax revenue[6] (at the expense of international trade tax revenue) if they are to maintain a sustainable stream of public revenue over time. This type of tax reform (also referred to in the literature as "tax transition reform"[7]) is akin in spirit to the so-called tariff–tax reform (or point-for-point reform) that entails a proportional tariff reduction combined with a point-by-point increase in consumption tax (e.g., Keen and Ligthart 2002; Kreickemeier and Raimondos-Møller 2008). The tariff–tax reform is expected to reduce the distortions induced by trade taxes while keeping consumer prices unchanged and affecting the production sector of the economy. Such a tax reform would promote the efficient allocation of resources in the production sector and enhance production-efficiency-driven welfare gain (e.g., Kreickemeier and Raimondos-Møller 2008). It can be public revenue and welfare enhancing (e.g., Fujiwara 2013; Keen and Ligthart 2002; Kreickemeier and Raimondos-Møller 2008; Naito 2006; Naito and Abe 2008).

In practice, a few studies, such as Cagé and Gadenne (2018), have shown that many developing countries have not been able to substitute domestic tax revenue with the trade tax revenue lost in the wake of trade liberalization. The majority of other studies have concluded that developing countries (excluding low-income countries) have been able to replace the lost trade tax revenue with other sources of domestic tax revenue (e.g., Arezki et al. 2021; Baunsgaard and Keen 2010; Crivelli 2016; Mansour and Keen 2009). For low-income countries, Baunsgaard and Keen (2010) (supported by Moller 2016) have found

that the replacement rate was low, but Waglé (2011) has observed a much more robust tax recovery than obtained by Baunsgaard and Keen (2010).

Following a number of recent studies, the present analysis considers the extent of 'tax transition reform' as the extent of convergence of a developing country's tax revenue structure towards the tax revenue structure of developed countries, given the very weak dependence of the latter's tax revenue structure on international trade tax revenue (e.g., Gnangnon 2019, 2020, 2021; Gnangnon and Brun 2019a, 2019b). It is worth noting that as defined here, the tax transition reform does not question whether the domestic taxation (which combines domestic direct taxes and indirect taxes) is optimally designed. Rather, it intends to capture the efforts made by countries to reduce their tax revenue structure's dependence on international trade tax revenue, using 'developed countries' as a benchmark. Gnangnon and Brun (2019a) have provided empirical evidence that a greater extent of tax transition reform leads to a higher tax revenue mobilization, notably in countries that further enhance their participation in international trade, i.e., those that improve their trade openness level.

The present analysis relies on this definition of tax transition reform to develop an indicator of the extent (magnitude) of tax transition reform that would be used to empirically investigate the effect of the shadow economy on tax transition reform.

The empirical analysis concerning the effect of the shadow economy on revenue-enhancing structural tax reform has relied on an unbalanced panel dataset of 40 developing countries (including 24 low-income countries (LICs) and 16 emerging markets (EMs)) over the period from 2000 to 2015. It has used several econometric estimators, including the fixed effects estimator for nonlinear panel data analysis developed by Fernández-Val and Weidner (2016) and the two-stage probit least squares estimator (see Amemiya 1978; Maddala 1983). The analysis concerning the effect of the shadow economy on tax transition reform has used an unbalanced panel dataset of 114 countries over the period from 1995 to 2015, along with the standard fixed effects estimator and the Method of Moments Quantile Regression (MMQR) with the fixed effects approach developed by Machado and Santos Silva (2019).

Several findings have emerged from the empirical analysis. First, the shadow economy reduces the likelihood of structural tax reform, particularly in low-income countries. Several areas of tax policy reform and revenue administration reform are negatively affected by the expansion of the shadow economy and include the personal income tax, the corporate income tax, the goods and services tax, the excise tax, the property tax, and the revenue administration areas. Second, an increase in the size of the shadow economy impedes the tax transition reform process in countries whose tax revenue structure is highly dependent on international trade tax revenue. Finally, the shadow economy fosters tax transition reform in countries that further open up to international trade.

The rest of the paper is structured as follows. Section 2 builds on the relevant literature to discuss, from a theoretical perspective, the effect of the shadow economy on tax reform, including both revenue-enhancing structural tax reform and tax transition reform. Section 3 lays down the empirical strategy, including the different model specifications and the econometric approaches used to estimate these models. Section 4 interprets empirical outcomes, and Section 5 deepens the analysis. Section 6 concludes.

2. Discussion on the Effect of the Shadow Economy on Tax Reform

This section builds on the relevant literature to discuss how the shadow economy could affect revenue-enhancing structural tax reform (Section 2.1) as well as tax transition reform, which helps countries reduce the dependence of their tax revenue structure on international trade tax revenue to the benefit of domestic tax revenue (Section 2.2).

2.1. Effect of the Shadow Economy on Revenue-Enhancing Structural Tax Reform

The discussion on the effect of the shadow economy on tax reform is tightly linked to the relatively limited literature on the effect of the shadow economy on tax revenue

mobilization. While there is a large volume of work on the determinants of taxation, few studies have considered the effect of the shadow economy on tax revenue (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015). Mazhar and Méon (2017) have reported empirically a negative effect of the shadow economy on tax revenue (i.e., up to a 0.67-point decline) in both developed and developing countries. Ishak and Farzanegan (2020) have found, among a set of developed and developing countries, that the positive tax revenue effect of the decline in oil rents decreases as the size of the shadow economy expands, especially when the latter exceeds 35% of the GDP. Moreover, the shadow economy undermines government tax efforts during economic downturns. Vlachaki (2015) has observed empirically that the shadow economy exerts a positive impact on indirect tax revenue as long as the size of the shadow economy does not exceed the cut-off value of 67% of the GDP, as otherwise, the impact becomes negative.

As taxation (notably the complexity and the burden of the tax system) and regulation are major causes of the expansion of underground activities (e.g., Johnson et al. 1998a, 1998b; Schneider 1994, 2005; Schneider and Enste 2000; Neck et al. 2012), an increase in the size of the shadow economy would likely erode the tax base and reduce tax revenue.

As noted above, underground activities are productive economic activities that are deliberately concealed from tax authorities, inter alia, to avoid the payment of value added or other taxes and social security contributions. This signifies that the expansion of the shadow economy would de facto contribute to shrinking the tax base and reducing tax revenue. Not only would the domestic tax base be eroded as a result of the expansion of underground activities, but the international trade tax base[8] would also be shrunk, given that tariffs and export taxes are collected on the transactions carried out at the borders by officially registered trading firms. The fall in tax revenue reduces the quality and quantity of public goods and services supplied by the state and by the administration (e.g., Schneider 2005). In these circumstances, governments may be tempted to raise domestic tax rates on individuals and firms that operate in the formal sector so as to compensate for the lost tax revenue arising from the expansion of the shadow economy. However, such an increase in tax rates would further motivate economic agents to participate in the shadow economy, further reducing tax revenue and ultimately leading to a greater deterioration of the quality of public goods (such as infrastructure) and of the administration (e.g., Schneider 2005). Similarly, any increase in tariffs on imported goods or on export taxes with a view to raising international trade tax revenue that would compensate for the lost tax revenue (due to the expansion of the shadow economy) would increase the costs of operating in the formal economy and lead individuals and firms to move their activities underground, for example, through smuggling (e.g., Mishkin 2009; Buehn and Farzanegan 2012; Saunoris and Sajny 2017). Thus, trade taxes are likely to further expand the size of the shadow economy and are not the appropriate means for collecting higher tax revenue when countries face an expansion of informality.

At the same time, the issue of taxation of the informal economy for public revenue purposes has been the subject of a longstanding debate in the relevant literature (see, for example, Joshi et al. 2014 for a literature survey). For example, Keen (2012, pp. 19–21, 30–32) has argued that in general, the potential revenue yields from taxing the shadow economy in developing countries are low, given the high administrative costs involved in this strategy, the regressive nature of the tax incidence[9], and the tax enforcement risks that expose vulnerable firms to harassment. In the same vein, Loayza (1996) has argued that the expansion of the shadow economy reduces the productivity of the tax system in both the short and long terms.

Another view held in the literature is that the taxation of the informal sector can help sustain 'tax morale' and tax compliance among larger firms (e.g., Terkper 2003; Torgler 2003). In connection to this is the idea that while taxing small firms is yet likely to yield low public revenue in the short term, it could also generate substantial revenue in the long term by bringing firms into the formal sector and ensuring higher tax compliance.

In addition, from the neoclassical perspective, an underground economy can contribute to the expansion of the formal sector because it responds to the economic environment's demand for urban services and small-scale manufacturing. In this regard, Asea (1996, p. 166) has argued that the voluntary self-selection between the formal and informal sectors can be a potential source for economic growth insofar as the informal sector may be instrumental in creating markets, increasing financial resources, generating dynamic entrepreneurial spirit, and transforming the legal, social, and economic institutions necessary for accumulation.

Schneider (2005) has combined these different lines of theoretical arguments and argued that while the expansion of the shadow economy erodes the tax base and undermines economic growth in low-income countries, an increase in the shadow economy in high-income countries may enhance the development of the official economy (and hence enhance tax revenue yields) if additional value is created in the shadow economy and the resulting additional income is spent in the official economy.

Against this backdrop, we argue that in developing economies, the expansion of the shadow economy is likely to erode the tax base, result in a lower tax revenue, and reduce the likelihood of sustained tax increases, notably if the income earned from underground activities is not spent in the formal sector (which is likely to be the case for low-income countries). In these circumstances, an increase in the size of the shadow economy would undermine the structural tax reform process, given that the prospects of collecting higher tax revenue (both domestic and trade tax revenue) are bleak. Therefore, we postulate that an increase in the size of the shadow economy is likely to reduce the likelihood of revenue-enhancing structural tax reform, notably in low-income countries (Hypothesis 1).

2.2. Effect of the Shadow Economy on Tax Transition Reform

As noted in the introduction, the present analysis follows a number of recent studies (e.g., Gnangnon 2019, 2020, 2021; Gnangnon and Brun 2019a, 2019b) and defines tax transition reform as the convergence[10] of developing countries' tax revenue structure towards the tax revenue structure of developed countries, given the very weak dependence of the latter's tax revenue structure on international trade tax revenue. As noted above, our definition of the tax transition reform does not question whether the domestic taxation (which combines domestic direct taxes and indirect taxes) is optimally designed. Rather, it aims to measure the efforts by countries to reduce the dependence of their tax revenue structure on international trade tax revenue.

Given the necessity for undertaking or fostering tax transition reform in developing countries, one could question whether the expansion of the shadow economy would alter policymakers' efforts to implement the tax transition reform effectively and efficiently. This question is particularly relevant for countries whose tax revenue structure is highly dependent on international trade tax revenue[11] (e.g., low-income countries). Indeed, by eroding the domestic tax base, the expansion of the shadow economy could limit the scope of the tax transition reform, as policymakers in these countries—notably in countries whose tax revenue structure is highly dependent on trade tax revenue—would be less inclined to reform their tax revenue structure so as to reduce its dependence on international trade tax revenue. More importantly, they may even be tempted to continue to rely on trade tax revenue as an important source of non-resource tax revenue by eventually raising trade taxes (although in a way consistent with their commitments at the WTO, for countries that are WTO members). However, raising trade taxes would reduce countries' participation in international trade, deprive their citizens of the multiple benefits of international trade (e.g., Atkin and Donaldson 2022; Singh 2010), further encourage economic agents' participation in the shadow economy, and ultimately lead to an increase in the size of the shadow economy (e.g., Berdiev and Saunoris 2018; Berdiev et al. 2018; Buehn and Farzanegan 2012; Mishkin 2009; Saunoris and Sajny 2017). Against this backdrop, we can postulate that the shadow economy could reduce the extent of tax transition reform, notably in countries whose tax revenue structure is highly dependent on international trade tax revenue (Hypothesis 2).

The subsequent question that stems from this discussion is whether trade openness matters for the effect of the shadow economy on the extent of tax transition reform. The rationale for this question is twofold. First, as noted above, trade openness is not only at the heart of the implementation of tax transition reform, but it also plays a key role in the development of the shadow economy. Second, Gnangnon and Brun (2019a) have shown that tax transition reform not only leads to a greater tax revenue mobilization, but the magnitude of its positive tax revenue effect rises as these countries further open up their economies to international trade.

The answer to the question of whether trade openness matters for the effect of the shadow economy on tax transition reform depends on how trade openness itself affects the shadow economy, given that greater trade openness de facto triggers the need for implementing tax transition reform. For example, if higher trade openness leads to a shrinking of the shadow economy, then trade openness will contribute to expanding the domestic tax base (as informality falls) and consequently facilitate the implementation of tax transition reform. In contrast, if greater trade openness further expands the informal sector, then the scope for raising domestic revenue diminishes, and this would undermine the implementation of tax transition reform.

The literature on the effect of trade openness on the shadow economy has revealed mixed evidence, although recent studies tend to point to an effect where a reduction in the shadow economy causes an increase in a countries' level of openness to international trade. A firm that aims to engage in international trade activities should register and operate in the formal sector. High trade barriers substantially increase the costs of operating in the official sector, i.e., the formal economy, and lead individuals and firms to develop their activities in the shadow sector, for example, through smuggling (e.g., Buehn and Farzanegan 2012; Mishkin 2009; Saunoris and Sajny 2017). As a consequence, the removal of trade barriers would increase the opportunity costs of developing activities in the shadow sector, i.e., raising the benefits of operating in the official sector (e.g., Berdiev and Saunoris 2018; Berdiev et al. 2018; Schneider and Enste 2000), and incentivize participants in the shadow economy to move to the formal sector. Reducing trade barriers can also lower informality by allowing firms to have access to high-quality or lower-cost intermediate inputs, to enter in the export markets or increase exports, as well as enjoy higher export prices (e.g., Amiti and Konings 2007; Bas and Strauss-Kahn 2015; Bas and Paunov 2021; Fan et al. 2015). Furthermore, trade openness can also encourage innovation (e.g., Akcigit and Melitz 2022; Grossman and Helpman 1991), including in countries that have enhanced their protection of intellectual property rights (e.g., Allred and Park 2007; Chen and Puttitanun 2005; Gmeiner and Gmeiner 2021; Lerner 2009). The benefits of the protection of innovative products could motivate innovative firms and individuals to formalize their activities. In contrast, trade openness may result in an expansion of the shadow economy if the attraction of multinational corporations—as a result of the openness of the economy to international trade—leads such firms to hide some economic activities for tax evasion purpose, for example, through transfer prices (e.g., Canh et al. 2021). Recent empirical evidence points to a negative effect of trade openness on the shadow economy. For example, Pham (2017) has observed that trade globalization (i.e., trade integration) reduces the size of the shadow economy. Berdiev et al. (2018) have revealed that greater freedom to trade internationally leads to a shrinking of the shadow economy. Similar findings have been reported by Berdiev and Saunoris (2018), who have obtained a negative effect of economic (including trade) globalization on the shadow economy. Canh et al. (2021) have observed that trade openness has exerted a negative effect on the shadow economy in both the short and long terms, with this negative impact being larger in high-income economies.

On the other hand, by increasing foreign competition, trade openness can result in the expansion of the informal sector in developing countries. Goldberg and Pavcnik (2003) have noted that greater trade openness can lead to the expansion of the informal sector, as it could threaten the jobs of workers in the formal sector and encourage the reallocation of the production from the formal to the informal sector. They have observed empirically that

labor market regulations play a major role in the effect of trade reforms on the informal sector. This is because trade reforms (a tariff reduction) increase informality in the presence of labor market rigidities (which was the case in Brazil), but reduce it when the labor market is flexible (which was the case in Columbia). Bosch et al. (2012) have also uncovered that trade liberalization has led to an increase in informality by approximately 1% to 2.5% in Brazilian metropolitan labor markets. Sinha (2009) has reviewed the literature[12] on the effect of trade openness on the informal sector and concluded that the informal economy could benefit from trade in the context of capital mobility, formalization of credit, and upgrading of skills, as all these factors allow firms to cut production costs and overheads. Recently, Dix-Carneiro et al. (2021) have developed a theoretical framework to evaluate various effects of international trade in countries (e.g., developing countries) characterized by a large informal sector. They have observed, among other things, that greater trade openness reduces informality in the tradable sector but may increase informality in the non-tradable sector (depending on the starting point and extent of trade liberalization). These factors, therefore, leave the net effect of trade openness on the informal sector ambiguous, and eventually small.

Overall, this discussion does not provide clear guidance on the direction of the effect of trade openness on the shadow economy, and this suggests that this issue is essentially empirical, even though recent empirical analyses on the matter tend to report a negative shadow economy effect of trade openness. On the basis of these recent findings, we can argue that the shadow economy would foster tax transition reform in countries that further open up their economies to international trade (Hypothesis 3).

Nonetheless, we bear in mind that as the effect of trade openness on the shadow economy is an empirical issue, it is possible that if trade openness leads to an expansion of the informal sector, then the shadow economy will reduce the extent of tax transition reform as countries further participate in international trade.

The empirical analysis will test Hypotheses 1–3 set out in this section.

3. Empirical Strategy

This section presents the model specifications used to address empirically the issues at the heart of the present analysis and discusses the economic approaches used to estimate these models. Section 3.1. deals with the empirical strategy concerning the effect of the shadow economy on revenue-enhancing structural tax reform, and the analysis in Section 3.2. concerns the effect of the shadow economy on tax transition reform.

3.1. Empirical Strategy concerning the Effect of the Shadow Economy on Structural Tax Reform
3.1.1. Model Specification

The present analysis on the effect of the shadow economy on revenue-enhancing structural tax reform builds on the recent work by Gupta and Jalles (2022a) and also draws from the literature[13] on the structural determinants of tax revenue mobilization that essentially capture a country's tax base (e.g., Baunsgaard and Keen 2010; Bornhorst et al. 2009; Brun et al. 2015; Chachu 2020; Crivelli and Gupta 2014; Prichard 2016; Reinsberg et al. 2020).

Building on the work by Duval et al. (2020), who have explored the main factors underpinning reforms, and the fiscal policy literature (e.g., Bergh and Henrekson 2011), Gupta and Jalles (2022a) have underlined the importance of the real GDP growth rate, the inflation rate, the unemployment rate, and trade openness as key potential drivers of revenue-enhancing structural tax reform (measured by large episodes of tax revenue mobilization in developing countries). Gupta and Jalles (2022a) have observed that large tax revenue mobilizations take place in the context of a higher real economic growth[14] (e.g., Besley and Persson 2014) and greater trade openness (e.g., Belloc and Nicita 2011). The unemployment rate could result in a de-mobilization of total tax revenue, but its effect depends on the type of the tax reform. For example, while a higher unemployment rate increases the likelihood of the reform of the personal income tax and the corporate income tax, as well as the revenue administration, it exerts no significant effect on other types

of tax reform, including goods and services tax reform, value added tax reform, excise tax reform, trade tax reform, and property tax reform. On the other hand, high inflation rates reduce the value of tax collection, notably if the tax system is not protected from inflation (e.g., Tanzi 1977). Hence, the outcomes of tax reforms are likely to be uncertain in an inflationary environment (characterized by high inflation rates) because of the resulting strong economic volatility and the availability of the possibility of seigniorage by the government (e.g., Gupta and Jalles 2022a).

Other potential structural factors could also matter for revenue-enhancing structural tax reform. These include the real per capita income, institutional and governance quality, the dependence on natural resources, and the population size. Higher economic development (proxied by an increase in the real per capita income) reflects an expansion of the taxable income and, eventually, a lower resistance by citizens to pay their taxes (e.g., Scheve and Stasavage 2010). An improvement in the institutional and governance quality (e.g., lower corruption levels, greater political stability, an improvement in the level of democracy) is likely to lead to greater tax revenue mobilization (e.g., Bird et al. 2008) and to promote tax reform (e.g., Gupta and Jalles 2022a; Hassan and Prichard 2016; Kirchler et al. 2008; Lledo et al. 2004; Mahon 2004). A dependence on natural resources tends to be associated with a decline in the mobilization of non-resource tax revenue (e.g., Bornhorst et al. 2009; Chachu 2020; Crivelli and Gupta 2014; James 2015). A rent dependency over the long term can also undermine the tax administration effort of collecting tax revenue. According to Besley and Persson (2011, p. 21), an increase in the dependency on resource rents that accrue directly to the government budget may reflect smaller market incomes and hence a smaller tax base. Overall, countries endowed with natural resources would be less inclined to undertake significant tax reforms that would yield large non-resource tax revenue. Finally, countries with large populations may face difficulties in capturing new taxpayers compared to less populous countries, as in populous countries, tax systems may lag behind in their ability to capture new taxpayers (e.g., Bahl 2003, p. 13). In this case, we can expect that an increase in the population size may reduce the likelihood of enhancing revenue-generating structural tax reform, given the uncertainty associated with the outcome of this reform. In contrast, if the tax administration has improved its capacity to capture new taxpayers, then an increase in the population size may provide policymakers with the opportunity to strengthen the tax transition reform process, notably if this increase in the population size goes hand in hand with an increase in domestic consumption.

The baseline model is as follows:

$$STR_{it} = \alpha_0 + \alpha_1 SHADOW_{it} + \alpha_2 Log(GDPC)_{it} + \alpha_3 OPEN_{it} + \alpha_4 RENT_{it} + \alpha_5 UR_{it} + \alpha_6 GROWTH_{it} + \alpha_7 INST_{it} + \alpha_8 INFL_{it} + \alpha_9 Log(POP)_{it} + \mu_i + \epsilon_{it} \tag{1}$$

where i and t stand for a country and a year, respectively, in the unbalanced panel dataset of 40 developing countries (including 24 low-income countries (LICs) and 16 emerging markets (EMs)) over the period from 2000 to 2015. This panel dataset is built using available data[15]. The parameters α_0 to α_9 will be estimated. μ_i stands for countries' time-invariant unobserved specific characteristics. ϵ_{it} represents the error term.

"STR" is the indicator of overall (revenue-enhancing) structural tax reform. It identifies the episodes of large tax revenue mobilization and is, therefore, a discrete variable. $STR_{it} = 1$ if $STR_{it}^* > 0$ and 0 otherwise. STR_{it}^* is a latent variable not directly observed.

These episodes have been identified by Akitoby et al. (2020), who have focused on countries with more tangible results of tax revenue mobilization over the period from 2000 to 2015. Akitoby et al. (2020) have used the narrative approach, which allows the identification (over the period from 2000 to 2015) of the precise nature and exact timing of major tax actions in several areas of tax policy and revenue administration that truly led to increases in revenue, as opposed to just a long list of (small or not economically meaningful) policy changes (e.g., Gupta and Jalles 2022a, 2022b). They have used the following criteria for the identification of these episodes: (i) countries that have increased their tax-to-GDP

ratios by a minimum of 0.5 percent each year for at least three consecutive years (or 1.5 percent within three years); (ii) countries with above-average increases in their tax-to-GDP ratios; and/or (iii) countries with better tax performance compared with peers in the same income group, using the approach employed in von Haldenwang and Ivanyna (2012) (see Akitoby et al. 2020 for more details on the methodology).

The variable "STR" is, therefore, a dummy variable that takes the value of 1 for a year characterized by a large tax revenue mobilization in a tax policy and revenue administration area and the value of 0 for other years. Thus, "STR" does not make a distinction between areas of tax reforms, including tax policy reforms and the reform of the revenue administration. While the reforms are country-specific and not weighted, Akitoby et al. (2020) have not provided narrative information on the types of reforms included in each episode (see also Gupta and Jalles 2022a). In addition to the indicator of the overall tax reform, Akitoby et al. (2020) have identified episodes of major reforms in nine areas, including Personal Income Tax ("PIT"); Corporate Income Tax ("CIT"); Goods and Services Tax ("GST"); Value Added Tax ("VAT"); Excise Tax ("EXCISE"); Trade Tax ("TRTAX"); Property Tax ("PROPERTY"); Subsidies ("SUBSIDIES"); and Revenue Administration ("REVADM").

The control regressors "OPEN", "RENT", "UR", and "GROWTH" are, respectively, the trade openness (in percentage of GDP), the share of total natural resource rents in GDP (in percentage), the unemployment rate, and the annual economic growth rate (constant 2015 USD) (in percentage). The regressor "INST" is the measure of the institutional and governance quality. Finally, the regressors "GDPC" and "POP" stand for, respectively, the real per capita income (constant 2015 USD) and the population size, and they have been logged (using the natural logarithm) in order to reduce their skewed distributions. The variable "INFL" is the transformed indicator of the inflation rate in order to reduce its skewed distribution (see Appendix A.1).

All variables are described in Appendix A.1, and their related standard descriptive statistics are reported in Appendix A.2. Appendices A.2.1 and A.2.2 show the pairwise correlation among the variables. All correlation coefficients are lower than 0.8, as recommended by Studenmund (2011) (see Appendices A.2.1 and A.2.2). We deduce that our regressions would not suffer from a severe multicollinearity problem. Appendix A.3 shows the list of the 40 developing countries, including the 24 LICs and 16 EMs used in the panel dataset.

3.1.2. Econometric Approach

The econometric literature has established that the use of the fixed effects[16] approach to estimate the parameters of nonlinear models such as binary response models results in inconsistent estimates under asymptotic sequences where the time dimension (T) of the panel dataset is fixed and the cross-section dimension (N) of the panel dataset tends to infinity, as well as if N is fixed and T tends to infinity. The problem associated with the use of the fixed effect estimator in these circumstances is referred to as the incidental parameter problem (e.g., Lancaster 2002; Neyman and Scott 1948). To address this problem, Fernández-Val and Weidner (2016) have derived analytical and jackknife bias corrections[17] for fixed effects estimators of logit and probit models with individual and time effects in panels where the two dimensions (N and T) are moderately large[18]. We henceforth refer to the Fernández-Val and Weidner (2016)' estimator as the "FVW approach". Table A1 reports the outcomes obtained from the use of the logit and probit FVW approaches over the full sample and the sub-samples of LICs and EMs.

Nonetheless, the FVW approach does not help address the endogeneity problem that can arise from the bi-directional causality between the binary indicator of structural tax reform and the indicator of the shadow economy. In addition, the introduction of the variable of interest in the analysis (namely, the shadow economy indicator) with a one-year lag in model (1) might not help fully handle this endogeneity concern. In fact, the influence of taxation on the shadow economy has been documented in the literature[19]. For example,

burdensome taxes and a complex tax system lead to the expansion of the size of the shadow economy by driving agents underground (e.g., Johnson et al. 1998a, 1998b; Schneider 1994, 2005; Schneider and Enste 2000; Neck et al. 2012; Thiessen 2003). This underlines the endogeneity nature of the "shadow economy".

To overcome this problem, we use the two-stage probit least squares (2SPLS) model, which allows the implementation of structural tax reform to be simultaneously determined with the size of the shadow economy (see Maddala 1983; Rivers and Vuong 1988). This involves estimating a system of equations, with the first equation being model (1), which seeks to explain the effect of the size of the shadow economy on structural tax reform, and the second equation being the one that aims to explain the effect of structural tax reform on the size of the shadow economy. The 2SPLS estimator is similar to the generalized least squares estimator developed by Amemiya (1978)—referred to as the Amemiya generalized least squares (AGLS) estimator or generalized two-stage probit estimator—used to estimate simultaneous equations that involve a linear probability model (i.e., an equation whose dependent variable is a continuous variable) and a probit model (i.e., an equation whose dependent variable is a binary variable). According to Newey (1987), the AGLS estimator is asymptotically equivalent to the minimum χ^2 estimation procedure. It is more efficient than the two-stage least squares instrumental variable estimators in overidentified systems (see also Londregan and Poole 1990).

In fact, the 2SPLS model is similar to the two-stage least squares model, with the exception that one of the endogenous variables is dichotomous (here, the indicator of structural tax reform). Rather than using the ordinary least squares (OLS) estimator for the equation of structural tax reform, we employ the probit estimator to estimate it. The estimation of the 2SPLS model involves two main steps. In the first step, we estimate two reduced form equations using all exogenous regressors; the equation of the structural tax reform is estimated using the probit estimator, and the predicted values of the regression are extracted. The equation of the shadow economy is estimated using the OLS estimator, and the predicted values of the dependent variable (i.e., the shadow economy) are extracted. In the second step, each of these two predicted (fitted) values of the endogenous variables are used as regressors (in replacement of the original endogenous variables) in each reduced form equation (see Keshk 2003). Put differently, the predicted values of the indicator of the variable measuring structural tax reform are introduced in the equation of the shadow economy along with other exogenous regressors. The resulting model is estimated using the OLS approach. The fitted values of the shadow economy (extracted from the first step) are introduced in the equation of the structural tax reform, and the resulting equation is estimated using the probit estimator. In this second stage, standard errors are corrected to eliminate the bias arising from the use of the predicted values rather than the original values of the endogenous variables in the relevant equations[20].

What then are the regressors included in the model of the shadow economy?

The model specification[21] of the shadow economy includes the real per capita income, a trend variable, along with six other regressors introduced with a one-year lag in the model so as to mitigate reverse causation concerns. These six variables are the economic growth rate ("GROWTH"), the unemployment rate ("UR"), the transformed indicator of the inflation rate (to reduce the skewed distribution of the indicator of inflation rate) ("INFL"), the education level ("EDU"), the level of trade openness ("OPEN"), and the institutional and governance quality ("INST"). All these variables are described in Appendix A.1. Note that the variables "GROWTH", "UR", "EDU", and "OPEN" are expressed in percentage. The fall in the real GDP per capita (which is a proxy for economic development) can encourage individuals and firms to move underground (e.g., Berdiev and Saunoris 2018; Berdiev et al. 2018; Thiessen 2003). An improvement in economic growth rate enhances opportunities in the official sector and hence discourages individuals and businesses from moving underground (e.g., Berdiev et al. 2018). Likewise, an improvement in the education level raises the opportunity costs of operating in the shadow economy—it reduces significantly the gains of operating underground—and hence the participation in underground activities

(e.g., Berdiev et al. 2015, 2018; Buehn and Farzanegan 2013; Gërxhani and van de Werfhorst 2013). Buehn and Farzanegan (2013) have nevertheless found that higher levels of education are associated with the expansion of the shadow economy in countries characterized by weak political institutions. On another note, an inflationary environment encourages the expansion of the shadow economy because higher inflation rates induce a greater demand for currency (e.g., Alm and Embaye 2013). An improvement in the institutional and governance quality reduces the development of activities underground (e.g., Berdiev et al. 2018; Torgler and Schneider 2009; Dreher et al. 2009; Schneider 2010; Teobaldelli and Friedrich 2013). Studies have also pointed to unemployment rate as a key factor underpinning the expansion of the shadow economy (e.g., Bajada and Schneider 2009; Canh et al. 2021; Dell'Anno and Solomon 2008; Kanniainen et al. 2004). The effect of trade openness on the shadow economy has already been discussed in Section 2.

The simultaneous equations estimated by the 2SPLS approach use as an indicator of structural tax reform not only the overall structural tax reform ("STR"), but also each of the above-mentioned nine areas of tax policy and revenue administration reform. Table A2 reports the outcomes arising from the estimation of the simultaneous equations over the full sample and the sub-samples of LICs and EMs, where the structural tax reform indicator is the overall structural tax reform. Table A3 presents the outcomes obtained from the estimation of the simultaneous equations over the full sample, using as a measure of structural tax reform the binary indicators of major reforms in each of the nine tax policy and revenue administration areas.

3.2. Empirical Strategy concerning the Effect of the Shadow Economy on Tax Transition Reform
3.2.1. Model Specification

The baseline model specification concerning the effect of the shadow economy on tax transition reform includes not only all regressors used in model (1), but also the indicator that captures countries' tax revenue dependence on international trade tax revenue, given that the effect of the shadow economy on tax transition reform is likely to depend on the extent of countries' tax revenue structure dependence on international trade tax revenue (see Hypothesis 2).

Countries that enjoy a higher real per capita income are likely to undertake a greater extent of tax reform than relatively less developed countries. This is because such countries are characterized by an expansion of the taxable income, and tax administrations may have a greater technical capacity (in terms of tax administration capacity) to collect domestic tax revenue than in relatively less developed countries. By reducing international trade tax revenue (e.g., Arezki et al. 2021; Cagé and Gadenne 2018; Khattry and Rao 2002), trade liberalization (or trade openness) leads countries to rely on domestic public revenue, including domestic tax revenue, as the alternative sources of public revenue (e.g., Adandohoin 2021; Arezki et al. 2021; Baunsgaard and Keen 2010; Buettner and Madzharova 2018; Crivelli 2016; Hatzipanayotou et al. 2011; Keen and Ligthart 2002; Reinsberg et al. 2020). As a result, the extent of tax transition reform is likely to be greater in countries that further open up their economies to international trade[22] (e.g., Baunsgaard and Keen 2010; Gnangnon 2020; Gnangnon and Brun 2019a) than in other countries. Likewise, an improvement in the economic growth reflects an increase in the breadth of the tax base (e.g., Besley and Persson 2014) and hence the ability to rely on domestic tax revenue for collecting non-resource tax revenue. In other words, we expect a higher economic growth rate to influence positively the extent of tax transition reform. Incidentally, an increase in the inflation rate and a rise in the unemployment rate can erode the tax base and limit countries' ability to engage in or foster the tax transition reform process. For example, Lora (2012) has argued that revenue-enhancing tax reforms are likely to take place in an inflationary environment[23] and in the context of declining international trade tax revenue. Higher inflation rates may also lead interest groups and citizens to oppose the implementation of tax reforms. Nonetheless, Mahon (2004) has reported a positive effect of the inflation rate on the likelihood of tax

transition reform. Gnangnon (2020) has reported evidence of a negative effect of inflation on tax transition reform.

As also noted above, a high dependence on natural resources is likely to result in a lower mobilization of non-resource domestic tax revenue. As a consequence, resource-dependent countries would be less inclined to engage in or strengthen the tax transition process. In light of the argument developed above concerning the effect of the population size on revenue-enhancing structural tax reform, we also argue here that a higher population size may discourage or delay the implementation of tax transition reform. Finally, in light of the above discussion concerning the positive tax reform effect of the improvement in the quality of institutions and governance, we also expect here that a better institutional and governance quality would enhance the tax transition process.

The baseline model specification considered here, therefore, takes the following form:

$$
\begin{aligned}
TAXREF_{it} = \beta_0 &+ \beta_1 SHADOW_{it} + \beta_2 SHTRTAX_{it} + \beta_3 \text{Log}(GDPC)_{it} + \beta_4 OPEN_{it} + \beta_5 RENT_{it} + \beta_6 UR_{it} \\
&+ \beta_7 GROWTH_{it} + \beta_8 INST_{it} + \beta_9 INFL_{it} + \beta_{10} \text{Log}(POP)_{it} + \mu_i + \delta_t + \omega_{it}
\end{aligned}
\tag{2}
$$

where i and t are as defined above. The panel dataset is unbalanced and covers 114 countries over the period of 1995 to 2015[24]. To ensure that the estimates would not be contaminated by short-run fluctuations in the values of the regressors over the business cycle, we use 3-year non-overlapping sub-periods[25] in the panel dataset. These sub-periods are 1995–1997, 1998–2000, 2001–2003, 2004–2006, 2007–2009, 2010–2012, and 2013–2015.

β_0 to β_{10} are parameters to be estimated. μ_i stands for countries' time-invariant unobserved specific characteristics. δ_t represents time dummies that represent global trends affecting tax transition reform. ω_{it} represents the error term.

The variable "TAXREF" measures the extent of tax transition reform. As noted above, it measures the extent to which a developing country's tax revenue structure converges toward the developed countries' tax revenue structure (e.g., Gnangnon 2019, 2020, 2021; Gnangnon and Brun 2019a, 2019b). It is important to stress here that this indicator of tax transition reform does not provide an indication of whether the domestic tax rate's structure in developing countries is optimally designed but aims primarily to capture developing countries' effort to increase the dependence of their tax revenue structure on domestic tax revenue (regardless of whether the latter relies on direct or indirect tax revenue), i.e., at the expense of international trade tax revenue.

Following the above-mentioned studies, the tax transition reform indicator is computed by drawing from the semi-metric Bray–Curtis dissimilarity index (e.g., Bray and Curtis 1957; Finger and Kreinin 1979). For a given country in a given year, $TAXREF = (1 - d_{it})$, where d_{it} is the Bray–Curtis dissimilarity index computed[26] for a given country in a year.

$$
d_{it} = \frac{|DIRTAX_{it} - DIRTAXAve_t| + |INDIRTAX_{it} - INDIRTAXAve_t| + |TRTAX_{it} - TRTAXAve_t|}{[(DIRTAX_{it} + DIRTAXAve_t) + (INDIRTAX_{it} + INDIRTAXAve_t) + (TRTAX_{it} + TRTAXAve_t)]}
\tag{3}
$$

For a developing country i in a year t, the indicators DIRTAX, INDIRTAX, and TRTAX are, respectively, the ratio of non-resource direct tax revenue in GDP; the ratio of non-resource indirect tax revenue in GDP; and the ratio of international trade tax revenue to GDP. The variables DIRTAXAve, INDIRTAXAve, and TRTAXAve are the arithmetic averages (over developed countries[27] in a given year) of, respectively, the non-resource direct tax revenue to GDP ratio, the non-resource indirect tax revenue to GDP ratio, and the international trade tax revenue to GDP ratio. Higher values of the indicator "TAXREF" for a developing country reflect a convergence of the country's tax revenue structure towards that of developed countries, i.e., the country experiences a greater extent of tax transition reform. In contrast, lower values of this indicator show that the country experiences a divergence of its tax revenue structure from that of developed countries, which reflects

a greater dependence of this developing country's tax revenue structure on international trade tax revenue.

The regressor "SHADOW" is our main regressor of interest in the analysis. It represents the size of the shadow (or underground) economy measured by the share of the shadow economy in the official GDP. For the sake of analysis, this variable is not expressed in a percentage. The underlying data are drawn from Medina and Schneider (2018), who have employed the multiple indicators, multiple causes (MIMIC) method introduced by Schneider et al. (2010) to compute this indicator. This method uses multiple causes of the shadow economy and multiple indicators that reflect changes in the size of the shadow economy to derive the indicator measuring the size of the shadow economy[28] (see Schneider and Buehn 2018). The approach first links the (unobserved) shadow economy (which is the latent variable) to some observed indicators (that are anticipated to be causal in nature) in a factor analytical model. In a second step, it estimates a structural model to specify the relationship between the shadow economy and a set of causal variables (see Schneider et al. 2010 for further details on this approach). This indicator of the shadow economy has been extensively used in the literature[29], including in recent studies on the effect of the shadow economy on taxation (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015).

The control regressors "OPEN", "RENT", "UR", and "GROWTH" are as defined above, with the particularity here that they are not expressed in a percentage for the sake of analysis (i.e., to obtain estimates that would be easily interpretable). The regressor "INST" is the measure of the institutional and governance quality. The regressor "SHTRTAX" is the share of international trade tax revenue in total non-resource tax revenue. It is also not expressed in a percentage for the sake of analysis. All the other regressors, including "INST", "GDPC", "INFL", and "POP" are as defined above. The description and source of all these variables are provided in Appendix A.1. Appendix A.4 reports the standard descriptive statistics on these variables, and Appendix A.4.1 shows the pairwise correlation between these variables. As can be noted from Appendix A.4.1, all correlation coefficients are lower than 0.8, as suggested by Studenmund (2011). This suggests that our regressions would not suffer from a severe problem of multicollinearity. Appendix A.5 displays the list of the 114 countries, including the 44 LICs contained in the panel dataset.

We use data over the full sample (panel dataset of 114 countries over non-overlapping sub-periods) to get a glimpse of the correlation between the shadow economy and tax transition reform indicators. Specifically, we present in Figure A1 the development of these two indicators, and in Figure A2, the correlation pattern between the two indicators. It appears from Figure A1 that the indicator of the tax transition reform exhibits an upward trend, which suggests that on average, countries tend to foster their tax transition reform over time. On the other hand, the size of the shadow economy tends to decline over time, which indicates a tendency for countries to experience a shrinking of the underground economy over time. Figure A2 shows a negative correlation pattern between the shadow economy and the tax transition reform.

3.2.2. Econometric Approach

The use of the pooled ordinary least squares estimator or the fixed effects approach to estimate model (2) would help uncover the effect of regressors, including the variable of interest—which is here the shadow economy—at the mean of the conditional distribution of the dependent variable (i.e., here, the tax transition reform indicator). However, this estimation procedure provides an incomplete picture of the conditional distribution of the dependent variable, as explanatory variables may not affect only the mean of the conditional distribution, but also the median of the distribution or other quantiles.

To capture the distributional heterogeneity of the effect of the shadow economy on the tax transition reform, we use the panel quantile regression approach, which in addition to being robust to the presence of heteroscedasticity and outliers (Koenker 2004), allows the exploration of the distributional heterogeneity along the dependent variable,

i.e., the tax transition reform indicator. In particular, we use the Method of Moments Quantile Regression (MMQR) with fixed effects approach (also referred to as "Quantile via Moments") developed by Machado and Santos Silva (2019). This is a non-parametric approach that permits us to examine the effect of the shadow economy at different quantiles of the tax transition reform distribution function, while concurrently accounting for the presence of fixed effects.

The MMQR has several advantages over the conventional panel quantile regression approaches developed by Koenker (2004), Lamarche (2010), and Canay (2011). First, the MMQR uses the method moments to account for countries' time-invariant unobserved specific effects (in contrast with several quantile regression approaches) and address the incidental parameters problem caused by a large number of fixed effects, as it allows the individual effects to affect the entire distribution[30]. Second, the MMQR relies on the assumption that the explanatory variables only affect the distribution of the dependent variable through known location and scale functions, rather than being simply location shifters, as in conventional quantile regression approaches (i.e., where the effect of the mean value is consistent with that of the whole distribution state) (Heckman et al. 1997). Third, the MMQR applies to models that have endogenous explanatory variables, which is not the case for other existing conventional quantile regression methods.

Following Machado and Santos Silva (2019), we consider the following estimation of the condition quantiles of TTR_{it} as $Q_{TTR}(\tau/X)$ for a location-scale model:

$$TTR_{it} = \mu_i + X_{it}\beta + (\delta_i + Z_{it}\gamma)\vartheta_{it} \tag{4}$$

where $Pr(\delta_i + Z_{it}\gamma > 0 = 1)$ and the subscripts i and t are as defined above. The parameters μ_i and δ_i represent each country's (i) time-invariant unobserved specific (fixed) effects. X_{it} represent the explanatory variables contained in model (2). Z_{it} is a k-vector of identified differential transformations of the components of X. X_{it} is assumed to be independently and identically distributed (i.i.d) across individuals and time. The residuals ϑ_{it} are also assumed to be statistically independent of X_{it} and are normalized to satisfy the moment conditions described in Machado and Santos Silva (2019). As a consequence, the panel quantile function takes the following form:

$$Q_{TTR_{it}}(\tau/X) = [(\mu_i + \delta_i q(\tau)) + X_{it}\beta + Z_{it}\gamma q(\tau)] \tag{5}$$

where $\mu_i(\tau) = \mu_i + \delta_i q(\tau)$ is the scalar parameter that indicates the quantile-τ fixed effects for individual country i or the distributional effect at τ. As noted above, the individual fixed effects in the MMQR approach do not represent location (intercept) shifts (as in the ordinary least squares fixed effects approach) but are time-invariant unobserved individual characteristics that have varying effects on the conditional distribution of TTR_{it} (i.e., heterogenous impacts across different quantiles of the conditional distribution of TTR_{it}).

From Equation (5), the conditional quantile tax transition reform's function $q(\tau)$ (i.e., the τ-th quantile) based on the MMQR approach is obtained from the optimization of the following function:

$$\min_q \sum_i \sum_t \theta_\tau \left(\hat{R}_{it} - (\hat{R}_{it} + Z'_{it}\hat{\gamma}) q \right) \tag{6}$$

where the check function $\theta_\tau(A) = (\tau - 1)AI\{A \leq 0\} + \tau AI\{A > 0\}$ is the standard quantile loss function.

In the present analysis, we estimate model (5) (and its different variants described below) by means of the MMQR approach, where the conditional quantile tax transition reform's functions $q(\tau)$ are Q10th, Q20th, Q30th, Q40th, Q50th, Q60th, Q70th, Q80th, and Q90th. Robust[31] standard errors of the estimates are reported.

While the MMQR is our main econometric approach to examine the static effect of the shadow economy on tax transition reform across various quantiles of the distribution of the tax transition reform indicator, we also find it useful to explore the static effect of the shadow economy on tax transition reform at the mean of the distribution of the tax

transition reform indicator, using the standard within the fixed effects approach[32] (denoted "FEDK"). The FEDK estimator is used to test Hypotheses 1–3 specified in Section 2, bearing in mind that the estimates obtained may be biased due to the possible reverse causality from a set of regressors[33] to the dependent variable.

We first test Hypothesis 1 by estimating the (static) baseline model (2) as it stands. The results of this estimation are presented in column [1] of Table A4. We then test Hypothesis 2 by estimating a specification of model (2) that incorporates the multiplicative variable between the indicator of the shadow economy and the indicator of countries' tax revenue structure dependence on international trade tax revenue. The results of this estimation are reported in column [2] of Table A4. Next, we investigate whether the effect of the shadow economy on tax transition reform is the same (or varies) in LICs and other countries in the full sample (i.e., non-LICs). To that effect, we introduce in the base model (2) the dummy variable[34] "LIC" as well as the interaction variable between this dummy and the shadow economy indicator. The outcomes of the estimation of this variant of model (2) are displayed in column [3] of Table A4. As these estimates show the net 'average' effects of the shadow economy on the tax transition reform in LICs and non-LICs in the full sample, they might not fully reflect how these effects vary across countries (depending on their real per capita income as a proxy for their development level) in the full sample. To get a clearer picture of the effect of the shadow economy on the tax transition reform conditioned on countries' development level, we estimate another variant of model (2), which is merely the baseline model (2) in which we introduce the multiplicative variable between the indicator of the shadow economy and the variable capturing the real per capita income. The outcomes of the estimation of this model are presented in column [4] of Table A4. Finally, outcomes reported in column [5] of Table A4 allow the testing of Hypothesis 5. These outcomes are obtained by estimating another specification of model (2), which is merely the baseline model (2) to which we add the multiplicative variable between the indicator of the shadow economy and the variable measuring the level of trade openness.

We now turn to the regressions based on the MMQR, which, as mentioned above, is our main econometric approach to empirically test Hypotheses 1–3. Hypothesis 1 is tested by estimating model (5) (as it stands) using the MMQR approach. The results of this estimation are presented in Table A5. All estimations' results that allow testing of Hypotheses 2 and 3 are summarized in Table A6 for the sake of brevity, and the full estimations' outcomes can be obtained upon request. Hypothesis 2 is tested by estimating a specification of model (5) that includes the multiplicative variable between the indicator of the shadow economy and the indicator of countries' tax revenue structure dependence on international trade tax revenue (see results in Table A6). Next, we push the analysis further by examining whether the effect of the shadow economy on the tax transition reform across each of the nine quantiles depends on countries' level of development (proxied by their real per capita income) within each quantile. To that effect, we estimate another variant of model (5) that incorporates the multiplicative variable between the indicator of the shadow economy and the real per capita income (see results in Table A6). Finally, we test Hypothesis 3 by estimating a final specification of model (5) that includes the interaction variable between the indicator of the shadow economy and the variable measuring the level of trade openness (see results in Table A6).

4. Empirical Results

This section interprets the results obtained from the estimation of the different models described above.

4.1. Interpretation of Results of Tables A1–A3

Results in Table A1 taken by pairs of columns (i.e., columns [1] and [2]; columns [3] and [4]; and columns [5] and [6]) are similar and almost of the same magnitude. They show, on the one hand, that over the full sample, the expansion of the shadow economy reduces significantly (at the 5% level) the likelihood of structural tax reform, i.e., the likelihood

of sustained increases in tax revenue. These results hold in particular for LICs, with the coefficient of the variable "STR" being significant at the 1% level. However, for EMs, there is no significant effect of the shadow economy on structural tax reform. This outcome may be attributed to the small size of the sub-sample of EMs. Regarding control variables, we obtain from columns [1] and [2] of Table A1 (over the full sample) that as expected, an increase in the endowment in natural resources reduces the likelihood of structural reform, while an increase in the population size and a higher unemployment rate lead to a higher likelihood of structural tax reform. These findings run in contrast with our theoretical expectations and may indicate that countries tend to mobilize large tax revenue when their population size increases and when the unemployment rate rises. These findings may also reflect differentiated outcomes across different areas of structural tax reform. Columns [1] and [2] also show that the likelihood of structural tax reform increases as the real per capita income falls. This may suggest that countries that experience an improvement in the real per capita income tend to experience a lower likelihood of structural tax reform than relatively less developed countries. We also note, with a surprise (as it runs against our theoretical expectations), that the likelihood of structural tax reform falls when the institutional and governance quality improves. This outcome may indicate that countries that enjoy a better institutional and governance quality tend to experience a lower likelihood of structural tax reform than countries with a lower quality of the institutions and governance. At the conventional significance levels, trade openness, the economic growth rate, and the inflation rate appear to exert no significant effect on the likelihood of structural tax reform in the full sample. In LICs, the likelihood of structural tax reform increases in countries that are less endowed in natural resources and in those with a lower quality of institutions and governance[35]. Likewise, structural tax reform is likely to be propelled in countries when the population size increases. Concerning EMs, we observe that the likelihood of structural tax reform is higher in less advanced countries than in relatively more advanced ones (the estimate of the real per capita income is negative and significant at the 1% level). This likelihood of tax reform also increases in an inflationary environment, as well as in the context of lower trade openness, an increase in the population size, and a lower endowment in natural resources. The other regressors do not appear to affect significantly the likelihood of structural tax reform in EMs. It is important to note that the outcomes concerning some control variables do not align with those obtained by Gupta and Jalles (2022a), possibly because we have included more control variables in the present analysis than Gupta and Jalles (2022a) did. Nevertheless, the lags of (many) regressors in the analysis might not help fully address the possible reverse causality between these regressors and the dependent variable and may, therefore, explain the fact that some outcomes discussed above do not align with the expectations.

Outcomes in Table A2 concerning the effect of the shadow economy on structural tax reform confirm the findings from Table A1, although with different estimates. In particular, we obtain from column [1] of the table that over the full sample, an expansion of the shadow economy reduces (at the 1% level) the likelihood for structural tax reform to take place. This finding applies to LICs (the coefficient of the variable "SHADOW" is negative and significant at the 5% level), but not to EMs (the coefficient of "SHADOW" is still negative, but not significant at the conventional significance levels). Regarding the effect of control variables on the structural tax reform over the full sample (column [1]), we observe that less developed countries among developing countries experience a higher likelihood of structural tax reform than do relatively advanced countries among them (see the negative and significant coefficient of the real per capita income at the 5% level). Other control variables do not show significant coefficients at the 10% level. As for LICs, trade openness promotes structural tax reform at the 5% level, while other variables exert no significant effect (at the 10% level) on the likelihood of structural tax reform. In contrast, trade openness reduces (at the 5% level) the probability for structural tax reform to take place in EMs, a finding that is consistent with the outcomes in columns [4] and [6]

of Table A1. This suggests that EMs with lower levels of trade openness tend to experience large tax revenue mobilization than those with higher trade openness levels.

Incidentally, outcomes concerning the second equation (i.e., the one where the shadow economy is the dependent variable) show that the structural tax reform does not affect the shadow economy either over the full sample, LICs, or EMs.

Results in the first part of Table A3 show that at the 5% level, the expansion of the shadow economy reduces the likelihood of structural reform in several tax policy and revenue administration areas, including the personal income tax, goods and services tax, excise tax, property tax, and revenue administration areas. The largest negative effect occurs for the areas of reform in the property tax and goods and services tax, followed by excise tax, personal income tax, and revenue administration. The shadow economy also negatively affects the likelihood of reform in corporate income tax and trade tax, but only at the 10% level. These findings lend credence to Hypothesis 1. Incidentally, there is no significant effect of the shadow economy on the probability of value added tax reform or subsidies reform at the conventional significance levels. The effects of control variables on the likelihood of structural reform vary across areas of tax reform and are sometimes conflicting across these areas, although they are sometimes consistent with the findings by Gupta and Jalles (2022a). For example, an improvement in the real per capita income tends to reduce the likelihood of structural reform in all areas, except for the corporate income tax and trade tax areas. Economic growth and the inflation rate do not appear to be strong determinants of structural reform across tax policy areas and in the revenue administration area. Trade openness increases the probability of structural reforms in personal income tax, corporate income tax, goods and services tax, and revenue administration areas, with its highest positive effect being on the goods and services tax area. In the meantime, greater trade openness reduces the likelihood of reforms in trade tax, subsidies, and revenue administration areas, but not in other tax policy areas. Likewise, the increase in the population size reduces the probability of structural reform in the areas of goods and services tax, trade tax, and subsidies, but exerts no significant effect on other reform areas at the conventional significance levels. At the 5% level, the endowment in natural resources reduces the probability of structural reforms in personal income tax, corporate income tax, goods and services income tax, and trade tax areas (with this negative effect being larger on the latter two areas), but exerts no significant effect on other areas. Concurrently, the institutional and governance quality tends not to influence the probability of structural reform in all areas except the corporate income tax area (here, at the 1% level, the likelihood of reform decreases as the quality of institutions and governance improves). Finally, consistent with the findings of Gupta and Jalles (2022a), the unemployment rate increases the likelihood of reform in the areas of personal income tax and corporate income tax. We additionally find that the likelihood of value added tax, property tax, and subsidies reforms increases when the unemployment rate rises[36]. For other areas, we obtain no significant effect of the unemployment rate on the probability of structural reform at the 5% level.

Results of the second equation (see the second part of Table A3) are quite instructive. We note that at least at the 5% level, goods and services tax reform, trade tax reform (for example, in the sense of higher trade taxes), and subsidies reform are associated with an expansion of the shadow economy, with the effect of trade tax reform being the largest one in terms of magnitude. The value added tax reform also exerts a positive effect on the shadow economy, but this effect is significant only at the 10% level.

We now take up outcomes in Tables A4–A7 concerning the effect of the shadow economy on the tax transition reform. For the sake of brevity, in the rest of the analysis, we use "TTR" for the expression "tax transition reform".

4.2. Interpretation of Results of Table A4

We first consider outcomes in Table A4. Results in column [1] indicate that at the 1% level, the expansion of the shadow economy is associated with an increase in the

extent of TTR. Specifically, a 1-point increase in the values of the indicator of the shadow economy is associated with a rise in the extent of TTR by 0.24 points. This finding may be viewed as somewhat contradicting Hypothesis 2, but outcomes in column [2] of the same Table reveal that the coefficient of the multiplicative variable ["SHADOW*SHTRTAX"] is negative and significant at the 1% level, while the coefficient of "SHADOW" is positive and significant at the 1% level. Hence, on average over the full sample, the shadow economy is positively associated with TTR in countries whose share of international trade tax revenue in non-resource tax revenue is lower than 0.677 (=0.386/0.570), i.e., 67.7%. However, for countries whose values of the variable "SHTRTAX" exceed 67.7%, the shadow economy reduces the extent of TTR. Figure A3 displays, at the 95 percent confidence intervals, the marginal impact of the shadow economy on the extent of TTR conditioned on the share of international trade tax revenue in non-resource tax revenue. It shows that this marginal impact decreases as the share of international trade tax revenue in non-resource tax revenue increases, but it is negative and significant only for values of the indicator "SHTRTAX" higher than 0.84 (i.e., 84%). Thus, the shadow economy reduces the extent of TTR in countries whose share of international trade tax revenue in non-resource tax revenue exceeds 84%. At the same time, it is positively and significantly associated with TTR in countries whose values of the variable "SHTRTAX" are lower than 0.5 (i.e., 50%) but exerts no significant effect on TTR in countries whose values of "SHTRTAX" range between 50% and 84%. All these outcomes tend to confirm Hypothesis 2 that the shadow economy could reduce the extent of tax transition reform in countries whose tax revenue structure is highly dependent on international trade tax revenue (here, when the share of international trade tax revenue in non-resource tax revenue exceeds 84%).

Outcomes in column [3] of Table A4 show that LICs experience a higher negative effect of the shadow economy on TTR than non-LICs. The net effects of the shadow economy on TTR in LICs and non-LICs amount to 0.041 (=0.415 − 0.374) and 0.415, respectively. We conclude that while the shadow economy affects TTR positively and significantly in both LICs and non-LICs, this positive effect is far larger (almost ten times) for non-LICs than for LICs. Once again, these effects across the two sub-samples certainly hide differentiated effects across countries within each sub-sample, conditioned on the tax revenue structure dependence on international trade tax revenue.

Estimates in column [4] of Table A4 confirm the findings in column [3] of the table, as we observe a positive and significant (at the 1% level) coefficient of the interaction variable ["SHADOW*Log(GDP)"], while the coefficient of the indicator "SHADOW" is negative and significant at the 1% level. We deduce from these results that, on average, over the full sample, the shadow economy positively affects TTR in countries whose real per capita income[37] exceeds USD 481 [=exponential (1.124/0.182)]. Hence, the shadow economy is negatively associated with TTR in very low-income countries (i.e., those whose real per capita income is lower than USD 481) but positively associated with TTR in other countries. We provide in Figure A4, at the 95 percent confidence intervals, the marginal impact of the shadow economy on TTR for varying levels of the real per capita income. We observe that this marginal impact increases as the real per capita income rises, and the shadow economy positively and significantly affects TTR in countries whose real per capita income exceeds USD 1105. In other countries (those with a real per capita income lower than USD 1105), there is no significant effect of the shadow economy on TTR. It is important to note that these outcomes do not contradict the ones obtained for LICs and non-LICs (from column [3] of Table A4), since the results for LICs and non-LICs capture average effects of the shadow economy on TTR over each of these sub-samples, while estimates in column [4] indicate how the effect of the shadow economy on TTR changes for different values of the real per capita income.

Results in column [5] of Table A4 allow us to examine how the shadow economy affects TTR as countries further open up their economies to international trade. We observe that the coefficient of the indicator "SHADOW" is not significant at the 10% level, while the estimate associated with the multiplicative variable ["SHADOW*OPEN"] is positive

and significant at the 1% level. We infer from these outcomes that, on average over the full sample, the shadow economy exerts a positive and significant effect on the extent of TTR, with the magnitude of this positive effect becoming larger as countries enjoy greater trade openness. These findings are reflected in Figure A5, which shows, at the 95 percent confidence intervals, the marginal impact of the shadow economy on TTR for varying degrees of trade openness. It can be observed in the figure that this marginal impact is always positive, but significant only for values of the trade openness indicator higher than 0.422 (i.e., 42.2%). In other words, the shadow economy is associated with an increase in the extent of TTR in countries whose trade openness level exceeds 42.2%, with the magnitude of this positive effect being larger as the degree of trade openness rises. Conversely, in countries that experience a trade openness level lower than 42.2%, there is no significant effect of the shadow economy on TTR. Overall, these findings confirm Hypothesis 3.

Outcomes concerning control variables are similar across all five columns of Table A4. We note specifically from column [1] of the table that at the 1% level, a greater extent of TTR is driven by a decrease in the share of international trade tax revenue in total non-resource tax revenue, an improvement in the real per capita income, a greater trade openness, a lower endowment in natural resources, an increase in the unemployment rate, a higher economic growth rate, an improvement in the institutional and governance quality, and a rise in the population size. The inflation rate reduces the extent of TTR at the 5% level (see columns [2], [3], and [4]) and at the 10% level (see columns [1] and [5]). These findings tend to align with our theoretical expectations.

4.3. Interpretation of Results of Tables A5 and A6

Let us now consider the outcomes reported in Table A5, i.e., the results obtained from the use of the MMQR approach. We note from results in column [2] that the scale parameter of the shadow economy indicator is negative but not statistically significant at the 10% level. On the other hand, we observe in column [1] of the same table that the location parameter associated with the same indicator is positive and significant at the 1% level, thereby suggesting that the shadow economy exerts a positive effect on TTR across quantiles. Taken together, these two outcomes indicate that the scale of the positive effect of the shadow economy on TTR decreases (i.e., becomes weaker) across the conditional distribution of TTR, from the lowest quantile (Q10th) to the highest quantile (Q90th), respectively. Specifically, we observe across columns [3] to [11] that the expansion of the shadow economy positively and significantly affects (at least at the 5% level) TTR from the lowest quantile to the 70th quantile. However, it positively affects TTR in countries located in the 80th quantile only at the 10% level and exerts no significant effect on TTR for countries located in the highest quantile (i.e., the 90th quantile). In other words, the shadow economy tends to exert its highest positive effect on TTR in countries that enjoy a great extent of TTR, and the magnitude of this positive effect decreases as the extent of TTR becomes lower (up to the 70th quantile). At the 5% level, its effect on TTR is statistically nil in countries located in the 80th and 90th quantiles. In terms of the magnitude of these effects, we find in column [3] of Table A5 that a 1-point increase in the value of the index of the shadow economy is associated with an increase in the extent of TTR by 0.356 points for countries located in the 10th quantile. The same interpretation applies to estimates reported in columns [4] to [9].

As noted in Section 2, the genuine effect of the shadow economy on the TTR is likely dependent on countries' share of international trade tax revenue in non-resource tax revenue. In connection to this, we note that the location parameter of the indicator "SHTRTAX" is negative and significant at the 5% level, while the scale parameter of this variable is also significant at the 5% level, but negative. Taken together, these results suggest that the scale of the negative effect of countries' tax revenue structure's dependence on international trade tax revenue on TTR increases in magnitude (i.e., becomes less negative) from the lowest to the highest quantile across the conditional distribution of TTR. However, this negative effect is significant at the 5% level for countries located in the 10th to 50th

quantiles and at the 10% level for countries in the 60th quantile. For countries located in other quantiles, it is not significant at the conventional significance levels. In terms of the magnitude of the impact, we observe, for example, for countries in the 10th quantile, that a 1-point increase in the share of international trade tax revenue in total non-resource tax revenue is associated with a 0.11-point decrease in the values of the TTR index. Summing up these findings, we observe that at the 5% level, an increase in countries' tax revenue dependence on international trade tax revenue reduces the magnitude of TTR in countries located in the 10th to 50th quantiles, with the magnitude of this effect being larger in countries that have experienced a great extent of TTR than those that have undertaken a relatively lower magnitude of TTR. At the 5% level, the tax revenue's dependence on international trade tax revenue exerts no significant effect on TTR for countries located in the 60th to 90th quantiles (i.e., those that are less engaged in TTR).

Concerning the outcomes in Table A5 associated to the trade openness indicator (which is also a key variable of interest in the analysis), the location and scale parameters are both positive, but significant at the 1% level for the former and not significant at the 10% level for the latter. It follows that the effect of trade openness on TTR is positive across all quantiles of the conditional distribution, and the magnitude of this effect increases as we move from the lowest to the highest quantiles. A 1-point increase in the degree of trade openness is associated with an increase in the magnitude of TTR by 0.038 for countries in the 10th quantile and by 0.068 for countries in the 90th quantile of the conditional distribution of the TTR indicator.

The endowment in natural resources exerts a negative effect on TTR across all quantiles of the conditional distribution of TTR, with the magnitude of this negative effect becoming larger as we move from the 10th quantile to the 90th quantile. At the 5% level, the unemployment rate positively and significantly affects TTR in countries situated in the 60th to 90th quantiles, with the magnitude of this positive effect increasing as we move to the higher quantile. While the economic growth rate exerts no significant effect at the conventional significance levels on TTR across all quantiles of the conditional distribution of TTR, the institutional and governance quality affects significantly (and yet positively, as expected and as shown by the positive and significant location parameter) only countries located in the 10th to 40th quantiles, with the magnitude of this effect decreasing as we move to the higher quantile (as exemplified by the negative, although not significant, scale parameter of this variable). As also expected, an increase in the inflation rate reduces the extent of TTR in the 10th to 50th quantiles, with countries in a higher quantile experiencing a lower negative TTR effect of inflation than countries located in a lower quantile. There is no significant effect of inflation on TTR in the 60th to 90th quantiles. Finally, across all quantiles of the conditional distribution of TTR, the extent of TTR rises as the population size increases. Countries located in a higher quantile experience a higher TTR effect of the population size than countries in the lower quantile of the conditional distribution of TTR.

We now take up outcomes presented in Table A6. It is important to note at the outset that for the sake of brevity, we have not reported in this table the estimates of control variables, as they are similar to those in Table A5 and can be obtained upon request.

The first set of results presented in this table allow testing of Hypothesis 2, i.e., whether the effect of the shadow economy on TTR depends on the share of international trade tax revenue in non-resource tax revenue. We observe that the location parameter of the multiplicative variable ["SHADOW*SHTRTAX"] is negative and significant at the 1% level, which shows that the interaction term related to that multiplicative variable is always negative across all quantiles of the conditional distribution of TTR. Concurrently, the scale parameter of this multiplicative variable is also positive but not significant at the 10% level. This outcome suggests that the effect of the multiplicative variable on TTR across the conditional distribution of TTR increases (i.e., the negative effect here becomes weaker and lower in magnitude) as we move from the lowest to the highest quantile. At the same time, the coefficient of the indicator "SHADOW" is always positive across all quantiles and is significant at least at the 5% level from the 10th to the 80th quantiles, but

significant only at 10% level in the 90th quantile of the conditional distribution of TTR. We conclude, in support of Hypothesis 2, that the shadow economy reduces the extent of TTR in countries that experience an increase in the share of international trade tax revenue in total non-resource tax revenue, and the greater this share, the higher the negative effect of the shadow economy on the extent of TTR. Countries located in a lower quantile (e.g., 10th quantile) experience a higher negative effect of the shadow economy on TTR (as the share of international trade tax revenue in non-resource tax revenue) than countries in a higher quantile (e.g., 20th quantile or other quantiles). The average turning point of the indicator "SHTRTAX" within each quantile above which the shadow economy reduces the extent of TTR is 90.6% for countries located in the 90th quantile and progressively decreases to reach 52.9% for countries located in the 10th quantile.

Outcomes in the second part of Table A6 indicate that the coefficient of the variable ["SHADOW*Log(GDP)"] is always positive and significant at least at the 5% level across all quantiles of the conditional distribution of TTR. At the same time, the estimates of "SHADOW" are negative across all quantiles but significant only at the 10% level in the 10th and 20th quantiles, but at the 5% level in all other quantiles. It follows from these outcomes that as the real per capita income increases, countries tend to undertake a greater extent of TTR (see the positive location parameter of the multiplicative variable), and the magnitude of this positive effect decreases as we move from the lowest quantile to the highest quantile of the conditional distribution of TTR (see the negative, although not significant, value of the scale parameter of the multiplicative variable).

Finally, we observe in the last part of Table A6 that the interaction term of the inter-action variable ["SHADOW*OPEN"] is always positive and significant, at least at the 5% level, from the 20th to the 90th quantiles of the conditional distribution of TTR, but positive and significant at the 10% level for countries located in the 10th quantile. Moreover, the estimate related to this multiplicative variable is higher the higher the quantile. These results suggest that the magnitude of the positive effect of the shadow economy on the extent of TTR increases as the degree of trade openness rises within each quantile, and higher quantiles experience a greater positive effect of the shadow economy on TTR than lower quantiles.

5. Further Analysis

While the estimates arising from the MMQR approach allow us to obtain a nice picture of the effect of the shadow economy on tax transition reform across different quantiles of the distribution of the latter, it could be equally useful to investigate the dynamic effect of the shadow economy on tax transition reform, although at the mean of the conditional distribution of the tax transition reform indicator. Therefore, we conclude the empirical analysis by estimating a dynamic specification of model (2) that includes the lagged dependent variable as a right-hand side regressor in order to capture the inertia that characterizes fiscal variables (see also Gnangnon 2020). The new specification of model (2) is as follows:

$$
\begin{aligned}
TAXREF_{it} = {} & \varphi_1 TAXREF_{it-1} + \varphi_2 SHADOW_{it} + \varphi_3 SHTRTAX_{it} \\
& + \varphi_4 Log(GDPC)_{it} + \varphi_5 OPEN_{it} + \varphi_6 RENT_{it} + \varphi_7 UR_{it} \\
& + \varphi_8 GROWTH_{it} + \varphi_9 INST_{it} + \varphi_{10} INFL_{it} + \varphi_{11} Log(POP)_{it} \\
& + \mu_i + \delta_t + \varepsilon_{it}
\end{aligned}
\tag{7}
$$

The subscripts *i* and *t* still stand for a country and a time-period (3-year non-overlapping sub-periods), respectively. All variables are as defined above. φ_1 to φ_{11} are new parameters to be estimated. ε_{it} represents the error term.

Model (7) is estimated using Blundell and Bond's (1998) two-step system generalized method of moments estimator (denoted SGMM). In the absence of valid external instru-ments (which are hard to obtain in practice), this estimator is used in an attempt to mitigate endogeneity concerns. These include the endogeneity concern (Nickell bias—Nickell 1981) due to the correlation between the lagged dependent variable and countries' time-invariant

unobserved specific effects in the error term and the one arising from the bi-directional causality between some regressors and the dependent variable that generates a correlation between those regressors and the error term.

The use of the SGMM estimator involves performing a joint estimation of an equation in levels and an equation in differences using lags of endogenous regressors in terms of both levels and first differences as instruments. Thus, by using moment conditions to derive valid instruments for the endogenous variables based on past values of those variables, this estimator helps reduce the imprecision and potential bias arising from the use of the difference GMM estimator of Arellano and Bond (1991) and, in this regard, is asymptotically more efficient than the difference GMM estimator (e.g., Bond 2002; Blundell and Bond 1998). We tackle the instrument's proliferation concern raised by Roodman (2009) by limiting to two the number of lags used to generate instrumental variables. For all regressions performed using the SGMM estimator, we report the outcomes of three key diagnostic tests, namely the Arellano–Bond test of the presence of first-order serial correlation in the first-differenced error term (AR(1)) and the Arellano–Bond test of the absence of second-order autocorrelation in the first-differenced error term (denoted AR(2)), and the Hansen-J test of over-identifying restrictions (OID) that helps test the validity of instrumental variables used in the regressions. The estimated models are considered as correctly specified if the *p*-value of the statistic related to the AR(1) test is lower than 0.10 at the 10% level, and the *p*-values of the statistics related to the AR(2) and OID test are higher than 0.1 at the 10% level.

We estimate different variants of model (7) by means of the SGMM approach to test Hypotheses 1–3 (see outcomes in Table A7). Column [1] of Table A7 reports the outcomes that help test Hypothesis 1 and that stem from the estimation of model (7) as specified above. Outcomes in column [2] of the same table allow testing of Hypothesis 2 and are uncovered by estimating a first variant of model (7) that incorporates the multiplicative variable between the indicator of the shadow economy and the indicator of countries' tax structure dependence on international trade tax revenue. Column [3] of the table reports the estimates that allow the exploration of the effect of the shadow economy on the tax transition reform for LICs versus non-LICs. These outcomes are obtained by estimating a second variant of model (7) that includes the dummy variable "LIC" and the multiplicative variable that captures the interaction between this dummy variable and the indicator of tax transition reform. Estimates displayed in column [4] of Table A7 allow the investigation of how the (average short- and long-term) effects of the shadow economy on tax transition reform vary across countries in the full sample. These outcomes are obtained by estimating a third variant of model (7) that includes the interaction variable between the shadow economy indicator and the variable measuring the real per capita income. Finally, outcomes contained in column [5] of Table A7 are instrumental in testing Hypothesis 3. They are obtained by estimating a fourth specification of model (7), i.e., model (7) that incorporates the multiplicative variable between the indicators of the shadow economy and of trade openness.

The results of the diagnostic tests concerning the correctness of the different specifications of model (7) estimated using the SGMM estimator are reported at the bottom of Table A7. These outcomes confirm the appropriateness of this estimator in the empirical analysis. In addition, the coefficient of the one-period lag of the dependent variable is positive and significant at the 1% level across all columns of the table, and this underlines the importance of considering the dynamic baseline specification (7) in the analysis.

The results in all five columns of the table are consistent (in terms of patterns—although with different coefficients) with those in Table A4. Results in column [1] of Table A7 suggest that at the 5% level, the shadow economy positively and significantly affects the extent of TTR, on average, over the full sample. A 1-point increase in the values of the index of the shadow economy indicator is associated with an increase in the extent of TTR by 0.07 points (which is far lower than the coefficient of 0.241 obtained in column [1] of Table A4). Meanwhile, estimates in column [2] of Table A7 reveal a negative and significant

(at the 1% level) effect of the interaction term of the variable ["SHADOW*SHTRTAX"] and a positive and significant coefficient at the 1% level of the indicator "SHADOW". We conclude that on average, over the full sample, an expansion of the shadow economy leads to a lower extent of TTR in countries whose share of international trade tax revenue in total non-resource tax revenue exceeds 0.217 (=0.123/0.567) or 21.7%. For these countries, the greater this share, the larger the negative effect of the shadow economy on the extent of TTR. In contrast, for countries whose share of international trade tax revenue in non-resource tax revenue is below 21.7%, the expansion of the shadow economy leads to a greater extent of TTR, and the lower this share (for these countries), the larger the positive TTR effect of the shadow economy. Figure A6 presents, at the 95 percent confidence intervals, the marginal impact of the shadow economy on the extent of TTR for varying shares of international trade tax revenue in non-resource tax revenue. The pattern observed in Figure A6 is similar to that of Figure A3 and shows that this marginal impact decreases as the values of "SHTRTAX" increase. Countries whose values of "SHTRTAX" are below 0.14 (i.e., 14%) experience a positive effect of the shadow economy on the extent of TTR. On the other hand, countries whose values of "SHTRTAX" exceed 0.3 (i.e., 30%) experience a negative effect of the shadow economy on the extent of TTR, and for these countries, the magnitude of this negative effect is larger the greater the share of international trade tax revenue in non-resource tax revenue. Finally, countries whose values of "SHTRTAX" range between 14% and 30% experience no significant effect of the shadow economy on TTR.

Estimates in column [3] of Table A7 show (as in Table A4) that LICs experience a lower effect of the shadow economy on the extent of TTR than non-LICs. The net effects of the shadow economy on the extent of TTR amount to −0.01 (=0.192 − 0.202) and 0.192, respectively, for LICs and non-LICs. It ensures that the shadow economy exerts a negative and significant effect (in both the short and long term) on the extent of TTR in LICs, while in non-LICs, it affects positively the extent of TTR. These outcomes are slightly different from the ones obtained from the analysis of the results reported in column [3] of Table A4.

We note from column [4] of Table A7 that the patterns of results are similar to those in column [4] of Table A4. In particular, we observe that, on average, over the full sample, the shadow economy leads to a lower extent of TTR in countries whose level of real per capita income is lower than USD 1611 [=exponential(1.632/0.221)]. For countries whose real per capita income exceeds USD 1611, the shadow economy positively affects the extent of TTR, and the magnitude of this positive effect rises as the real per capita income increases. Figure A7 displays, at the 95 percent confidence intervals, the marginal impact of the shadow economy on TTR for varying levels of the real per capita income. As in Figure A4, we observe that this marginal impact increases as the real per capita income improves. An expansion of the shadow economy discourages the pursuance of TTR in countries whose real per capita income is lower than USD 1233.34 (i.e., mainly LICs) and induces a higher extent of TTR in countries whose real per capita income is higher than USD 1233.34.

Finally, the pattern of results in column [5] of Table A7 is similar to that in the same column of Table A4. On average, over the full sample, an expansion of the shadow economy discourages the pursuance of TTR in countries whose level of trade openness is lower than 0.5744 (=0.139/0.242) or 57.44%. Thus, countries that are less opened to international trade experience a negative effect of the shadow economy on the extent of TTR, while countries whose degree of trade openness exceeds 57.44% enjoy a positive TTR effect of the shadow economy, with the magnitude of this effect rising as the level of trade openness increases. These findings are reflected in Figure A8, which provides, at the 95 percent confidence intervals, the marginal impact of the shadow economy on the TTR for varying degrees of trade openness. The graph in Figure A8 is similar to the one in Figure A5 and shows that this marginal impact increases as countries further open up their economies to international trade, especially for countries whose trade openness level exceeds 0.707, i.e., 70.7%. Countries that have opened their economies less to international trade, i.e., those whose degree of trade openness is lower than 0.422, i.e., 42.2%, experience a negative effect of the shadow economy on the extent of TTR, and the lower the degree of trade

openness (among these countries), the larger is the negative effect of the shadow economy on the extent of TTR. Countries whose level of trade openness ranges between 42.2% and 70.7% experience no significant effect of the shadow economy on the extent of TTR. Overall, results in column [5] of Table A7 confirm Hypothesis 3.

Estimates of control variables tend to be consistent across all columns of Table A7 and with those with Table A4, with the exception of the coefficient of the real per capita income, which was positive in Table A4 but negative and significant here at the 1% level.

6. Conclusions

This paper has examined the effect of the shadow economy on tax reform in developing countries, focusing on two types of tax reform, namely structural tax reform, which is characterized by large episodes of tax revenue mobilization, and tax transition reform, characterized by a reform of the tax revenue structure so as to reduce its dependence on international trade tax revenue. The analysis on the effect of the shadow economy on structural tax reform has used the dataset developed by Akitoby et al. (2020) and covers a sample of 40 developing countries (including 24 LICs and 16 EMs) over the period from 2000 to 2015. The analysis concerning the effect of the shadow economy on tax transition reform covers an unbalanced panel dataset of 114 countries over the period from 1995 to 2015. The empirical analysis has used various estimators and established several findings. First, the shadow economy reduces the likelihood of structural tax reform over the full sample, notably in low-income countries. In addition, over the full sample, the shadow economy reduces (at the 5% level) the likelihood of structural reform in several tax policy and revenue administration areas, including the personal income tax, the corporate income tax, the goods and services tax, the excise tax, the property tax, and the revenue administration areas. Second, the shadow economy undermines the TTR process in countries whose tax revenue structure is dependent on international trade tax revenue; for these countries, the greater the share of international trade tax revenue in non-resource tax revenue (especially above a cut-off point), the larger the negative effect of the shadow economy on the extent of TTR. Second, the shadow economy tends to reduce the extent of tax transition reform in LICs, but it tends to increase it in non-LICs. Finally, the shadow economy positively influences the TTR process in countries that further open up their economies to international trade, as the higher the level of trade openness, the larger the positive TTR effect of the shadow economy.

A key message conveyed by this analysis is that while the expansion of the shadow economy reduces the likelihood of a sustained increase in tax revenue, including across several tax policy and revenue administration areas, it could also enhance the implementation of the tax transition reform in countries that improve their participation in international trade. In light of the strong benefits of international trade and given that fostering tax transition reform is associated with a greater tax revenue mobilization, it ensures that the expansion of the shadow economy is likely to significantly impede the tax transition reform process and reduce the mobilization of tax revenue in countries that implement restrictive measures to their participation in international trade. A critical issue raised by the findings is how to reduce the size of the shadow economy. The answer to this question goes beyond the scope of this paper, as reducing the shadow economy could involve the deployment of several economic and social policies.

The present study complements a few previous studies on the effect of the shadow economy on tax revenue mobilization (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015) by showing that not only could the shadow economy reduce tax revenue in developing countries, but it could also undermine tax reform in these countries.

Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Effect of the shadow economy on revenue-enhancing structural tax reform over the full sample. Estimator: FVW Logit and Probit approaches.

Variables	All Countries		LICs		LICs	
	Logit	Probit	Logit	Probit	Logit	Probit
	STR	STR	STR	STR	STR	STR
	(1)	(2)	(3)	(4)	(5)	(6)
SHADOW$_{t-1}$	−0.022 **	−0.019 **	−0.0399 ***	−0.036 ***	−0.0008	0.0008
	(0.009)	(0.009)	(0.0139)	(0.0135)	(0.0158)	(0.0154)
Log(GDPC)	−1.149 ***	−0.744 **	−0.085	0.674	−4.16 ***	−3.248 ***
	(0.321)	(0.307)	(0.514)	(0.503)	(0.564)	(0.528)
OPEN$_{t-1}$	−0.0022	−0.0014	0.0018	0.0014	−0.013 ***	−0.015 ***
	(0.0013)	(0.0011)	(0.0012)	(0.0012)	(0.0035)	(0.003)
RENT$_{t-1}$	−0.028 ***	−0.027 ***	−0.028 ***	−0.026 ***	−0.049 ***	−0.037 **
	(0.0066)	(0.0066)	(0.008)	(0.0078)	(0.017)	(0.016)
UR$_{t-1}$	0.038 ***	0.035 ***	−0.0036	−0.013	−0.020	−0.028 *
	(0.011)	(0.010)	(0.0309)	(0.0308)	(0.017)	(0.0152)
GROWTH$_{t-1}$	−0.008	−0.002	−0.016 **	−0.009	0.006	0.003
	(0.005)	(0.005)	(0.007)	(0.007)	(0.009)	(0.0096)
INST$_{t-1}$	−0.145 **	−0.186 ***	−0.2588 ***	−0.374 ***	0.169	−0.0112
	(0.067)	(0.0652)	(0.085)	(0.084)	(0.110)	(0.1091)
INFL$_{t-1}$	0.0129	−0.324	−0.011	−0.455	1.993 **	1.921 **
	(0.512)	(0.504)	(0.654)	(0.641)	(0.8198)	(0.783)
Log(POP)	6.300 ***	5.213 ***	7.807 ***	7.733 ***	4.027 ***	4.435 ***
	(0.576)	(0.524)	(1.177)	(1.161)	(1.165)	(1.058)
Observations— Countries	536-39	536-39	312-23	312-23	208-16	208-16
Pseudo-R^2	0.2359	0.2189	0.3211	0.3128	0.316	0.3060
LR Chi2 (*p*-value)	155.34 (0.0000)	144.17 (0.0000)	128.42 (0.0000)	125.07 (0.0000)	77.11 (0.0001)	74.74 (0.0002)
Log likelihood	−251.594	−257.18	−135.739	−137.415	83.589	−84.774

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust Standard Errors are in parentheses. FVW Logit estimator refers to the Fixed Effects Logit estimator proposed by Fernández-Val and Weidner (2016) with the jackknife bias corrections. FVW Probit estimator refers to the Fixed Effects Probit estimator proposed by Fernández-Val and Weidner (2016) with the jackknife bias corrections. Average Partial Effects are reported.

Table A2. Effect of the shadow economy on revenue-enhancing structural tax reform over the full sample and sub-samples of LICs and EMs. Estimator: 2SLS Probit.

	Full Sample	**LICs**	**EMs**
Dependent Variable	**STR**	**STR**	**STR**
	(1)	**(2)**	**(3)**
SHADOW	−0.097 ***	−0.117 **	−0.027
	(0.035)	(0.047)	(0.038)
Log(GDPC)	−0.283 **	−0.562	−0.168
	(0.1405)	(0.348)	(0.375)
$GROWTH_{t-1}$	−0.004	−0.037	−0.015
	(0.017)	(0.024)	(0.024)
$INFL_{t-1}$	−0.483	−0.159	−2.112
	(1.200)	(1.723)	(1.850)
$OPEN_{t-1}$	0.004	0.008 **	−0.014 **
	(0.002)	(0.003)	(0.007)
Log(POP)	−0.064	−0.062	−0.033
	(0.064)	(0.091)	(0.158)
$RENT_{t-1}$	−0.0146	−0.005	−0.025
	(0.0106)	(0.011)	(0.023)
$INST_{t-1}$	−0.150	−0.042	−0.163
	(0.106)	(0.123)	(0.176)
UR_{t-1}	0.028	0.034	0.0135
	(0.021)	(0.039)	(0.022)
Constant	5.576 **	8.0598 *	3.315
	(2.596)	(4.258)	(6.795)
Observations— Countries	481-40	274-24	207-16
First Stage Pseudo-R^2	0.0240	0.045	0.056
Log likelihood	−289.781	−167.688	−113.137
Dependent Variable	**SHADOW**	**SHADOW**	**SHADOW**
	(1)	**(2)**	**(3)**
STR	−47.415	−8.377	14.237
	(86.157)	(11.606)	(16.055)
Observations— Countries	481-40	274-24	207-16
Adjusted R^2	0.2403	0.3594	0.1801

Note: * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01. Robust Standard Errors are in parentheses (corrected standard errors are reported in brackets—see Keshk 2003). To save space, we have not reported results of control variables on the equation of the determinants of the shadow economy. It appeared that many control variables were not significant here, reflecting opposing effects of these control variables across various tax policy and revenue administration areas.

Table A3. Effect of the shadow economy on different areas of revenue-enhancing structural tax reform over the full sample. Estimator: 2SLS Probit.

Dependent Variable	PIT	CIT	GST	VAT	EXCISE	TRTAX	PROPERTY	SUBSIDIES	REVADM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SHADOW	−0.097 **	−0.062 *	−0.257 ***	−0.035	−0.102 ***	−0.092 *	−0.263 ***	−0.1095	−0.085 **
	(0.043)	(0.0355)	(0.069)	(0.035)	(0.0377)	(0.0486)	(0.098)	(0.1009)	(0.034)
Log(GDPC)	−0.9266 ***	−0.053	−2.090 ***	−0.575 ***	−0.445 ***	−0.176	−1.439 ***	−1.652 ***	−0.462 ***
	(0.2068)	(0.144)	(0.377)	(0.151)	(0.1535)	(0.198)	(0.444)	(0.6166)	(0.1416)
$GROWTH_{t-1}$	−0.007	−0.002	−0.064 *	−0.008	−0.023	0.0256	−0.034	0.0265	−0.004
	(0.022)	(0.018)	(0.033)	(0.017)	(0.019)	(0.023)	(0.047)	(0.0388)	(0.017)
$INFL_{t-1}$	−0.340	−2.430	−1.08	−1.022	0.878	0.775	−5.252	−3.27	−0.257
	(1.716)	(1.525)	(2.691)	(1.364)	(1.248)	(1.74)	(4.355)	(4.767)	(1.206)
$OPEN_{t-1}$	0.0097 ***	0.007 ***	0.017 ***	0.0025	0.001	−0.008 **	−0.0088	−0.043 **	0.0054 **
	(0.003)	(0.002)	(0.004)	(0.0024)	(0.002)	(0.00366)	(0.0096)	(0.0209)	(0.0023)
Log(POP)	0.013	0.063	−0.688 ***	0.046	−0.108	−0.317 ***	−0.018	−0.876 ***	−0.0995
	(0.087)	(0.066)	(0.155)	(0.067)	(0.069)	(0.0906)	(0.169)	(0.310)	(0.0634)
$RENT_{t-1}$	−0.041 **	−0.027 **	−0.051 **	−0.021	−0.024 *	−0.054 **	−0.1103	−0.015	−0.012
	(0.0155)	(0.0114)	(0.024)	(0.011)	(0.012)	(0.0216)	(0.0536)	(0.043)	(0.010)
$INST_{t-1}$	0.052	−0.324 ***	0.241	0.041	−0.098	−0.126	0.037	0.032	−0.073
	(0.145)	(0.1196)	(0.19)	(0.111)	(0.115)	(0.134)	(0.265)	(0.2909)	(0.105)
UR_{t-1}	0.091 ***	0.0495 **	0.0674 *	0.066 ***	0.025	−0.011	0.1315 **	0.283 ***	0.032
	(0.027)	(0.0216)	(0.0406)	(0.021)	(0.023)	(0.029)	(0.0566)	(0.0756)	(0.020)
Constant	7.903 **	−0.393	32.738 ***	3.482	7.784 ***	8.82	18.947 **	27.128 ***	6.9045 ***
	(3.273)	(2.578)	(6.385)	(2.576)	(2.834)	(3.818)	(7.549)	(9.138)	(2.569)
Observations— Countries	481-40	481-40	481-40	481-40	481-40	481-40	481-40	481-40	481-40
First Stage Pseudo-R^2	0.1059	0.055	0.3266	0.0606	0.0338	0.1028	0.3064	0.471	0.0338
Log likelihood	−154.713	−195.108	−92.769	−209.270	−252.224	−129.961	−53.265	−31.591	−278.549
Dependent Variable	SHADOW	SHADOW	SHADOW	SHADOW	SHADOW	SHADOW	SHADOW	SHADOW	SHADOW
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Indicator of the type (area) of structural tax reform	1.753	−0.179	2.798 ***	3.807 *	26.826	4.142 ***	0.797	1.343 **	14.562
	(1.484)	(1.447)	(0.946)	(3.416)	(31.182)	(1.4099)	(0.627)	(0.584)	(32.248)
Observations— Countries	481-40	481-40	481-40	481-40	481-40	481-40	481-40	481-40	481-40
Adjusted R^2	0.2011	0.1984	0.2350	0.2021	0.2405	0.2526	0.203	0.2267	0.2014

Note: * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01. Robust Standard Errors are in parentheses. Corrected standard errors are reported in brackets (see Keshk 2003). To save space, we have not reported results of control variables on the equation of the determinants of the shadow economy. It appeared that the coefficients of many control variables have significant coefficients, in line with the theoretical expectations.

Table A4. Correlation between the shadow economy and tax transition reform. Estimator: FEDK.

Variables	TTR	TTR	TTR	TTR	TTR
	(1)	(2)	(3)	(4)	(5)
SHADOW	0.241 ***	0.386 ***	0.415 ***	−1.124 ***	0.0221
	(0.0870)	(0.111)	(0.0976)	(0.0937)	(0.118)
SHADOW*SHTRTAX		−0.570 ***			
		(0.141)			
SHADOW*LICs			−0.374 ***		
			(0.0442)		
SHADOW*Log(GDP)				0.182 ***	
				(0.0126)	
SHADOW*OPEN					0.403 ***
					(0.119)
SHTRTAX	−0.0597 ***	0.111 ***	−0.0595 ***	−0.0517 ***	−0.0504 ***
	(0.0139)	(0.0373)	(0.0139)	(0.0139)	(0.0140)
Log(GDPC)	0.0962 ***	0.103 ***	0.104 ***	0.0422 ***	0.115 ***
	(0.0130)	(0.0148)	(0.0142)	(0.0133)	(0.0108)
OPEN	0.0380 ***	0.0412 ***	0.0400 ***	0.0515 ***	−0.0794 ***
	(0.00668)	(0.00702)	(0.00666)	(0.00894)	(0.0284)
RENT	−0.293 ***	−0.293 ***	−0.276 ***	−0.287 ***	−0.301 ***
	(0.0562)	(0.0628)	(0.0590)	(0.0540)	(0.0491)
UR	0.241 ***	0.225 ***	0.155 ***	0.0616 *	0.140 ***
	(0.0473)	(0.0471)	(0.0488)	(0.0333)	(0.0374)
GROWTH	0.160 ***	0.147 ***	0.144 ***	0.120 ***	0.124 ***
	(0.0262)	(0.0167)	(0.0257)	(0.0279)	(0.0288)
INST	0.0229 ***	0.0227 ***	0.0211 ***	0.0201 ***	0.0213 ***
	(0.00443)	(0.00465)	(0.00431)	(0.00376)	(0.00426)
INFL	−0.0372 *	−0.0374 **	−0.0445 **	−0.0417 **	−0.0388 *
	(0.0207)	(0.0184)	(0.0203)	(0.0192)	(0.0202)
Log(POP)	0.207 ***	0.192 ***	0.186 ***	0.186 ***	0.199 ***
	(0.0211)	(0.0200)	(0.0175)	(0.0174)	(0.0195)
Constant	−3.576 ***	−3.441 ***	−3.305 ***	−2.828 ***	−3.525 ***
	(0.426)	(0.412)	(0.375)	(0.369)	(0.407)
Observations—Countries	666-114	666-114	666-114	666-114	666-114
Within R-squared	0.3741	0.3841	0.3841	0.3975	0.4008

Note: * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01. Robust Standard Errors are in parentheses.

Table A5. Effect of the shadow economy on tax transition reform. Estimator: Method of Moments Quantile Regression (MMQR).

Variables	Location [a]	Scale [b]	Q10th	Q20th	Q30th	Q40th	Q50th	Q60th	Q70th	Q80th	Q90th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SHADOW	0.265 ***	−0.0610	0.356 ***	0.333 ***	0.313 ***	0.289 ***	0.262 ***	0.236 **	0.215 **	0.195 *	0.163
	(0.0953)	(0.0451)	(0.116)	(0.106)	(0.101)	(0.0967)	(0.0955)	(0.0983)	(0.103)	(0.110)	(0.123)
SHTRTAX	−0.0668 **	0.0286 **	−0.110 ***	−0.0989 ***	−0.0891 ***	−0.0783 ***	−0.0656 **	−0.0533 *	−0.0436	−0.0341	−0.0188
	(0.0275)	(0.0143)	(0.0347)	(0.0316)	(0.0295)	(0.0281)	(0.0276)	(0.0284)	(0.0299)	(0.0320)	(0.0365)
Log(GDPC)	0.152 ***	−0.00427	0.158 ***	0.157 ***	0.155 ***	0.154 ***	0.152 ***	0.150 ***	0.148 ***	0.147 ***	0.145 ***
	(0.0329)	(0.0185)	(0.0524)	(0.0466)	(0.0418)	(0.0371)	(0.0325)	(0.0297)	(0.0288)	(0.0292)	(0.0325)
OPEN	0.0517 ***	0.00945	0.0375 **	0.0411 ***	0.0443 ***	0.0479 ***	0.0521 ***	0.0561 ***	0.0593 ***	0.0625 ***	0.0675 ***
	(0.0127)	(0.00615)	(0.0155)	(0.0143)	(0.0135)	(0.0129)	(0.0128)	(0.0131)	(0.0138)	(0.0147)	(0.0166)
RENT	−0.308 ***	−0.0196	−0.279 ***	−0.286 ***	−0.293 ***	−0.301 ***	−0.309 ***	−0.318 ***	−0.324 ***	−0.331 ***	−0.341 **
	(0.0958)	(0.0480)	(0.103)	(0.0965)	(0.0931)	(0.0925)	(0.0965)	(0.104)	(0.113)	(0.123)	(0.141)
UR	0.203 *	0.0472	0.133	0.150	0.167	0.184	0.205 *	0.226 **	0.242 **	0.257 **	0.282 **
	(0.109)	(0.0491)	(0.139)	(0.128)	(0.120)	(0.113)	(0.108)	(0.108)	(0.110)	(0.115)	(0.127)
GROWTH	0.132	−0.0140	0.153	0.148	0.143	0.138	0.132	0.126	0.121	0.116	0.109
	(0.0843)	(0.0461)	(0.123)	(0.110)	(0.100)	(0.0912)	(0.0838)	(0.0812)	(0.0824)	(0.0862)	(0.0974)
INST	0.0137 **	−0.00375	0.0193 **	0.0179 **	0.0166 **	0.0152 **	0.0136 *	0.0119 *	0.0107	0.00943	0.00742
	(0.00699)	(0.00323)	(0.00927)	(0.00852)	(0.00791)	(0.00738)	(0.00698)	(0.00686)	(0.00695)	(0.00723)	(0.00799)
INFL	−0.0709 **	0.0289 **	−0.114 ***	−0.103 ***	−0.0935 ***	−0.0826 **	−0.0697 **	−0.0573	−0.0475	−0.0380	−0.0225
	(0.0340)	(0.0128)	(0.0358)	(0.0342)	(0.0335)	(0.0336)	(0.0343)	(0.0358)	(0.0375)	(0.0397)	(0.0433)
Log(POP)	0.298 ***	0.0153	0.275 ***	0.281 ***	0.286 ***	0.292 ***	0.299 ***	0.305 ***	0.310 ***	0.315 ***	0.324 ***
	(0.0416)	(0.0207)	(0.0573)	(0.0522)	(0.0480)	(0.0443)	(0.0415)	(0.0405)	(0.0412)	(0.0430)	(0.0478)
Constant	−5.486 ***	−0.177	−5.221 ***	−5.287 ***	−5.348 ***	−5.414 ***	−5.493 ***	−5.569 ***	−5.629 ***	−5.687 ***	−5.781 ***
	(0.883)	(0.461)	(1.280)	(1.156)	(1.054)	(0.959)	(0.878)	(0.841)	(0.844)	(0.875)	(0.974)
Observations—Countries	666-114	666-114	666-114	666-114	666-114	666-114	666-114	666-114	666-114	666-114	666-114

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust Standard Errors are in parentheses. (a) indicates the location parameters, and (b) refers to the scale parameters.

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Table A6. Effect of the shadow economy on the tax transition reform Estimator: Method of Moments Quantile Regression (MMQR).

	Location [a]	Scale [b]	Q10th	Q20th	Q30th	Q40th	Q50th	Q60th	Q70th	Q80th	Q90th
Effect of the Shadow Economy on Tax Transition Reform Conditioned on the Share of Trade Tax Revenue in Non-Resource Tax Revenue											
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SHADOW*SHTRTAX	−0.535 ***	0.0500	−0.609 **	−0.591 **	−0.574 ***	−0.555 ***	−0.532 ***	−0.510 ***	−0.494 ***	−0.477 ***	−0.450 **
	(0.177)	(0.102)	(0.269)	(0.242)	(0.217)	(0.194)	(0.175)	(0.166)	(0.167)	(0.175)	(0.199)
SHADOW	0.405 ***	−0.0988 *	0.552 ***	0.517 ***	0.482 ***	0.444 ***	0.400 ***	0.356 ***	0.325 ***	0.291 **	0.238 *
	(0.115)	(0.0592)	(0.161)	(0.146)	(0.134)	(0.123)	(0.114)	(0.111)	(0.113)	(0.118)	(0.131)
SHTRTAX	0.0931 **	−0.00291	0.0974	0.0964	0.0954 *	0.0943 *	0.0929 **	0.0917 **	0.0908 **	0.0897 **	0.0882 *
	(0.0457)	(0.0262)	(0.0710)	(0.0639)	(0.0571)	(0.0508)	(0.0451)	(0.0420)	(0.0417)	(0.0432)	(0.0488)
Turning point of "SHTRTAX"			**0.906** (=0.552/0.609)	**0.875** (=0.517/0.591)	**0.85** (=0.482/0.574)	**0.8** (=0.444/0.555)	**0.752** (=0.400/0.532)	**0.698** (=0.356/0.510)	**0.658** (=0.325/0.494)	**0.61** (=0.291/0.477)	**0.529** (=0.238/0.450)
Effect of the Shadow Economy on Tax Transition Reform Conditioned on the Real per Capita Income											
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SHADOW*Log(GDP)	0.146 ***	−0.00657	0.156 ***	0.153 ***	0.151 ***	0.149 ***	0.146 ***	0.143 ***	0.140 ***	0.138 ***	0.135 **
	(0.0472)	(0.0192)	(0.0573)	(0.0535)	(0.0506)	(0.0485)	(0.0472)	(0.0475)	(0.0487)	(0.0507)	(0.0549)
SHADOW	−0.829 **	−0.0513	−0.752 *	−0.771 *	−0.790 **	−0.808 **	−0.832 **	−0.854 **	−0.872 **	−0.889 **	−0.914 **
	(0.359)	(0.150)	(0.427)	(0.400)	(0.379)	(0.365)	(0.359)	(0.365)	(0.379)	(0.397)	(0.434)
Log(GDPC)	0.0908 ***	−0.00843	0.104 **	0.100 **	0.0973 **	0.0943 **	0.0904 ***	0.0867 ***	0.0837 **	0.0810 **	0.0768 **
	(0.0349)	(0.0183)	(0.0513)	(0.0462)	(0.0418)	(0.0381)	(0.0346)	(0.0331)	(0.0331)	(0.0342)	(0.0377)

Table A6. *Cont.*

Effect of the Shadow Economy on Tax Transition Reform Conditioned on the Level of Trade Openness

Variables	Location [a]	Scale [b]	Q10th	Q20th	Q30th	Q40th	Q50th	Q60th	Q70th	Q80th	Q90th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SHADOW*OPEN	0.388 ***	0.0574	0.298 *	0.325 **	0.343 **	0.363 ***	0.386 ***	0.416 ***	0.434 ***	0.452 ***	0.485 ***
	(0.110)	(0.0525)	(0.173)	(0.152)	(0.138)	(0.125)	(0.111)	(0.0959)	(0.0897)	(0.0868)	(0.0890)
SHADOW	0.0589	−0.109 *	0.229	0.179	0.144	0.107	0.0624	0.00607	−0.0290	−0.0621	−0.125
	(0.121)	(0.0584)	(0.173)	(0.153)	(0.142)	(0.132)	(0.122)	(0.117)	(0.116)	(0.120)	(0.131)
OPEN	−0.0635	−0.00962	−0.0484	−0.0529	−0.0559	−0.0592	−0.0632	−0.0681 **	−0.0712 **	−0.0741 **	−0.0797 **
	(0.0396)	(0.0187)	(0.0622)	(0.0549)	(0.0500)	(0.0452)	(0.0400)	(0.0347)	(0.0325)	(0.0313)	(0.0319)

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust Standard Errors are in parentheses. (a) indicates the location parameters, and (b) refers to the scale parameters. For the sake of brevity, we report here the outcomes concerning variables of key interest in the analysis. Estimates concerning other control variables are similar to those presented in Table A5 and can be obtained upon request.

Table A7. Effect of the shadow economy on tax transition reform Estimator: Two-Step System GMM.

Variables	TTR	TTR	TTR	TTR	TTR
	(1)	(2)	(3)	(4)	(5)
TTR_{t-1}	0.495 ***	0.520 ***	0.522 ***	0.458 ***	0.499 ***
	(0.0143)	(0.0137)	(0.0119)	(0.0188)	(0.0116)
SHADOW	0.0723 **	0.123 ***	0.192 ***	−1.632 ***	−0.139 ***
	(0.0301)	(0.0357)	(0.0342)	(0.176)	(0.0203)
SHADOW*SHTRTAX		−0.567 ***			
		(0.129)			
SHADOW*LICs			−0.202 ***		
			(0.0394)		
SHADOW*Log(GDP)				0.221 ***	
				(0.0237)	
SHADOW*OPEN					0.242 ***
					(0.0114)
LICs			0.0762 ***		
			(0.0214)		
SHTRTAX	−0.159 ***	−0.0165	−0.133 ***	−0.163 ***	−0.160 ***
	(0.0180)	(0.0512)	(0.0141)	(0.0222)	(0.0164)
Log(GDPC)	−0.0171 ***	−0.0170 ***	−0.00111	−0.0883 ***	−0.0165 ***
	(0.00410)	(0.00232)	(0.00465)	(0.00811)	(0.00238)
OPEN	0.0187 ***	0.0189 ***	0.0151 ***	0.0368 ***	−0.0467 ***
	(0.00552)	(0.00452)	(0.00480)	(0.00528)	(0.00306)
RENT	−0.297 ***	−0.279 ***	−0.293 ***	−0.288 ***	−0.288 ***
	(0.0224)	(0.0174)	(0.0161)	(0.0214)	(0.0129)
UR	0.0586	0.0238	−0.00910	0.0559	−0.00349
	(0.0485)	(0.0392)	(0.0444)	(0.0506)	(0.0437)
GROWTH	0.515 ***	0.514 ***	0.504 ***	0.425 ***	0.454 ***
	(0.0393)	(0.0280)	(0.0375)	(0.0377)	(0.0275)
INST	0.0191 ***	0.0179 ***	0.0188 ***	0.0256 ***	0.0239 ***
	(0.00314)	(0.00233)	(0.00162)	(0.00341)	(0.00186)
INFL	0.0191	0.0312 ***	0.00267	0.0469 ***	0.00553
	(0.0158)	(0.0112)	(0.0107)	(0.0147)	(0.0103)
Log(POP)	0.00578 **	0.00511 ***	0.00436 *	0.00690 **	0.00517 **
	(0.00278)	(0.00166)	(0.00234)	(0.00288)	(0.00212)
Observations—Countries	555-114	555-114	555-114	555-114	555-114
AR1 (*p*-value)	0.0270	0.0269	0.0263	0.0327	0.0283
AR2 (*p*-value)	0.1207	0.1094	0.10	0.10	0.1087
OID (*p*-value)	0.3849	0.5027	0.4040	0.4127	0.3012

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust Standard Errors are in parentheses. The variables "SHADOW", "SHTRTAX", "OPEN", "GROWTH", "UR", "INFL", "INST", "RENT", and the interaction variables have been treated as endogenous. The variable "POP" has been considered as exogenous. Time dummies have been included in the regressions. The latter have used 2 lags of endogenous variables as instruments.

Appendix A.1. Definition and Source of Variables

Variables	Definition	Source
STR	This is the first indicator of revenue-enhancing structural tax reform. It identifies the episodes of large tax revenue mobilization identified over the period from 2000 to 2015 (see Akitoby et al. 2020). The variable "STR" takes the value of 1 for a year characterized by a large revenue mobilization and the value of 0 for other years. The different areas of tax policy and revenue administration where major reforms took place are as follows: Personal Income Tax ("PIT"); Corporate Income Tax ("CIT"); Goods and Services Tax ("GST"); Value Added Tax ("VAT"); Excise Tax ("EXCISE"); Trade Tax ("TRTAX"); Property Tax ("PROPERTY"); Subsidies ("SUBSIDIES"); and Revenue Administration ("REVADM").	Data extracted from Akitoby et al. (2020)
TTR	This is the second indicator of tax reform, referred to as 'tax transition reform'. It reflects the extent of the reform of the tax revenue structure towards a lower dependence of the non-resource tax revenue on international trade tax revenue (and hence in favor of a greater dependence of the non-resource tax revenue on domestic tax revenue). Practically, it captures the convergence of the tax revenue structure of a given developing country towards the developed countries' tax revenue structure. Its values range between 0 and 100, with higher values reflecting greater tax revenue structure convergence, i.e., greater tax reforms.	Author's computation (see Section 3.2.1) based on data extracted from the 'UNU-WIDER Government Revenue Dataset'. Version 2021. https://www.wider.unu.edu/project/grd-%E2%80%93-government-revenue-dataset (Accessed in 20 June 2021).
SHADOW	This is the measure of the share of the size of the shadow economy in the official GDP. It has been computed by Medina and Schneider (2018) using the multiple indicators, multiple causes (MIMIC) method. The latter extracts covariance information from observable variables classified as causes or indicators of the latent shadow economy (see Schneider et al. 2010 for more details on this approach).	Data extracted from Medina and Schneider (2018)
SHTRTAX	This is the share of international trade tax revenue in total non-resource tax revenue. Non-resource tax revenue is the difference between total tax revenue (as a share of GDP, excluding social contributions) and tax revenue collected on natural resources (the latter includes a significant component of economic rent, primarily from oil and mining activities) as a share of GDP.	Author's calculation based on data extracted from the UNU-WIDER Government Revenue Dataset'. Version 2021. https://www.wider.unu.edu/project/grd-%E2%80%93-government-revenue-dataset (Accessed in 20 June 2021).
GDPC	Real per capita Gross Domestic Product (constant 2015 USD).	World Development Indicators (WDIs) of the World Bank
GROWTH	Real Growth Rate of the Gross Domestic Product, annual change (constant 2015 USD).	WDI
OPEN	This is the indicator of trade openness, measured by the share (in percentage) of the sum of exports and imports of GDP.	WDI
INFL	The variable "INFL" has been calculated using the following formula: $\text{INFL} = sign(INFLATION) * \log(1 + |INFLATION|)$ (2), where $|INFLATION|$ refers to the absolute value of the annual inflation rate (not in percentage), denoted "INFLATION". The inflation rate is based on Consumer Price Index (CPI), where missing values have been replaced with values of the GDP Deflator.	Authors' calculation based on data from the WDI.

Variables	Definition	Source
EDU	This is the average of the gross primary school enrollment (in percentage), gross secondary school enrollment (in percentage), and gross tertiary school enrollment (in percentage).	Author's calculation based on data collected from the WDI.
RENT	This is the share of total natural resource rents in GDP.	WDI
UR	Rate of total unemployment (i.e., for both male and female) as a share of total labor force.	WDI
POP	Total Population	WDI
INST	This is the variable capturing the institutional quality. It has been computed by extracting the first principal component (based on factor analysis) of the following six indicators of governance: political stability and absence of violence/terrorism; regulatory quality; rule of law; government effectiveness; voice and accountability; and corruption. Higher values of the index "INST" are associated with better governance and institutional quality, while lower values reflect worse governance and institutional quality.	Data on the components of "INST" variables have been extracted from World Bank Governance Indicators developed by Kaufmann et al. (2010) and updated recently. See online at: https://info.worldbank.org/governance/wgi/ (Accessed in 20 June 2022).

Appendix A.2. Descriptive Statistics on Variables Used in the Analysis over the Full Sample

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
STR	481	0.308	0.462	0	1
PIT	481	0.116	0.321	0	1
CIT	481	0.154	0.361	0	1
GST	481	0.083	0.276	0	1
VAT	481	0.175	0.380	0	1
EXCISE	481	0.233	0.423	0	1
TRTAX	481	0.089	0.286	0	1
PROPERTY	481	0.037	0.190	0	1
SUBSIDIES	481	0.027	0.162	0	1
REVADM	481	0.287	0.453	0	1
SHADOW	481	36.104	7.869	20.380	68.460
GROWTH	481	4.320	4.360	−36.392	20.716
UR	481	7.782	5.388	0.390	28.640
GDPC	481	3453.151	5453.988	295.737	35,852.240
INFLATION	481	0.064	0.067	−0.043	0.738
EDU	460	55.715	20.661	1.612	94.347
OPEN	480	77.687	33.455	20.964	311.354
INST	444	−1.100	1.336	−3.750	2.989
POP	481	14,100,000	20,400,000	255,068	102,000,000
RENT	481	7.674	10.221	0.006	58.650

Appendix A.2.1. Pairwise Correlation Statistics on Variables Used in the Analysis over the Full Sample of 40 LICs and Ems

	STR	PIT	PIT	GST	VAT	EXCISE	TRTAX	PROPERTY	SUBSIDIES	REVADM
STR	1.0000									
PIT	0.5445 *	1.0000								
CIT	0.6396 *	0.5638 *	1.0000							
GST	0.4518 *	0.3837 *	0.4142 *	1.0000						
VAT	0.6900 *	0.6184 *	0.5324 *	0.4168 *	1.0000					
EXCISE	0.8264 *	0.4902 *	0.5149 *	0.4576 *	0.5758 *	1.0000				
TRTAX	0.4700 *	0.2043 *	0.1087 *	0.3806 *	0.3549 *	0.4825 *	1.0000			
PROPERTY	0.2958 *	0.2017 *	0.1284 *	0.1390 *	0.4286 *	0.3579 *	0.1302 *	1.0000		
SUBSIDIES	0.2500 *	0.1394 *	0.1777 *	0.2748 *	0.2948 *	0.2115 *	0.1725 *	−0.0329	1.0000	
REVADM	0.9514 *	0.5723 *	0.6085 *	0.4748 *	0.7252 *	0.8142 *	0.4134 *	0.3109 *	0.2628 *	1.0000
SHADOW	−0.0323	0.1021 *	0.0009	−0.0080	0.0500	0.0398	0.0204	−0.0106	0.0346	0.0066
GROWTH	0.0869 *	0.0309	0.0170	−0.0007	0.0290	0.0398	0.0675	0.0090	−0.0555	0.0774 *
UR	−0.0669	0.0565	0.0455	−0.0326	0.0520	−0.0969 *	−0.0476	−0.0193	0.0788 *	−0.0583
GDPC	−0.0840 *	−0.0947 *	−0.0600	−0.0817 *	−0.0995 *	−0.0787 *	0.0079	−0.0216	−0.0613	−0.1197 *
INFLATION	−0.0411	−0.0184	−0.0400	−0.0676	−0.0488	−0.0098	−0.0071	−0.0932 *	−0.0345	−0.0374
EDU	−0.0466	−0.0478	−0.0026	−0.1790 *	0.0160	−0.0884 *	−0.0005	−0.0392	−0.1330 *	−0.0797 *
OPEN	0.0559	0.0641	0.1113 *	0.1057 *	−0.0214	−0.0363	−0.0862 *	−0.1194 *	−0.1223 *	0.0875 *
INST	−0.0525	0.0317	−0.0471	0.0569	−0.0012	−0.0382	0.0766	0.0373	−0.0452	−0.0617
POP	0.0421	−0.0763 *	0.0761 *	−0.1362 *	−0.0483	0.0490	−0.0081	0.0120	−0.0964 *	−0.0259
RENT	0.0554	−0.0661	0.0049	0.0076	−0.0629	−0.0085	−0.0871 *	−0.0570	−0.0399	0.0597

Note: * p-value < 0.1.

Appendix A.2.2. (Continued): Pairwise Correlation Statistics on Variables Used in the Analysis over the Full Sample of 40 LICs and EMs

	SHADOW	GROWTH	UR	GDPC	INFLATION	EDU	OPEN	INST	POP	RENT
SHADOW	1.0000									
GROWTH	−0.0616	1.0000								
UR	0.0592	−0.1413 *	1.0000							
GDPC	−0.1950 *	−0.1570 *	0.2600 *	1.0000						
INFLATION	0.0659	−0.1049 *	−0.1367 *	−0.0867 *	1.0000					
EDU	−0.0296	0.0223	0.1369 *	0.2237 *	0.0071	1.0000				
OPEN	0.0278	0.0480	0.2635 *	0.0584	−0.0350	0.2392 *	1.0000			
INST	−0.1968 *	−0.0366	0.4596 *	0.6609 *	−0.1875 *	0.3124 *	0.1120 *	1.0000		
POP	−0.1467 *	0.0610	−0.1418 *	−0.0357	0.0747	0.1044 *	−0.1956 *	−0.0459	1.0000	
RENT	−0.0512	0.0078	−0.0397	−0.2065 *	0.0372	−0.2887 *	0.0837 *	−0.5100 *	−0.0748	1.0000

Note: * p-value < 0.1. The variables "SHADOW", "OPEN", "UR", "GROWTH", and "RENT" are expressed in percentage.

Appendix A.3. List of the 40 Developing Countries Contained in the Full Sample, including Low-Income Countries (LICs) and Emerging Markets (EMs)

Full Sample (40 Developing Countries)		LICs	EMs
Algeria	Mauritania	Burkina Faso	Algeria
Armenia	Moldova	Burundi	Armenia
Bahamas, The	Morocco	Cabo Verde	Bahamas, The
Belize	Namibia	Cambodia	Belize
Bosnia and Herzegovina	Nepal	Central African Republic	Bosnia and Herzegovina
Bulgaria	Nicaragua	Comoros	Bulgaria
Burkina Faso	Paraguay	Congo, Rep.	Ecuador
Burundi	Philippines	Gambia, The	Georgia
Cabo Verde	Rwanda	Guinea	Jamaica
Cambodia	Senegal	Guinea-Bissau	Morocco
Central African Republic	Sierra Leone	Guyana	Namibia
Comoros	Solomon Islands	Kyrgyz Republic	Paraguay
Congo, Rep.	Turkey	Lao PDR	Philippines
Ecuador	Uganda	Liberia	Turkey
Gambia, The	Ukraine	Maldives	Ukraine
Georgia	Uruguay	Mauritania	Uruguay
Guinea		Moldova	
Guinea-Bissau		Nepal	
Guyana		Nicaragua	
Jamaica		Rwanda	
Kyrgyz Republic		Senegal	
Lao PDR		Sierra Leone	
Liberia		Solomon Islands	
Maldives		Uganda	

Appendix A.4. Descriptive Statistics on Variables Used in the Analysis Covering the Full Sample of 114 Developing Countries

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
TTR	666	0.595	0.183	0.054	0.971
SHADOW	666	0.344	0.116	0.098	0.709
SHTRTAX	666	0.191	0.189	0	1
UR	666	0.079	0.059	0.005	0.321
GDPC	666	6523.865	9088.266	237.276	57,723.070
INFLATION	666	0.106	0.290	−0.069	4.140
RENT	666	0.075	0.108	0.000	0.620
OPEN	666	0.877	0.561	0.003	4.193
GROWTH	666	0.043	0.034	−0.084	0.220
INST	666	−0.572	1.766	−4.892	3.955
POP	666	44,900,000	170,000,000	214,065.700	1,360,000,000

Note: The variables "SHADOW", "SHRTAX", "OPEN", "UR", "GROWTH", and "RENT" are not expressed in percentage for the sake of the analysis.

Appendix A.4.1. Correlation Statistics on Variables Used in the Analysis over the Full
Sample

	TTR	SHADOW	SHRTAX	UR	GDPC	INFLATION	RENT	OPEN	GROWTH	INST	POP
TTR	1.0000										
SHADOW	−0.2227 *	1.0000									
SHRTAX	−0.6623 *	0.1204 *	1.0000								
UR	0.2538 *	−0.0932 *	−0.0636	1.0000							
GDPC	0.0201	−0.4960 *	0.0847 *	−0.0112	1.0000						
INFLATION	−0.1212 *	0.1288 *	0.0006	−0.0465	−0.1154 *	1.0000					
RENT	−0.5589 *	0.0622	0.3595 *	−0.0192	0.0239	0.1067 *	1.0000				
OPEN	0.2059 *	−0.3237 *	−0.1299 *	0.0503	0.5067 *	−0.0793 *	−0.0586	1.0000			
GROWTH	−0.0674 *	−0.0272	−0.0157	−0.0912 *	−0.0846 *	−0.1384 *	0.0960 *	0.0139	1.0000		
INST	0.4808 *	−0.5667 *	−0.2017 *	0.1975 *	0.6540 *	−0.2006 *	−0.3995 *	0.4817 *	−0.0736 *	1.0000	
POP	0.0596	−0.1825 *	−0.0478	−0.1027 *	−0.0849 *	−0.0129	−0.0574	−0.1723 *	0.1536 *	−0.0614	1.0000

Note: * *p*-value < 0.1. The variables "SHADOW", "SHRTAX", "OPEN", "UR", "GROWTH", and "RENT" are not expressed
in percentage for the sake of the analysis.

Appendix A.5. List of the 114 Developing Countries, including 44 LICs in the Full Sample

Full Sample (114 Developing Countries)		
Albania	Ethiopia **	Mexico
Algeria	Fiji	Moldova **
Angola	Gabon	Mongolia
Argentina	Gambia, The **	Morocco
Armenia	Georgia	Mozambique **
Azerbaijan	Ghana **	Myanmar **
Bahamas, The	Guatemala	Namibia
Bahrain	Guinea **	Nepal **
Bangladesh **	Guinea-Bissau **	Nicaragua **
Belarus	Guyana	Niger **
Belize	Haiti **	Nigeria
Benin **	Honduras **	Pakistan
Bhutan **	Hong Kong SAR, China	Papua New Guinea **
Bosnia and Herzegovina	Hungary	Paraguay
Botswana	India	Philippines
Brazil	Indonesia	Poland
Brunei Darussalam	Iran, Islamic Rep.	Romania
Bulgaria	Israel	Rwanda **
Burkina Faso **	Jamaica	Saudi Arabia
Burundi **	Jordan	Sierra Leone **
Cabo Verde **	Kazakhstan	Singapore
Cambodia **	Kenya **	Slovak Republic
Central African Republic **	Korea Republic **	Slovenia
Chad **	Kuwait	Solomon Islands **
Chile	Kyrgyz Republic	South Africa
China	Lao PDR **	Sri Lanka
Comoros **	Latvia	Suriname

Full Sample (114 Developing Countries)		
Democratic Republic Congo **	Lebanon	Tajikistan **
Congo Republic **	Lesotho **	Tanzania **
Cote d'Ivoire **	Liberia **	Thailand
Cyprus	Libya	Tunisia
Czech Republic	Lithuania	Turkey
Dominican Republic	Madagascar **	Uganda **
Ecuador	Malaysia **	Ukraine
El Salvador	Maldives	United Arab Emirates
Equatorial Guinea	Malta	Uruguay
Eritrea **	Mauritania **	Zambia **
Estonia	Mauritius	Zimbabwe **

Note: Low-Income Countries (LICs) as defined by the IMF are marked with "**".
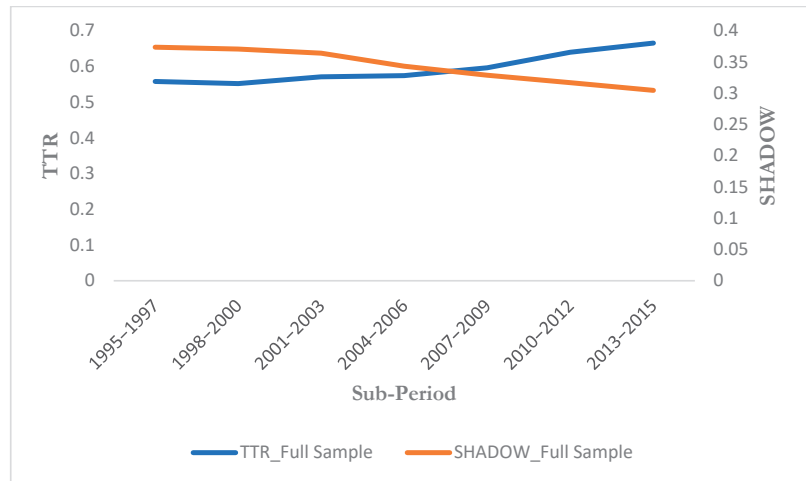
Figure A1. Development of the shadow economy and tax transition reform over the full sample. Source: Author.
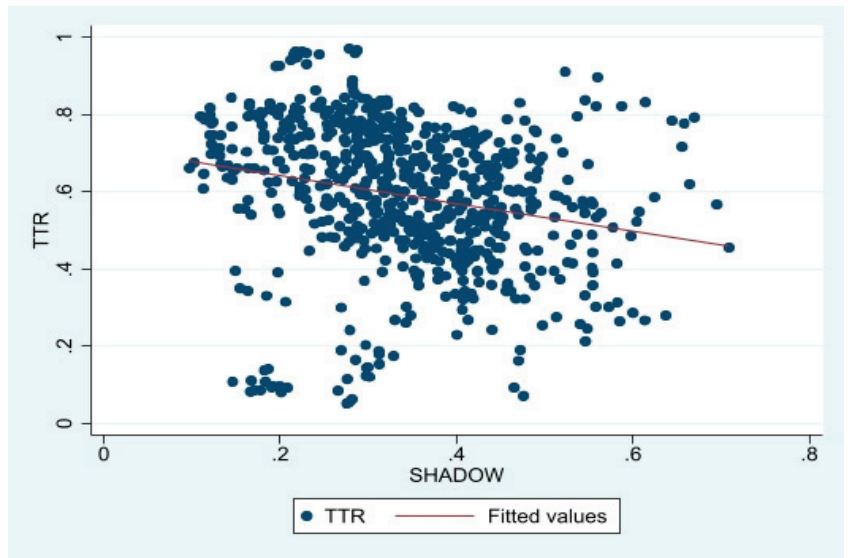
Figure A2. Correlation pattern between the shadow economy and tax transition reform over the full sample. Source: Author.
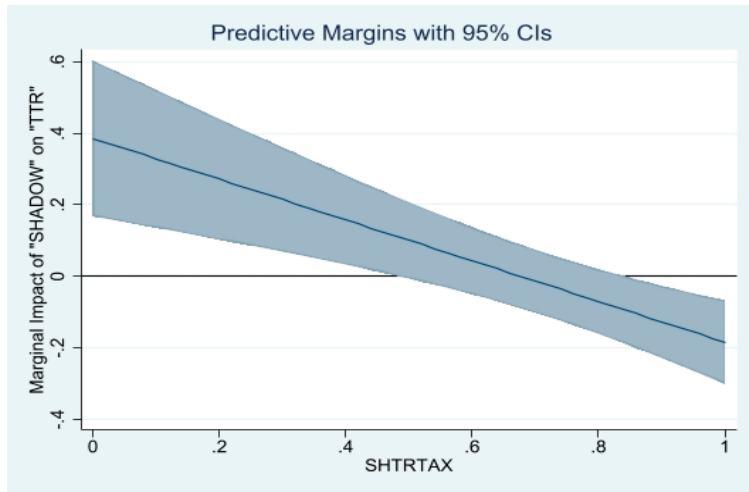
Figure A3. Marginal Impact of "SHADOW" on "TTR" for varying shares of trade tax revenue in non-resource tax revenue ("SHTRTAX"). Source: Author.
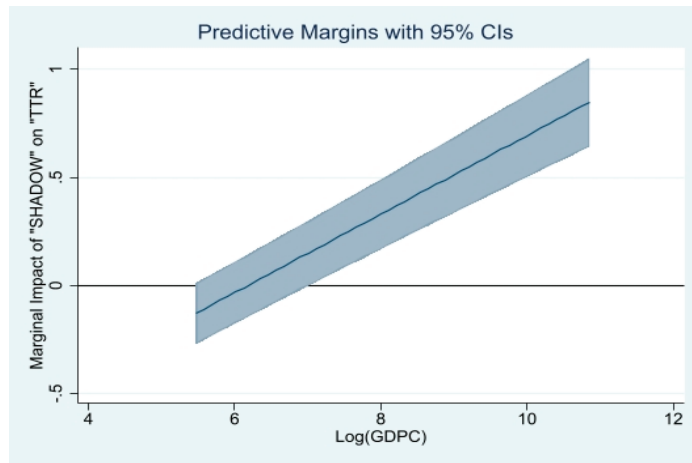
Figure A4. Marginal Impact of "SHADOW" on "TTR" conditioned on the real per capita GDP. Source: Author.
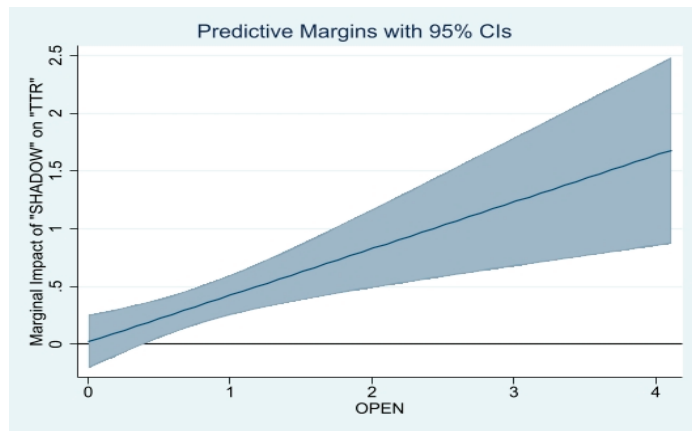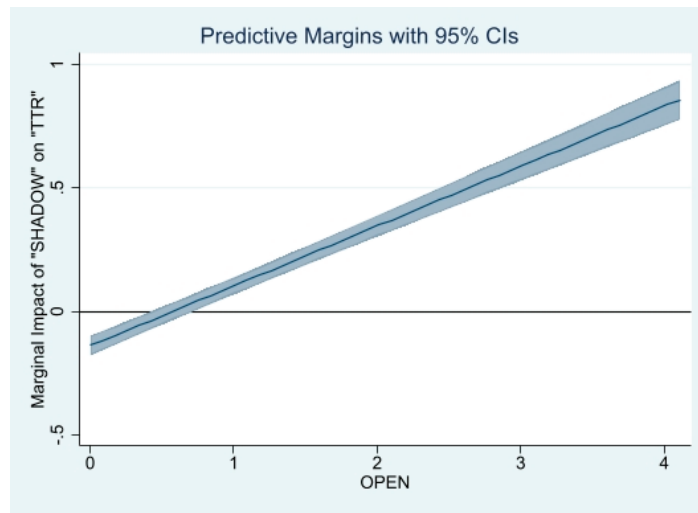

Figure A5. Marginal Impact of "SHADOW" on "TTR" for varying levels of trade openness. Source: Author.
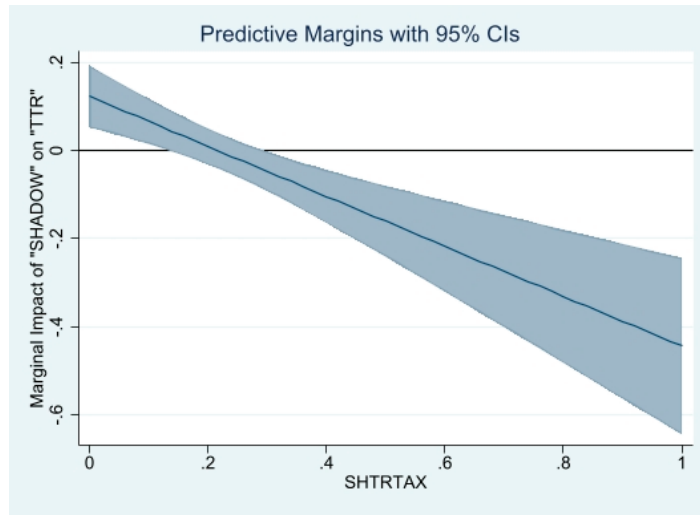
Figure A6. Marginal Impact of "SHADOW" on "TTR" for varying shares of trade tax revenue in non-resource tax revenue ("SHTRTAX"). Source: Author.
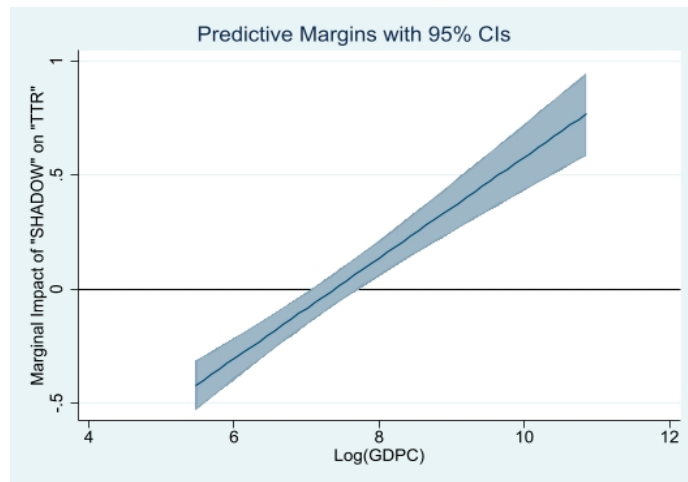
Figure A7. Marginal Impact of "SHADOW" on "TTR" conditioned on the real per capita GDP. Source: Author.

Figure A8. Marginal Impact of "SHADOW" on "TTR" for varying levels of trade openness. Source: Author.

Notes

[1]   These include for example, resources for monitoring and enforcement (e.g., well-trained and educated staff, insufficient data and technology (e.g., electronic payments systems)).

[2]   For example, the share of the shadow economy in GDP for countries such as Zimbabwe and Bolivia amounted to 60.6 percent and 62.3 percent, respectively, over the period from 1991 to 2015 (see Medina and Schneider 2018).

[3]   For example, the share of the shadow economy in GDP for countries such as Austria and Switzerland amounted to 8.9 percent and 7.2 percent, respectively, over the period from 1991 to 2015 (see Medina and Schneider 2018).

[4]   Such a trade liberalization takes place not only under the auspices of the WTO (i.e., through multilateral trade liberalization) but also through countries' participation in regional trade agreements and plurilateral trade agreements.

[5]   It is relatively easy for governments to collect trade tax revenue compared to domestic tax revenue in developing countries.

[6]   The advice has usually been made that in reforming the domestic tax revenue structure, policymakers in developing countries should broaden the consumption tax base (e.g., Ban and Gallagher 2015; Reinsberg et al. 2020; Kentikelenis and Seabrooke 2017; Kreickemeier and Raimondos-Møller 2008).

[7]   See for example, Adandohoin (2021); Chambas (2005); Gnangnon and Brun (2019a, 2019b); and Gnangnon (2019, 2020, 2021).

[8]   The literature on the effect of the shadow economy on international trade is limited. Some studies have found that the small size of the entities that operate in the shadow economy undermines the penetration in the regional or international trade markets and hence hampers countries' participation in international trade (e.g., Elbadawi and Loayza 2008; La Porta and Shleifer 2008). This is because operators (producers) in the informal sector face huge regulatory obstacles that substantially increase their businesses' transaction costs (e.g., Hall and Sobel 2008) and constrain their participation in international trade. A few other studies have noted that the increase in the shadow economy may help expand opportunities in trade under specific conditions, such as the existence of vertical linkages with the formal sector (e.g., Carr and Chen 2002) or the existence of the possibility to switch jobs from the informal to the formal sector with skill upgrading and new skills, which requires certain levels of education, opportunities for retraining, etc. (e.g., Davis and Haltiwanger 1990; Davis et al. 1996).

[9]   This raises equity concerns given that in developing countries, the incomes of operators in the shadow economy are low.

[10]   As we will see later, the indicator of tax transition reform used in the empirical analysis has been computed on the basis of this definition.

[11]   As we will see later in the analysis, the tax revenue's dependence on trade tax revenue is measured by the share of international trade tax revenue in non-resource tax revenue.

[12]   A rich theoretical literature has been developed on the effect of trade openness on the shadow economy, using various approaches and assumptions concerning the functioning of the labor market and the informal economy (e.g., Sinha 2009). The variety of the theoretical findings reflects the multiple approaches and assumptions made in the theoretical analyses. In these theoretical analyses, the effect of trade openness on the shadow economy depends on the degree of capital mobility between the formal and informal sectors, the existence of vertical linkages between the formal and the informal economy, and whether the informal

economy is disconnected from the formal economy and hence constitutes a residual economy (e.g., see a literature review in Bacchetta et al. 2009).

13 Few studies in the literature have dealt with the effect of the shadow economy on tax revenue (e.g., Ishak and Farzanegan 2020; Mazhar and Méon 2017; Vlachaki 2015).

14 According to Prichard (2018), booms in business cycles should allow for greater tax revenue mobilization.

15 As we will see below, our panel data cover only relatively few developing countries and the period from 2000 to 2015, because we rely on the episodes of tax reform identified by Akitoby et al. (2020).

16 This approach involves using the individual and time effects for the model and treating individuals' unobserved effects.

17 Cruz-Gonzalez et al. (2017) have developed routines in the Stata software to address the incidental parameter problem in panel models with individual and time effects and a binary response dependent variable.

18 However, this approach has the drawback of eliminating all individuals for which there is no variation in the binary response variable.

19 See for example, Gërxhani (2004) for a literature review.

20 Keshk (2003) has developed a routine in the Stata software to estimate the 2SPLS models.

21 In this equation, the shadow economy indicator is the dependent variable, and the structural tax reform indicator is an explanatory variable.

22 On another note, Gnangnon (2019) has provided empirical evidence that greater tax transition reform encourages countries to further open up their economies to international trade.

23 High inflation rates could lead to an appreciation of the real exchange rate, thereby favoring imports and hence generating higher trade tax revenue.

24 Limiting here our period of analysis to the year 2015 also helps ensure that we have the same end year (i.e., 2015) as in the panel dataset developed by Akitoby et al. (2020) and used to estimate model (A.1). We, nevertheless, use data from the year 1995 here, with a view to making full use of available data.

25 We use the 3-year sub-periods (and not, for example, 5-year sub-periods) because the time dimension of the panel data is relatively short. By allowing us to dampen the effect of business cycles on variables at hand, the use of the 3-year average data also helps reduce the time dimension of the panel data and concurrently ensure the availability of relatively sufficient information to perform the empirical analysis.

26 It is worth noting that the indicator of tax transition reform has been computed for each developing country per year, before computing the 3-year non-overlapping dataset.

27 While it is difficult to identify precisely which countries could be considered as 'developed countries' versus 'developing countries', we follow studies cited above that computed this indicator and opt for considering 'developed countries' as the so-called "old-industrialized countries". This set of countries has a structure of tax revenue that is weakly dependent on international trade tax revenue. The "old-industrialized countries" include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden Switzerland, the United Kingdom, and the United States of America (see the studies cited above).

28 The MIMIC method is a theory-based approach that can be used to estimate the influence of a set of exogenous causal variables on the latent variable (which is, here, the shadow economy) (see Frey and Weck-Hanneman 1984, who were among the first scholars that applied this approach).

29 Other recent empirical analyses that have used this indicator include, for example, Berdiev and Saunoris (2018), Berdiev et al. (2018, 2020), and Canh et al. (2021).

30 In fact, the conventional panel quantile regression methods allow the individual effects to only cause parallel (location) shifts of the distribution of the dependent variable with a view to mitigating the effect of the incidental parameters problem.

31 Rios-Avila (2020) has developed a routine (mmqreg) in the Stata software to estimate quantile regressions via the Methods of Moments. In running the regressions, we have used the "absorb" function to take into account time-invariant unobserved specific effects and time effects.

32 This estimator uses Driscoll and Kraay's (1998) technique to correct standard errors for the heteroscedasticity, autocorrelation, and the correlation among countries in the error term. In fact, the Driscoll and Kraay's (1998) technique uses a nonparametric covariance matrix estimator to generate standard errors that are heteroscedasticity-consistent and robust to very general forms of spatial and temporal dependence (e.g., Hoechle 2007; Vogelsang 2012).

33 These regressors are the shadow economy, the share of trade tax revenue in total non-resource tax revenue, the level of trade openness, the share of total natural resource rents in GDP, the unemployment rate, the economic growth rate, and the institutional and governance quality.

34 The dummy "LIC" takes the value of 1 for LICs, as defined by the International Monetary Fund, and 0 otherwise (Appendix A.5 contains the list of the 44 LICs used here). Note that as the model specification is estimated using the within fixed effects approach, the dummy LIC is dropped from the regression. This explains why we have not reported the estimate of this dummy variable. This estimate is indeed not relevant here.

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Article

Do Increased Tax Base and Reductions in the Underground Economy Compensate for Lost Tax Revenue Following a Tax Reduction Policy? Evidence from Italy 1982 to 2006

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Abstract: We here examine the frequent claim that an increase in the tax base and a decrease in tax evasion will compensate for a loss in tax revenues caused by a lower tax level. Using a unique data set for the estimated underground economy in Italy from 1982 to 2006, we found that a loss in tax revenues equivalent to 1% of the GDP would be partly compensated by an increase in GDP of 0.55%. The compensation would come from 0.31% of the GDP increase and from 0.24% of the reductions in the underground economy. These results apply to an economy with a high tax level (>32%) and a high underground economy ($\geq$25%). Applying a high-resolution lead–lag method to the data, we ensured that tax changes were leading the GDP and, thus, a potential cause for changes in the GDP.

1. Introduction

Revenue loss from tax reductions is often claimed to be compensated by increases in the gross domestic product (GDP) and decreases in the underground economy (UGE) by both the popular press (Krugman 2019) and politicians (Muller et al. 2016). However, the literature is not conclusive on the effects of tax reductions (Mountford and Uhlig 2009; Trabandt and Uhlig 2011; Arin et al. 2013; Seip 2019), or on the effects of tax evasion (Romer and Romer 2010; Muehlbacher et al. 2011). One reason is that a change in tax policy will have an effect over interannual time horizons, which over longer time periods may diminish or merge with other effects or changes in tax policies.

Here, we examine if a decrease in taxes, increases the GDP and decreases the underground economy (UGE), and if the two effects are sufficient to compensate for the loss in tax revenues at the lower tax level. The objective of the study is formulated in three hypotheses below and supported by rationales for the reasonability of the hypotheses. An examination of the results in the context of previous studies on taxation, the GDP, and the UGE is given in the discussion section.

We use a high-resolution lead–lag (HRLL) technique that allows us to identify lead–lag (LL) relations over very short time windows (n = 3 consecutive and synoptic observations, with n = 9, significance levels that can be identified, Seip and Grøn (2018)). The short time windows allow us to see how a leading role for one variable may change to a lagging role after a short period of ≈10 time steps. Alternative LL methods require much longer time series, typically n = 30–40. In most cases, they require that the series are stationary and Gaussian, e.g., for cross-correlation techniques and non-linear state space reconstructions (Sugihara et al. 2012; Kestin et al. 1998).

In the present study, all series were first linearly detrended so that the focus was on the decadal changes in the variable. In other studies, the first difference is used to detrend the relevant economic time series. However, the first difference may shift peak and trough patterns relative to their dates in the raw series as well as introduce more high-frequency noise. Second, we identified time windows during the period from 1982 to 2006 when changes in tax policies led to changes in the GDP and the UGE, and thus enhanced the probability that the tax policies were the cause for changes in the GDP and the UGE. To our knowledge, there is only one other study, Seip (2019), that identified time windows where tax changes led to changes in the GDP. However, that study dealt with US data and did not address issues with tax evasion.

Our study is restricted to the period from 1982 to 2006 because we had reliable estimates from two independent sources for the amount of tax evasion during this period. Orsi et al. (2014) used DSGE modeling, and Chiarini et al. (2013) used estimates from value-added tax reports.

We found that decreasing total taxes (TT) increased the GDP and decreasing personal taxes (PT) decreased the UGE. Overall, based on the Italian economy during the period from 1982 to 2006, the loss in tax revenue from decreasing taxes was partly compensated by approximately one-half of the losses from increasing the GDP and decreasing the UGE. The contribution from the GDP increase was the largest (56%). Our findings are generic and can be applied to economies with a high tax burden greater than about 32%, and a sizeable UGE above about 25% of the economy. Thus, the equations we arrive at for the relations between tax burden, the GDP, and the UGE could contribute to estimating the effects of changing taxes.

Hypotheses

We suggest three hypotheses. First hypothesis, **H1**: When total taxes decrease, the GDP will increase over an interannual time scale. The rationale is that when taxes decrease, the private sector will use the surplus gain to invest and increase effectiveness. Second hypothesis, **H2**: When personal taxes increase, the UGE will increase, because, in the tradeoff between higher personal gain and the chance of being caught, tax evasion and personal gain will be favored. Third hypothesis, **H3**: The loss in tax revenues (TR) from a reasonable ($\approx$1–5%) reduction in tax rates will be compensated by the gain in taxes from a higher GDP and a lower UGE.

GDP and UGE in Italy. It is reasonable to believe that the effect of a tax policy depends on the tax level (Trabandt and Uhlig 2011) and on the mix of taxes. Our study uses data on taxation, the GDP, and the UGE in Italy from 1982 to 2006 (2006 being the last year where UGE data were calculated (Orsi et al. 2014)). Total taxes varied between 27% and 36% of the GDP and personal taxes rose from 25% in 1982 to 46% in 2006. The UGE ranged between 7% and 26% of the total economy. Thus, the Italian economy lends itself to the study of the effects of tax levels on the economy. However, the effects of tax policy may depend on the ability of an economy to harvest the benefits of a tax cut (Bloom et al. 2013) and on the tax morale of the society in which it is implemented (Barone and Mocetti 2011; Alm 2012; Moro-Egido and Solano-García 2020).

The rest of the paper is organized as follows. In Section 2, we present the data. In Section 3, we give an outline of the method, particularly the high-resolution lead–lag (LL) method. In Section 4 we show the results, and in Section 5 we discuss the results and outline policy implications. In Section 6, we conclude.

2. Data

Our target variables are the GDP and the UGE during the period from 1982 to 2006 in Italy. We use (i) TT as a candidate causal variable for changes in the GDP and (ii) PT as a candidate causal variable for changes in the UGE. We also examine (iii) tax evasion control efforts. The UGE refers to activities that are productive and legal but concealed from public authorities to evade being taxed or to avoid regulations. Tax evasion refers

to the part of the UGE that is concealed to avoid taxes on income, value-added taxes, or other taxes (Dell'Anno and Davidescu (2019) citing OECD (2002)). Both TT and PT were supplied as percentages of the GDP by Orsi et al. (2014) but were recalculated to monetary units (Euro) for some purposes. Tax revenues are the government's income from tax level (%) and changes in the tax base (number of people and firms paying taxes).

In a recent study, Orsi et al. (2014), taking a cue from the model of Allingham and Sandmo (1972), have proposed a dynamic stochastic general equilibrium model, DSGE, that allows for an estimate of the underground economy in Italy for the period 1982 to 2006. Personal, corporate, and social taxes were included as variables in the DSGE model for the UGE. The Italian Institute of Statistics (ISTAT 2007) provided data for consumption, investment, wages, and fiscal revenues. The UGE is expressed as percentages of GDP. A second source for an estimate of tax evasion is given in Chiarini et al. (2013). The authors constructed a quarterly time series of tax evasion for the period 1980:1–2006:4 using the annual value-added taxes, VAT, estimated by the Italian Revenue Agency. The two estimates measure different aspects of tax losses and will be compared in the discussion section. The proportion of fiscal controls (Cp) is given by the ratio between the number of inspections and the number of companies susceptible to inspection on an annual basis. The time series were provided by the Agenzia delle Entrate (the Italian Revenue Agency) and have been made quarterly by Orsi et al. (2014).

There are several theories for factors that will change UGE, e.g., in the seminal study by Sandmo (2005) and, recently in relation to the COVID-19 pandemic, Williams and Kayaoglu (2020). Based on suggestions by Williams and Kayaoglu (2020, p. 83) on the impacts of the level of GDP, we add an examination of the relation between changes in GDP, $\Delta GDP = GDP_{t+4} - GDP_t$ and UGE.

Tax policy events. In the period after 1992, tax amnesties were introduced to reduce the number of pending lawsuits dealing with tax evasion. The most significant tax amnesty was in 1992, followed by a similar provision in 1993. In 2001, undeclared workers could voluntarily enter the formal workforce (Williams and Kayaoglu 2020). Later, from 2003 to 2004, a wide range of amnesty measures was offered to taxpayers to close tax disputes pending with the tax authorities. A survey of tax policy events in Italy is given in Chiarini et al. (2013, p. 279), and an assessment of the efficiency of fiscal control is given by Lisi and Pugno (2015, p. 358).

The Orsi et al. (2014) data are shown centered and normalized to unit standard deviation in Figure 1a. (See Section 3.1 on normalization below). The UGE time series by Orsi et al. (2014) and tax evasion series by Chiarini et al. (2013) are compared in Figure 1c. The figure shows the linear trend and the cyclic component of their UGE estimates. Figure 1d shows the time series for ΔGDP and UGE.
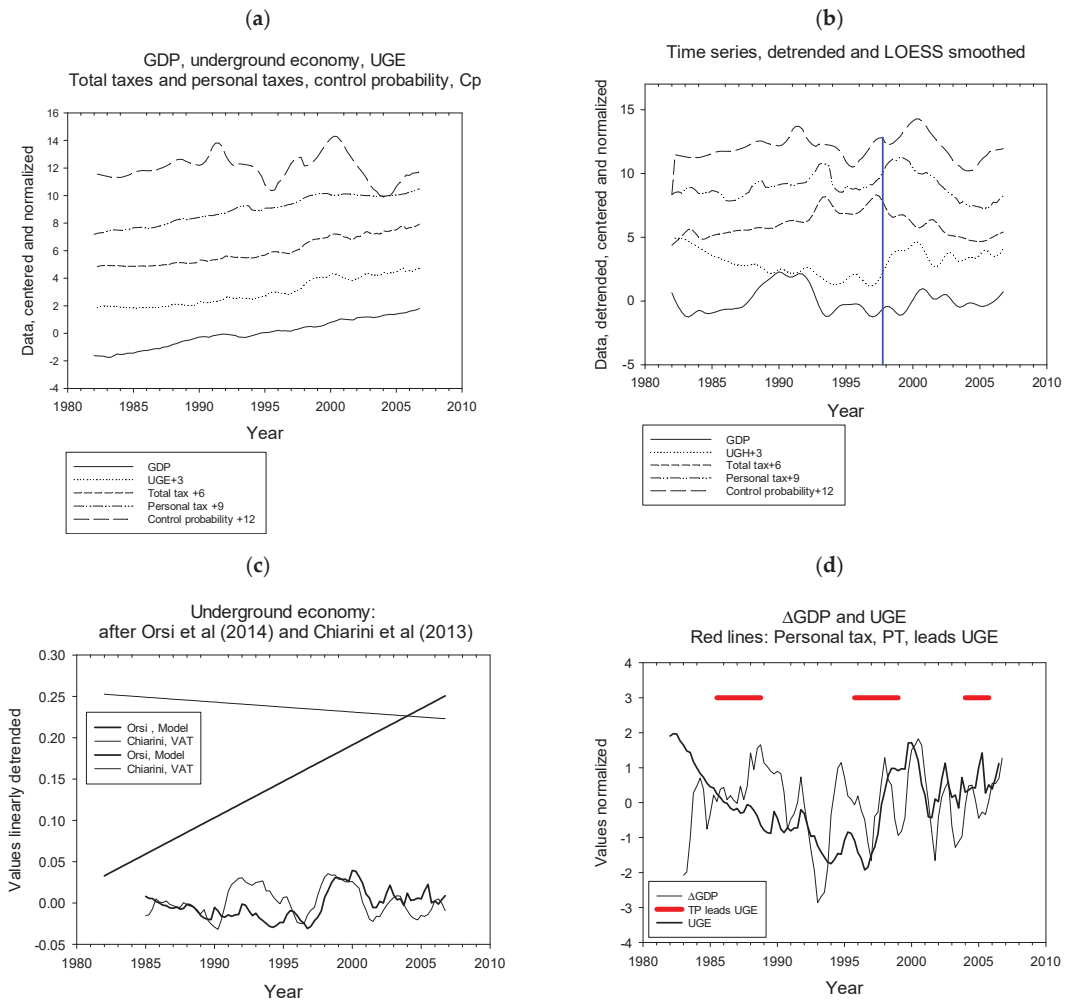
Figure 1. Time series. (**a**) Raw time series normalized to unit standard deviation and each series shifted vertically in steps of three units. (**b**) Series detrended and normalized. Drop-line(the blue line) shows the date 1997:4 when major tax shocks occurred in both personal and corporate taxes. (**c**) Comparison of two time series for UGE after Orsi et al. (2014) and tax evasion after Chiarini et al. (2013). The series are linearly detrended (trends: upper two straight lines). The residuals (lower two curves) are centered and normalized. (**d**) GDP first difference $\Delta GDP = GDP_{t+4} - GDP_t$ and UGE linearly detrended. Red horizontal lines show periods where PT leads UGE. GDP = gross domestic product, UGE = underground economy, TT = total taxes, PT = personal taxes.

3. Methodology

We first outline how we pretreated the data and thereafter our method for determining tax shocks. Lastly, we briefly present the high-resolution LL method for calculating lead–lag relations.

3.1. Detrending, Smoothing, and Normalizing

We first linearly detrended the Orsi et al. (2014) data and our analysis was based on these data. By centering and normalizing the data, we ensured that the choice of units did not impact the results when least-squares methods were applied to the data.

Chiarini et al. (2013) applied their analysis to the logarithm of the data and smoothed the data with the Hodrick and Prescott (1997) filter. The form of the noise on the observed data was not known (uniform or Gaussian, additive or multiplicative). Since the DSGE modelling studies included added stochastic elements, we slightly smoothed both the observed and the modelled series. For smoothing, we used the 2D LOESS smoothing algorithm SigmaPlot©. The algorithm is a locally weighted polynomial smoothing function. We used its parameter (f) to define local domains (f is the percentage of the full series) and a second-order polynomial function, (*p*) = 2, to interpolate. Since we always use *p* = 2, we used the nomenclature LOESS(f) to show the LOESS smoothing used. However, apart from LOESS smoothing, no parameters were included in the algorithm that defined leading or lagging relations between paired series. The series are shown as linearly detrended, slightly LOESS(0.1)-smoothed and normalized series in Figure 1b. The dropline shows the date 1997:4, when several adjustments were made to the tax regime.

3.2. Shocks

We estimated tax shocks by taking the first derivative of corporate, personal, and social security tax rates. By normalizing the rates to unit standard deviation and making histograms for the normalized rates, we identified tax shocks by comparing their distribution to a fitted Gaussian curve. Outliers were identified as rates at the tails of the distribution. Rate changes ≤ 3 and ≥ 3 for tax changes were used to find the dates where changes had been substantial. The procedure was similar for control probability. We also examined if there were shocks in UGE.

3.3. Lead-Lag (LL) Relations

The high-resolution LL method is relatively novel (Seip and McNown 2007), but has been applied in several contexts, e.g., paleontology (Seip et al. 2018) and economics (Seip et al. 2019). We used two sine functions with a common cycle period (λ) as an example: (i) The sine series that peaks less than $1/2\lambda$ before the other is defined as a leading series. However, the leading property applies to all parts of the series. (ii) One series is either leading or lagging the other series, and if the leading series is inverted, it becomes a lagging series. This latter property is relevant for the units applied to measure an economic parameter. For example, a trough in the central bank's interest rate is hypothesized to cause a peak in GDP; thus, it is a peak in the inverted rate, the interest rate reduction, which is assumed to peak before GDP. (iii) LL relations are calculated for three synoptic observations in the pared series and therefore the series do not have to be stationary.

The method is based on the dual representation of paired cyclic series, x(t) and y(t), as time series and as phase plots, with x(t) on the *x*-axis and y(t) on the *y*-axis. Recently, a similar method based on the dual representations and wavelet analysis has been described by Krüger (2021). An intuitive presentation of the first part of the method where the paired time series x(t) and y(t) are depicted in phase portraits is related to the standard Lissajous curves in electrical engineering. A visual diagram is provided on Wikipedia (2015). The second part, where we calculate rotational angles for trajectories in phase plots is related to the standard calculation of magnetic fields around an electric wire (Wikipedia 2023). The method is simple, implemented in one Excel sheet, and is available from the authors.

3.3.1. Explaining LL Relations

The description closely follows the description given in Seip (2019). To illustrate the method, we use two sine functions. One is a pure sine function with the cycle period λ. The other is a sine function that is phase-shifted, (PS), with $+1/8\lambda$. In addition, we added a small random component to the last sine function to make the example a little more realistic.

The two sine functions are shown in a dual representation, as time series along a time axis, Figure 2a, and in a phase plot with one series depicted on the *x*-axis and the other series depicted on the *y*-axis. In this example, the trajectories for the x(t), y(t) pairs

will rotate in a clockwise direction, as in Figure 2b. Pairs of ideal cyclic time series that are centered and normalized to unit standard deviation will show an elliptic form with center in the origin. With the major axis along the x = y-axis and with a phase shift of less than ¼ of a cycle period, the two series are pro-cyclic. With the major axis along the x = −y-axis and with phase shift in the range ¼λ to ½λ, the two series are counter-cyclic. If the trajectory rotates positively (counterclockwise per definition) then the *x*-axis variable leads the *y*-axis variable.
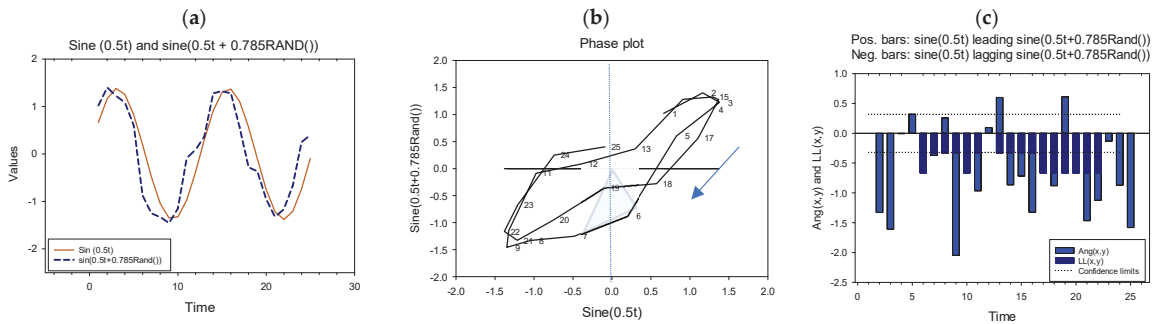

Figure 2. Example: Calculating leading–lagging (LL) relations and LL–strength. (**a**) Two sine functions: the smooth curve is a simple sine function, sin (0.5t), and the dashed curve has the form sin (0.5t + ϕ × RAND()) where ϕ = +0.785. (**b**) In a phase plot with sin (0.5t) on the *x*-axis and sin(0.5t + ϕ × RAND()) on the *y*-axis, the time series rotates clockwise; θ is the angle between two consecutive trajectories. The wedge suggests the angle between the origin and lines for observations 6 and 7. (**c**) Angles between successive trajectories (light blue bars) and LL strength (dark blue bars). Dashed lines suggest confidence limits for persistent rotation in the phase plot and persistent leading or lagging relations in the time series plot. Figure adapted from Seip and Zhang (2022).

We quantify the rotational patterns in phase plot using the function:

$$\theta = sign(\overline{v}_1 \times \overline{v}_2) \cdot A\cos\left(\frac{\overline{v}_1 \cdot \overline{v}_2}{|\overline{v}_1| \cdot |\overline{v}_2|}\right) \tag{1}$$

where $\overline{v}_1$ and $\overline{v}_2$ are two vectors formed by two sequential trajectories between three sequential points in the phase plots.

From these angles we identify a lead–lag (LL) strength. It is defined as a function of the number of positive angles, N_{pos}, minus the number of negative angles, N_{neg}, divided by the sum of the absolute values of both positive and negative angles over a certain time span.

$$LL = (N_{pos} - N_{neg})/(N_{pos} + N_{neg}) \tag{2}$$

The variable LL range between −1 (y-variable leads x-variable) to +1 (x-variable leads y-variable). Within a 95% confidence interval, (CI), −CI < LL < +CI, CI, there is no LL relationship, and no significant persistent cyclic variations in the time series plots. Here, we use $N_{pos} + N_{neg} = 9$.

3.3.2. Cycle Periods (CP)

One cycle period is λ ≈ 12.56 for the sine functions, as can be seen in Figure 2a. For a pair of perfect sine functions with a constant phase shift, a phase plot would show that the trajectory 1 to 13 would almost form a closed ellipse, and we can calculate and sum the angles between the origin and the points 1–13 to obtain a total angle of about 2π. Since the points 1–13 represent the time steps for the time series, ≈13 time steps also show the cycle period, λ, between two peaks in the time series. Thus, to obtain the cycle periods, λ, we

counted the number of time steps required for closure of the trajectories in phase space. This method is hereafter called the cumulative angle method.

3.3.3. Phase Shifts (PS) between Paired Series

The time series in Figure 2a are close, suggesting that the correlation coefficient between them may express the distance between them; that is, the phase shift PS. A PS of $\frac{1}{2}$ the common cycle period, λ, would suggest that the series are counter-cyclic and the regression coefficient, r = −1. A PS of zero would show that the series moves in perfect concert and are pro-cyclic. However, since the series show cycles with different lengths of the cycle periods, we must know the cycle period, λ, in advance to calculate the PS between them. PS is therefore estimated from the correlation coefficient, (r), for sequences of n = 5 observations, PS (5). Five observations are too short compared to the anticipated cycle periods. Thus, the PS will partly overestimate and partly underestimate the PS as the time window moves around the elliptic representation of the cyclic series in phase space. We calculated PS both with the moving average CP and with the average CP for the full time series. An expression for the phase shift between two cyclic series can be approximated by Equation (3):

$$PS \approx \lambda/2 \times (\pi/2 - Arcsine\ (r)) \tag{3}$$

For perfect sine functions, the phase shift is a function of the ratio between the major and the minor axes in the ellipse, Figure 2b.

3.3.4. Uncertainty Estimates

Using the Monte Carlo technique, we identified the 95% confidence interval (CI) as LL < −0.32 or LL > +0.32. The relationships are significant for these values if n > 9 (Seip and McNown 2015). The running average of LL was thereafter calculated over 9 successive observations. The number 9 is a tradeoff between the objective of calculating a CI and the objective of preserving a high-resolution LL measure. If the data is smoothed, the probability of detecting LL values with the same sign increases. Thus, the real CI will be larger.

3.3.5. Calculating GDP, UGE, and Tax Regressions

To calculate regressions between GDP, UGE, and tax variables, we use the original, but detrended variables. The regression equations will have the form:

$$GDP\ (10^9\ Euro) = \beta_1\ TT\ (\%) + \gamma_1 \tag{4}$$

$$UGE\ (10^9\ Euro) = \beta_2\ PT\ (\%) + \gamma_2 \tag{5}$$

GDP, UGE, TT, and PT are as defined before, and β_1 and β_2 are the regression coefficients for the GDP regression and the UGE regressions, respectively. The parameters γ_1 and γ_2 are the constants.

3.4. Self-Financing

Self-financing would mean that the loss in tax revenues caused by decreasing the tax level would be compensated by an increase in tax base (there are more taxpayers, and the taxpayers pay more tax because their income increases due to the tax cut) and because of a reduction in the underground economy. There might be some double counting depending upon the type of UGE that is reduced. We assume that all revenues collected above the revenues obtained before tax reduction are allocated to development with direct impact on GDP.

Table 1. Tax and economy shocks.

Personal Tax	Corporate Tax	Social Security Tax	Tax Control Probability	UGE Volatility
1989:4 (+3.2) **TT1**	1991:4 (−2.8) **TT2**	1989:4 (2.9)	1990:4 (1.56)	
1992:4 (+3.6) **TT2**	1992:4 (+3.3) **TT2**		1991:4 (−1.38) **TT2**	
1993:4 (−3.7) **TT2**				
1997:4 (+3.8) **PT2**	1997:4 (+3.2)	1997:4 (−7.5)	1997:4 (−1.38)	
	1999:4 (+2.5)			
	2000:4 (+4.1) **TT3**			
	2001:4 (−2.5) **TT3**			
	2005:4 (2.4)			2005:4 (−3.5)

TTn = included in Total tax/GDP window number n; PTn = included in personal tax/UGE window number n.

The tax revenue (TR) with 1% tax reduction would be:

$$TR_{t+1} \approx TR_t \times 0.99 + (\beta_1 \times 1 \times \gamma_1) + TR_t/GDP_t + (\beta_2 \times 1 \times \gamma_2) \qquad (6)$$

where TR_t/GDP_t is the fraction of GDP_t that is recovered as tax revenues. To find the change in GDP with changing TT, we calculated GDP (Euro) as a function of TT (%) for the period 1993:3 to 1996:2 (the time window 2, see below).

4. Results

We present the results for time windows restricted to sections where tax policies lead the economy. We first show results for tax shocks, thereafter for the pair TT and GDP, and then for PT and UGE. Finally, we calculate the combined effects of tax reductions on GDP and UGE.

4.1. Tax Shocks

There were four shocks in personal taxes, seven shocks in corporate taxes and two shocks in social security taxes. Furthermore, there were shocks in tax control probability and UGE volatility. For the TT versus GDP pair, we used the sum of all tax shocks, as shown in Table 1.

4.2. Comparison of Time Series

The time series sets in Orsi et al. (2014) and in Chiarini et al. (2013) cover approximately the same time span, Figure 1c. However, whereas the Orsi series show an increasing linear trend, the Chiarini series show a decreasing linear trend. The detrended cyclic series show ordinary linear regression (OLR) characteristics: R = 0.28, p = 0.009, n = 88.

The ΔGDP and the UGE time series are shown in Figure 1d. The series shows OLR characteristics during the periods when PT leads UGE (red horizontal lines) as R = 0.50, p = 0.003, n = 33, and missing = 43.

4.3. GDP and Total Taxes

LL relations. Figure 3a shows the results for TT and GDP. We inverted the tax variable so that a peak in tax reduction (minus TT) is followed by a peak in the GDP (assuming, in agreement with our first hypothesis, that a reduction in TT will increase GDP). However, the LL relation holds for all segments of the time window, not only for the peaks. The line in bold shows time windows where -TT leads GDP. Visually, a peak in tax reduction will peak before a peak in GDP. The TT leads GDP 37% of the time.
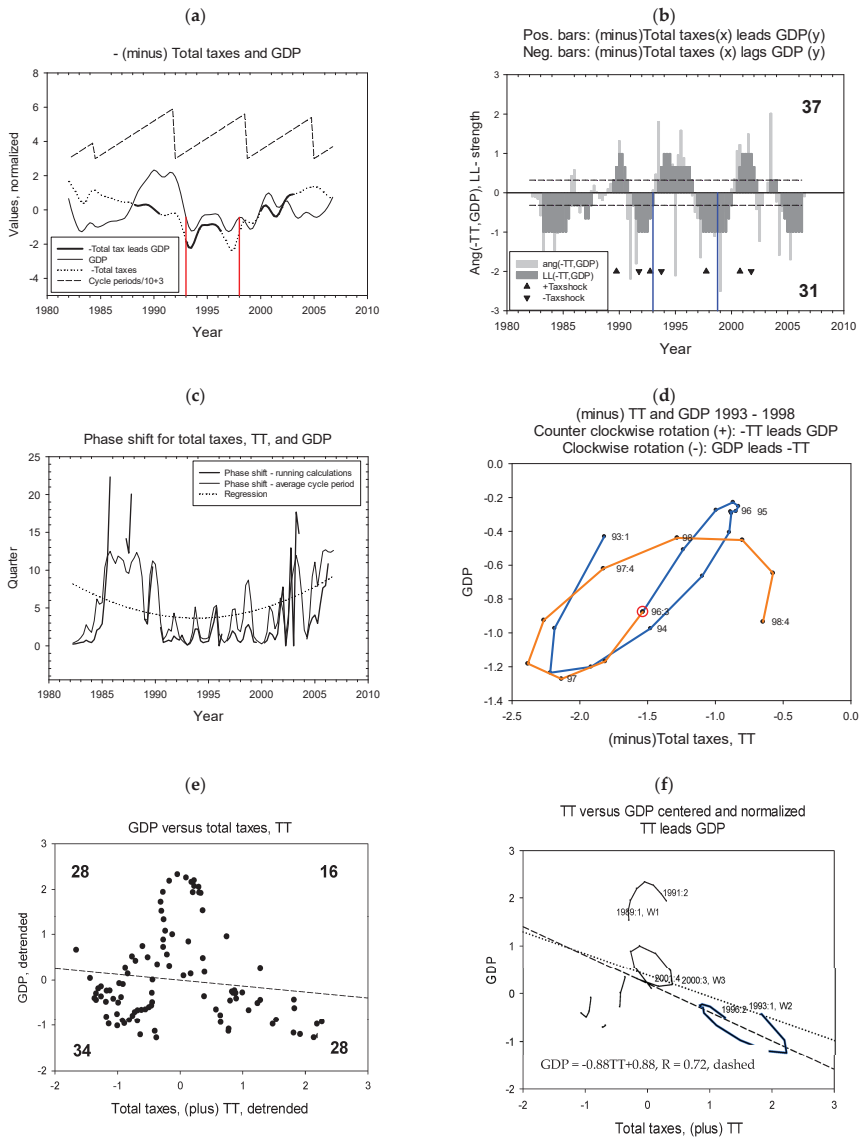
GDP and Total taxes

Figure 3. Lead–lag relations between total taxes, TT, and GDP. (**a**) Time series for reduction in TT (-TT) and GDP. Bold curve shows time windows where TT reduction leads GDP. Zigzag lines show cycle periods. Drop lines(the red lines) delineate the period 1993 to 1998. (**b**) LL relations between TT reduction and GDP. Light grey bars show LL relations with n = 3 and dark grey bars show LL relations with n = 9. Dashed lines show 95% confidence intervals. Triangles show positive and negative tax shocks. Drop lines(the blue lines) delineate the period 1993 to 1998. (**c**) Leading length (phase shift), calculation with running cycle period of 5 quarters and with average cycle period of 26 quarters. Leading length ranges between 3.7 and 8 quarters. (**d**) Phase plot for the period from 1993 to 1998. Note that rotational direction changes at about 1996:3 from counterclockwise rotation (+) to clockwise rotation (−). (**e**) GDP as a function of increasing total taxes, TT (all observations). Numbers show the number of states in each quadrant. (**f**) GDP as a function of increasing TT restricted to periods when TT reduction, -TT, leads GDP.

Table 2. Statistics for GDP and UGE.

	Windows	Slope	r^2	p	n	Power	# Cycles
GDP [1] All observations		−0.131	0.017	0.195	100	0.252	
Total taxes lead GDP		−0.833	0.486	0.001	100	0.999	
1	1988:2–1990:3	1.740	0.350	0.071	10	0.438	0.44
2	1991:1–1996:2	−0.605	0.737	0.001	14	0.99	1.00
3	2000:1–2003:1	0.104	0.020	0.650	13	0.065	0.93
	Weighted average	0.413	0.369	0.241	12	0.498	0.79
Average first 4Q		−3.16 ± 2.671	0.38 ± 0.171	0.397 ± 0.142	4	0.111 ± 0.042	-
UGE [2] All observations		−0.11	0.013	0.271	99	0.195	
Taxes lead UGE		0.31	0.075	0.123	33	0.337	
1	1986:2–1997:4	−0.24	0.48	0.08	7	0.404	0.45
2	1995:3–1998:4	−1.40	0.76	<0.001	14	0.993	0.91
	Weighted average	−1.01	0.66	−	−	0.80	0.76
Average first 4Q		0.603 ± 0.994	0.349 ± 0.349	0.495 ± 0.303	4	0.115 ± 0.106	-

[1] **GDP**: Statistics for x = TT (total taxes) and y = GDP. (Both variables linearly detrended and normalized to unit standard deviation.) Windows 1 to 3 are time windows where taxes are leading variables for GDP. The statistics: slope or β- value, r^2 = explained variance, p = probability, n = number of observations and power = the statistical sensitivity. # cycles = the number of cycles. Average first 4Q is the results for the four first quarters of each time window. [2] **UGE**: Statistics for x = PT (personal taxes) and y = UGE. Windows 1 to 2 are time windows where PT is leading UGE. Test statistics as for GDP.

Figure 3b shows the short-term LL relations (n = 3 quarters, light grey bars in the background) and the long-term LL relations (n = 9, dark grey bars). Figure 3b also shows, with triangles positioned upwards and downwards, when negative and positive tax shocks occur.

Cycle periods and LL lengths. The zigzag line in Figure 3a suggests cycle periods calculated by the cumulative angle method. There are three major common cycles for GDP and TT, each 10 to 14 quarters ≈ 2.5 to 3.5 years long. Figure 3c shows the two estimates for how long the leading time series is leading the lagging time series (GDP and TT shift in being leading and lagging).

The dashed line suggests that the LL time was about eight quarters at the beginning and at the end of the period, but about four quarters during the middle period. A phase plot for -TT and GDP during the five-year period from 1993 to 1998 is shown in Figure 3d. During this period, -TT shifts from leading GDP to lagging GDP, Figure 3b.

The trajectories in Figure 3d first rotate counterclockwise (+), showing that -TT leads GDP, then after 1996:3, the trajectories rotate clockwise (−), showing that GDP leads -TT. Neither of the (−) or (+) curves close.

GDP as a function of TT. Figure 3e shows a scatter plot for (plus) TT and GDP (100 quarters). A regression shows that increasing taxes decreases GDP. However, the result is not significant, $p = 0.195$, and the power is << 0.800. The phase plot in Figure 3f shows two characteristics of the paired time series: (i) the β-coefficient shows how the y-value changes with the x-value and (ii) the rotational direction shows how the LL relation between the x- and the y-series change with time.

In Figure 3f, the scatter plot that only includes the observations where -TT leads GDP, the β-coefficient (the slope) is −0.88, the power is 0.999, and $p < 0.001$. With higher taxes, above 32%, corresponding to 0 on the normalized TT-axis, the negative relation between taxes and GDP becomes pronounced. The numbers show the year and the quarter in the year of observation. No immediate effects of tax shocks appear in the response of GDP to tax changes. As a control, we also calculated the slope when GDP led the total tax series. The slope was then 0.00 and $p > 0.1$. (Graph not shown; the observations correspond to those in Figure 3e minus those in Figure 3f).

Shifting GDP backwards relative to TT. If we, for the data set where -TT leads GDP, shift GDP two quarters backwards relative to TT, the explained variance increases from

$R^2 = 0.40$ to $R^2 = 0.60$ and the β-coefficient decreases from −0.88 to −1.04. The probability p is still < 0.001. (The tax series are inverted to describe tax reductions, but are positive in the x = tax, y = GDP graphs, and the time series are normalized to unit standard deviation; results not shown in the table.) With 10–14 quarter time windows, taxes will change, and GDP responds to the changes. The pair, TT and GDP, undergo cycles from $\frac{1}{2}$ cycle period to one full cycle period.

We examined the slope for GDP in terms of monetary units and TT restricted to the three windows where TT changes lead GDP. This slope is similar to the slope for time window W2; that is, the time window starting at the largest taxes ≈ 32% tax, Figure 3f. The equation is:

$$\text{GDP } (10^9 \text{ Euro}) = 0.185 - 2.32 \times \text{TT(\%)}, \text{R} = -0.775, p < 0.001, \text{n} = 14 \qquad (7)$$

The average GDP for the period 1982 to 2006 is EUR 216×10^9. A 1% decrease in TT would increase GDP by EUR 2.16×10^9, or 0.99% of the average GDP. (Note that the calculations are on the detrended series.)

Figure 1d shows a comparison of the first difference of GDP, $\Delta\text{GDP} = \text{GDP}_{t+4} - \text{GDP}_t$, compared to the detrended UGE. The horizontal lines show time windows where PT leads UGE. The rationale for the comparison is that with increasing GDP, which is ΔGDP, more people may join the ordinary job market and leave the UGE. Table 2 also shows that the average response for the four first quarters is negative, although not significantly (the number of time steps, n, is only 4).

4.4. Underground Economy, UGE, and Personal Taxes

LL relations. Figure 4a shows the time series for PT and UGE. The bold sections of the PT series show the five time windows where PT leads UGE. The drop-down lines show boundaries for the time windows 1993 to 1998. In agreement with our assumption that an increase in taxes increases UGE, we here use tax increases as the x-variable in all four panels. PT leads UGE 21% of the time. Figure 4b shows the short-term LL relations (n = 3 quarters, light grey bars in the background) and the long-term LL relations (n = 9, dark grey bars).

Cycle periods and LL lengths. The zigzag line in Figure 4a suggests four common cycles for PT and UGE. The lead times for the leading series are from about three to about six quarters, Figure 4c. A phase plot of PT versus UGE during the period 1993 to 1998 is shown in Figure 4d. The trajectories rotate clockwise (−) from 1993 to 1994:3 and UGE leads PT, and then they rotate counterclockwise (+) to 1998 and PT leads UGE. The trajectories correspond to the LL relations in Figure 4b.

UGE as a function of PT. A regression shows that increasing personal taxes decreases UGE. However, the result is not significant, $p = 0.271$, and the power is << 0.800, as shown in Table 2 and Figure 4e. When we make a scatter plot only including the observations where personal taxes are leading UGE, increasing personal taxes increases UGE, and the result is significant, $p = 0.03$.

We made the regression with UGE (EUR 10^9) and PT (%) for the time window W2 and obtained the following equation:

$$\text{UGE } (10^9 \text{ Euro}) = -1.4 + 0.887 \times \text{PT(\%)}, \text{R} = 0.87, p = < 0.001, \text{n} = 14, \qquad (8)$$

The average UGE for the period 1982 to 2006 is EUR 32.8×10^9. A 1% decrease in PT would decrease UGE with EUR 0.513×10^9; that is, 1.6% of the average UGE and 0.24% of the average GDP. (Note that the series are detrended.) However, when we examine the graph in Figure 4f, there are five separate datasets where PT leads UGE. Only two of the sets have lengths larger than three quarters. For the long series we get a slope of 0.89.
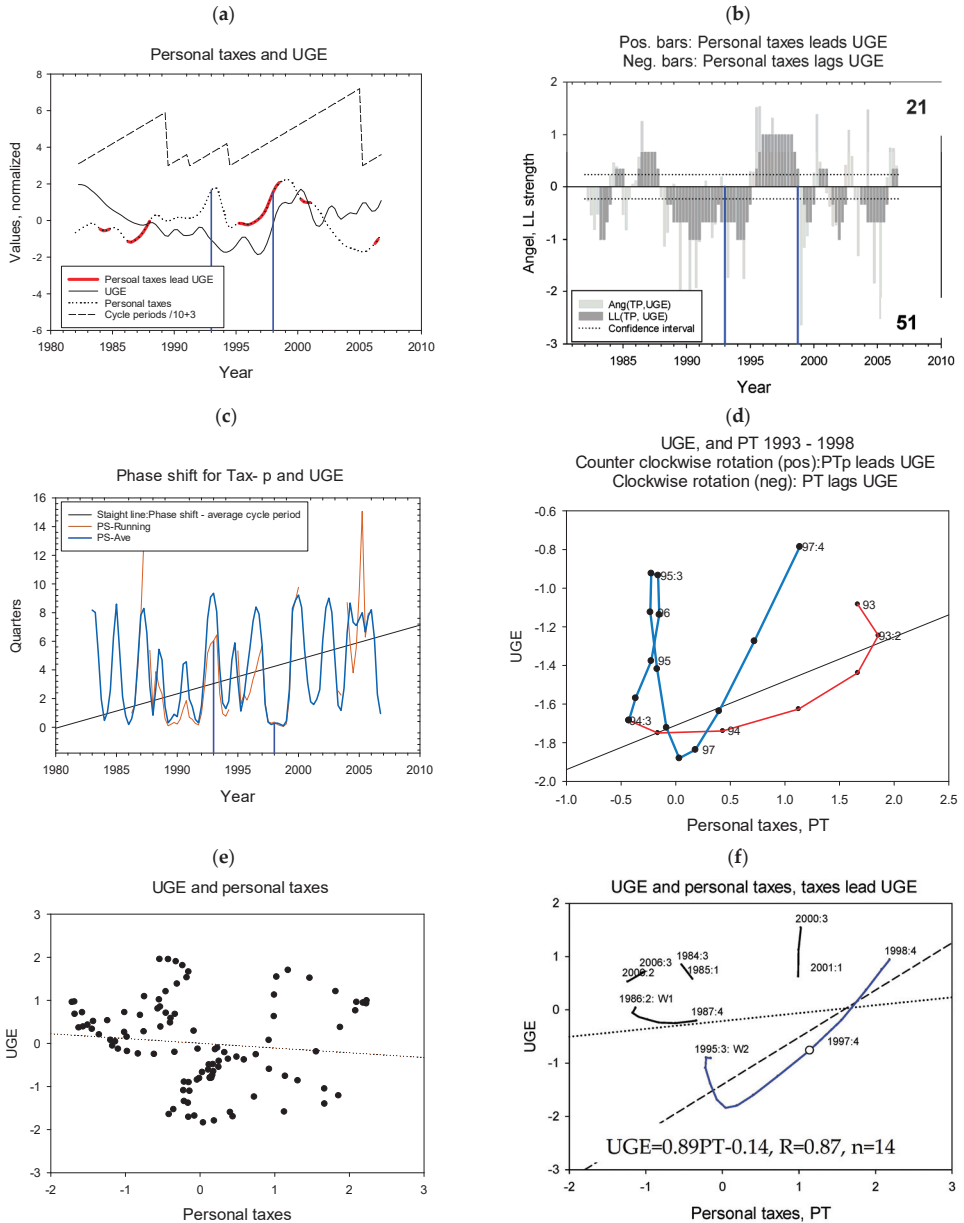
UGE and personal taxes

Figure 4. Leading and lagging relations between personal taxes, PT, and the underground economy, UGE. (**a**) Time series for personal taxes and UGE. Bold curve shows time windows where PT leads UGE. The zigzag line shows cycle periods. Colored droplines here and in panels (**b**,**c**) show sections of personal taxes and UGE series that is depicted in the phase plot in panel (**d**). (**b**) LL relations between PT and GDP. Light grey bars show LL relations with n = 3 and dark grey bars show LL relations with n = 9. Dashed lines show 95% confidence intervals. (**c**) Lead times (phase shifts) for PT versus UGE. (**d**) Phase plot for PT and UGE during the period between 1993 and 1998 Q4. (**e**) UGE as a function of increasing PT (all observations). (**f**) UGE as a function of increasing PT restricted to periods when PT leads UGE.

We also calculated UGE as a function of ΔGDP when PT was leading UGE. The equation became:

$$\text{UGE } (10^9 \text{ Euro}) \; 24.8 + 9.42 \times \Delta\text{GDP (Normalized to unit st.dev.)}, \text{R} = 0.5,$$
$$p < 0.003, \text{n} = 33, \text{missing} = 43 \tag{9}$$

Shifting UGE backwards relative to PT. If we shift UGE 2 quarters backwards (the full data set in Figure 4e), corresponding to the lag in the effect on tax reductions on UGE, the explained variance increases from $R^2 = 0.09$ to $R^2 = 0.18$ (statistics not shown in the table), the β-coefficient increases from 0.27 to 0.38, and the *p*-values decrease from 0.029 to 0.004. With time series 5–14 quarters long, taxes change, and UGE responds to the changes. For the pairs PT and UGE, the pairs undergo cycles from 1/3 cycle to one full cycle. Only the shock in PT in 1997:4 (+3.8) affects PT and UGE in a time window where PT → UGE. Table 2 also shows that the average response for the four first quarters is positive, although not significantly (n = 4).

4.5. Self-Financing Rate

The loss in tax revenues by decreasing the tax rate from 32% to 31% is EUR 0.76×10^9. First, we found in Section 4.3 that a 1% decrease in TT would increase GDP by 0.99%. The tax revenues from this increase, 31% of the increased GDP, will compensate for lost tax revenues by 0.99% × 0.31 = 0.31%. Second, we found that a reduction in personal taxes of 1% decreases UGE with 1.6%, corresponding to 0.24% of GDP. Together, the two contributions give an increase in GDP of 0.31% + 0.24% = 0.55%. Thus, reducing total taxes on GDP and personal taxes on UGE gives added revenues. The compensation factor for reducing taxes with 1% is thus 0.55%, and both factors contribute about equally.

5. Discussion

The economy acts on different time scales. Economic trends over multidecadal scales are more likely caused by technical or social innovations (Bloom et al. 2013; Hamilton 2018), and improvements in infrastructures are dependent on long-term tax incomes. In contrast, shorter decadal events could be caused by tax policy changes. In this section, we discuss relations on interannual and decadal time scales when taxes lead the economies.

5.1. Detrending, Smoothing, and Normalizing

To identify business cycle length variability in the series, we linearly detrended the data. For the period discussed here, we believe that a linear detrending is sufficient. However, strongly HP-smoothing the time series and using the residuals from the smoothed series as representative of decadal variability could have been an option (e.g., Chiarini et al. 2013). The relevance of business cycle periods of about five years for abatement measures to reduce UGE is also proposed by Goel et al. (2019, p. 102).

5.2. Comparing UGE Estimates

Estimating the size and variability of tax evasion (the underground economy, the shadow economy, or the dark economy) is difficult (Dell'Anno and Davidescu 2019). We have two independent estimates for tax evasion for the period 1982 to 2006. The two estimates express different aspects of UGE and tax evasion, but comparing them may still bring support for the size and variability of UGE. The residuals of both series showed a reasonable overall similarity (R = 0.28, *p* < 0.009). However, Chiarini et al. (2013) defined their trend as a HP-filter approximation to their tax evasion time series, and it is not linear. We cannot explain why we found a positive linear trend for the Orsi et al. (2014) estimate and a negative trend for the Chiarini et al. (2013) estimate based on VAT measurements. However, Dell'Anno and Davidescu (2019, p. 136) show that tax evasion and the shadow economy were counter-cyclic in Romania during the period 2000 to 2017. Chiarini et al. (2013, p. 279) compared their tax evasion series to tax events and concluded that patterns observed in the series can be explained by "structural innovations" related to the system.

These arguments extend to the UGE series obtained by Orsi et al. (2014), since the two series show good similarity on a business cycle scale.

5.3. GDP Results

We posited three hypotheses with respect to taxation, GDP, and UGE. The first, **H1**, was that reducing tax rates would increase GDP. We show that by decreasing the overall tax burden, GDP will increase. This effect is most pronounced during the first four quarters after the tax policy becomes a leading variable to GDP. Chiarini et al. (2022) suggest, with data from the US, that corporate tax evasion (which is part of our TT) may change the allocation of assets between consumption and productivity uses and thus also affect the business cycle. However, Ngelo et al. (2022) found that Indonesian firms that have a tax avoidance practice utilize the extra cash to invest in value-enhancing projects.

The cyclic components of TT and GDP have common cycle periods of about 20 quarters. Lead times between the two series range between 1 and 10 quarters, with averages of 3.1 and 4.6 quarters depending on the calculation method.

Since the effects of tax changes take time, the time series for GDP were shifted backwards in time relative to -TT. Shifting the series relative to each other caused the β-coefficient to decrease from −0.88 to −1.04, and the explained variance to increase. However, using one overall shift for the whole series is only an approximation, since the lead time between -TT and GDP change in size and in direction. The lead time using cross-correlation techniques resulted in a lead time of three quarters. This is a little less than the average lead time for the whole series. One would assume that the effect of reducing taxes depends upon the tax level at the time of tax changes. Our result suggests that the effect of reducing taxes has been most effective at tax levels above 32% in Italy during the period 1982 to 2006 (see Figure 3f). At lower tax levels, taxes and GDP start cycling with cycle periods of about 2–3 years (8–12 quarters), probably because low tax levels are not sustainable either economically or politically.

5.4. Underground Economy (UGE) Results

LL relations. Our second hypothesis, **H2**, states that changing the tax level influences the size of tax evasion, or UGE, in Italy. Here, we found that tax reductions would decrease UGE significantly. However, since the effects of tax changes take time, the time series for UGE were shifted backwards in time relative to PT. Shifting the two series (restricted to the windows where PT leads UGE) relative to each other caused the β-coefficient to increase from 0.27 to 0.38. The explained variance, R^2, increased from 0.09 to 0.18 and the probability, p, decreased from 0.03 to 0.004. We also examined tax evasion control probability but found conflicting results for short- and long-term effects. One reason may be that tax amnesties in Italy may be ineffective. Alstadsaeter et al. (2022) found that an amnesty, combined with increased probability of detecting undeclared (offshore) accounts, increased tax revenues in Norway. Mara (2021, p. 319) found that tax-rate increases on labor increased UGE significantly ($p < 0.05$), except in Mediterranean countries where the result was insignificant. The study included annual data 1995–2017 for 28 European union countries.

We found that UGE increased with positive changes in GDP. The result contrasts with the finding that undeclared work is more prevalent in countries with lower GDP (Mara 2021). Goel et al. (2019, p.101) found that GDP (and inflation) did not significantly affect UGE. One reason for the effects of changes in UGE may be that with growth in GDP more opportunities become available for work in sectors that traditionally employ workers in the underground economy, such as the personal service sector, which is 27% of GDP in Europe (Williams and Kayaoglu 2020, p. 85).

In the literature, there is conflicting evidence whether increasing tax rates increase tax evasion or not, and a summary from 1980 until 1995 is given in Ali et al. (2001). Empirical studies normally address long time series. Ali et al. (2001) used annual US data from 1980 to 1995; Cebula and Feige (2012) used US data from 1960 to 2008, but examined different time windows, the smallest time window being 28 years. These authors found a significant

positive correlation between compliance and tax rate and between compliance and penalty rate, although for some results these variables had to interact with screening variables, such as actual income (Ali et al. 2001; Cebula and Feige 2012). Overall, the literature studies are different in their assumptions, and therefore direct comparison with our results is not straightforward. A series of other tax evasion abatement measures can also be envisaged (Luttmer and Singhal 2014; Mascagni 2018). Lisi and Pugno (2015) conclude in a model study that closer monitoring of tax evasion attempts and lower taxation reduces the underground economy. However, our examination of tax evasion control probabilities in Italy was not conclusive.

5.5. Effect on Tax Revenues from Changes in GDP and UGE

Our third hypothesis, **H3**, that the loss in TR from decreased taxes would be compensated by increased taxes from enhanced GDP and decrease in the underground economy, UGE, was not supported. When tax levels were relatively high, at >32%, and GDP low, the compensation factor was only 0.55 to 1.00. The GDP contributed most (GDP: 56%, UGE 44%). Since GDP and unemployment are often counter-cyclic, e.g., Okun's law, the relevant information may not be low GDP, but that there is a high unemployment rate. Our results are based on observations and thus dependent on the conditions in the Italian economy in the period 1982–2006. Studies of the Laffer curve for Italy suggest that the maximum labor tax rate is between 41% and 62%; Ferreira-Lopes et al. (2018) and Trabandt and Uhlig (2011), respectively. A similar Laffer curve value, around 60%, was found by Busato and Chiarini (2013, p. 620).

5.6. Tax Shocks and Tax Policies

It turned out to be difficult to relate tax shocks to changes in GDP or UGE. The reason is probably that tax shocks may have been announced or anticipated, or that several minor changes in tax levels have been more important than the shocks. In addition, we do not know the effects of tax evasion amnesties during the period. It is difficult to find proxies for all information about future shocks that policy makers and corporation may have (Romer and Romer 2010). Hayo and Mierzwa (2022, p. 5) found that drafting tax bills influenced GDP in the USA, the United Kingdom, and Germany, data from 1977 to 2018. Chiarini et al. (2013, p. 279) argue that there are causal relations between tax policy decisions and short-term effects on the time series for tax evasion. These authors also found breaks in the economy in 1983:4 and in 1998:1. The inclusion of UGE in our evaluation of tax change effects was supported by Annicchiarico and Cesaroni (2018) who found that neglecting UGE may lead to an underestimate of the effects of tax reforms, thus emphasizing the effect of tax reductions also on UGE.

We found three GDP time windows and two UGE time windows longer than three quarters where taxes were leading GDP or UGE during the period 1982 to 2006. The first half of the 1990s showed high political instability, whereas the period 1996 to 2000 gave a more stable framework for tax collection. However, in 1997:4 there were tax shocks in all tax variables. Personal and corporate taxes were increased, whereas the social security tax and control probability were reduced. The events in 1997:4 may be due to the reorganization of the fiscal authority that started in 1997. The tax shocks in 1997:4 were included in the W2 time series for the UGE = f (PT) regression. For some tax shocks that were followed by a leading role for tax rates, there were political events that could help explain changes in tax policies, as in the year 1997. However, TT and PT were simultaneous leading variables for GDP and UGE only 10% of the time.

Several authors suggest that the effect of rapid changes in tax levels have typical time horizons of 4 to 6 years, e.g., Mountford and Uhlig (2009) and Romer and Romer (2010). We found that the time horizon varied between 2 and 6 years with an average of thirteen quarters. Thus, the LL method identifies potential causal relations between tax policy changes and the economies of similar lengths as found in the literature.

5.7. Robustness

Our calculation of self-financing of tax reductions has several caveats. First, taxes are complex constructs and using two tax levels (TT and PT) may oversimplify the real tax structure. Tax evasion by corporations may alter the wealth transfer between households and corporations, implying a reallocation of assets between consumption and productivity uses (Chiarini et al. 2022). Personal taxes in Italy are progressive and will influence groups differently. The components of the total taxes and their enforcement, Sepulveda (2023), act on different parts of the economy and determine how tax revenues are used, Alinaghi and Reed (2021, p. 14).

There may be several variables that have significant LL relations to each other, and for n series there will be m = n(n − 1)/2 pairs that can be compared. Seip and Grøn (2018) show how several LL relations can be interpreted by identifying time windows where LL relations are persistent. We assume that a persistent LL relation between two variables strengthens a cause–effect relation. However, LL relations may be due to third factors that influences the two variables, but one later than another, so that there appears to exist a LL relation. Thus, it is necessary that auxiliary, e.g., mechanistic, information exists that support a cause effect. Furthermore, it may be difficult to establish a "ground truth" for LL relations between real time series. An example where this was possible is a study on economic forecasting in Germany. The leading forecasting series was leading 78% of the time, which is in compliance with characteristics of leading series in economy, Seip et al. (2019). The results are based on several assumptions; for example, that all taxes recovered are used to increase GDP. However, some of the taxes may be used for other purposes, such as paying down government debt.

5.8. Policy Implications

At low tax rates, both the pair TT-GDP and the pair PT-UGE start to cycle. However, with high total taxes, around > 32%, low GDP, or high unemployment; reducing total and personal taxes give a fiscal multiplier of about 0.55 to 1.00. Thus, the benefit of a tax reduction policy would not be sufficient to compensate for lost tax revenues in Italy during the period 1982 to 2006. Although the results were obtained for a period two decades ago, the economy and the tax regimes in Italy have probably not changed to an extent that would invalidate the conclusion, e.g., Astarita et al. (2016) on recent tax reforms in Italy. Adding measures that reduce tax evasion may increase the multiplier (Moro-Egido and Solano-García 2020). Thus, with the high taxes that currently (2023) prevail in Italy, our study suggests that taxes could be reduced in concert with other tax policy measures, such as increased tax enforcement. This conclusion is in line with results from Acocella et al. (2020), who advise that tax compliance should be strengthened. Generic advice to increase tax compliance is also given by Moro-Egido and Solano-García (2020), Lisi and Pugno (2015), and Alstadsaeter et al. (2022), although Italy is not explicitly included in their studies on tax compliance.

5.9. Further Work

We have used two aggregate measures of taxes, but different taxes will act differently on the economy. Thus, we believe that a more detailed treatment of taxes, and a closer examination of how they affect the economy, would be beneficial. Further, some taxes may have two or more objectives, e.g., improving infrastructure or changing inequality levels (long-term goals) and boosting short-term GDP. How multiple goals should be balanced could be included in further work.

On the technical side, since several factors affect GDP, such as the central bank's short-term rent (CBR) as well as tax level, it would be interesting to see if only those periods in the economy where tax changes lead GDP, but CBR does not, would change the result.

6. Conclusions

There are several ways in which tax changes can influence the economy, and both positive and negative effects may be envisaged. Our contribution consists of applying a novel test to the effects of tax changes based on empirical data. We have achieved this by (i) removing multidecadal trends, (ii) restricting the study to time windows where tax changes are leading the economies and thus have a high probability of affecting the economy, (iii) examining both GDP and UGE, and (iv) including the finding that tax changes take time to affect GDP and UGE by shifting GDP and UGE backwards in time before regressions are applied.

We found that there are complete cycles between tax changes and GDP changes; that is, tax changes beget tax changes. With high total taxes > 32%, decreasing taxes increased GDP. The results for PT and UGE showed that increased personal taxes increased UGE. Tax policies were leading GDP and UGE for two to six quarters corresponding with literature values for the effects of tax policy variables. Our empirical findings provide useful insights into the effectiveness of policies aimed at reducing the tax burden to obtain incentives for economic growth and reduced UGE.

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Tax Compliance Challenge through Taxpayers' Typology

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Abstract: Tax compliance has become a very popular academic research topic. Understandably so, as all modern societies face the challenge of limiting tax evasion and the losses this phenomenon causes to government revenues. Given the increase in duties in the aftermath of the economic downturn affected by COVID-19, increasing taxpayer compliance is one of the main tasks for governments worldwide. This study aimed to identify critical gaps in understanding taxpayer heterogeneity. For this purpose, an exploratory factor analysis of taxpayer perceptual and attitudinal elements was carried out. Our analysis revealed six factors influencing taxpayer compliance with the tax system. Furthermore, the cluster analysis identified four groups of taxpayers, and significant differences between the clusters and the descriptive profile of each cluster were also found. The specificities of these clusters point to a conclusion that the time has come for policy makers to employ strategies that stimulate voluntary tax compliance with minimum cost to the tax system.

Keywords: tax compliance; tax evasion; economic determinants; psychological determinants; taxpayer segmentation

1. Introduction

Over the last forty years a significant number of studies have analysed taxpayers' motivation towards their tax liabilities. The literature often emphasises the complexities of tax compliance, suggesting it is influenced by a large number of determinants (Onu et al. 2018; Hashimzade et al. 2013). Tax compliance and related issues are as old as taxes themselves (Andreoni et al. 1998) and continue to be a hot topic, even today.

Despite the increase in research in this area, many studies continue to use the conventional economic model and its alterations to explain the taxpayers' reasoning. Allingham and Sandmo (1972) and similar models, derived from the theory of Nobel laureate Becker (1968), are based on the assumption that tax payments are made only because of the economic consequences that follow in the case of indiscipline. Although the traditional approach was under criticism (claiming it did not completely explain taxpayer compliance), its variations are still being developed and adapted further. Fischer et al. (1992) and Alm et al. (1995) argued that some non-economic factors also affect tax compliance. In the last two decades, many studies have discussed the division between economic and psychological factors that contribute to tax compliance (Bobek et al. 2007; Kirchler 2007; Lewis et al. 2009; Saad 2014; Alshira'h et al. 2020; Santoro et al. 2021). In this regard, Alm et al. (2012) and Marandu et al. (2015) claimed that tax compliance and its mechanisms could not be fully explained by purely economic considerations, just as enforcement is not the only determinant influencing it. In a recent large-scale experiment of 44 nations across five continents, Batrancea et al. (2019) suggested that both traditional and emerging, trust and power-based strategies were important in order to positively influence taxpayer compliance. Since there is still no consensus between researchers regarding the dominant tax compliance model, the conceptual objectives of this paper are to explore the existing theoretical knowledge of economic and psychological tax compliance concepts to define and describe the most important economic and psychological determinants of tax compliance.

The paradigm shift in the tax compliance concept has led to more research in this area, aimed at understanding the mechanisms of taxpayers' reasoning, intersecting different disciplines such as accounting, economics, political science, sociology and psychology. Over time, there has been significant sophistication in understanding the tax compliance concept, and interdisciplinary research has contributed significantly to this (Yong et al. 2019). Finally, two research approaches are now used in investigating tax compliance: economic and behavioural (Nguyen et al. 2020).

Based on the combination of these two approaches and the model proposed by Alm et al. (2012), this paper's empirical objectives are to examine the impact of established economic and psychological determinants on the taxpayers' tax compliance in the Republic of Croatia, to examine the impact of taxpayers' sociodemographic characteristics on their tax compliance in the Republic of Croatia and to compare the results with previous research. The data was collected through a survey and analysed using factor analysis to identify clusters of characteristics that lead to differences in tax compliance. The factor-cluster analysis can help achieve the research objective of better understanding the relationships and patterns between the variables within the identified clusters and factors. These patterns can be useful in understanding the underlying structure of the data and in making informed decisions based on the characteristics of the identified clusters. Finally, this work will hopefully contribute to a better understanding of taxpayer motivation and reasoning. The results of the study may shed light on possible improvements to the tax system that lead to more differentiated tax policies. In addition, the study aimed to identify not only the clusters of taxpayers, but also the economic and psychological factors that influence them. For the tax system to work and be satisfactory to the government and taxpayers, all factors that contribute to tax compliance must be defined and studied. The results provide tax policy makers with insight into taxpayer heterogeneity and may be useful for countries with similar economic and fiscal policies.

The remaining sections are Theoretical Perspective, Methodology, Results, and Discussion and Conclusions where the implications and limitations of the study are presented together with the directions for future research.

2. Theoretical Perspective

2.1. Tax Audits

Allingham and Sandmo's (1972) economic deterrence theory of tax compliance and the findings of many other authors have emphasised audit probability and rates as crucial factors in their tax compliance models. For example, Alm (1991) and Alm et al. (1995), argued that the taxpayers' judgments were affected significantly by the level of audit rate and audit strategy. Slemrod et al. (2001) reported that taxpayers who were provided with feedback about the certainty of being audited more closely scrutinised their tax report in the subsequent period than those who were not given such information. In line with Slemrod et al. (2001), other studies showed higher compliance in taxpayers who were more likely to be audited (Alm et al. 2012; Blackwell 2007; Dubin et al. 1990; Webley et al. 1991; Nguyen 2022). Kleven et al. (2011) conducted a large-scale field experiment in Denmark to test the predictions of an augmented classical tax compliance model. They showed that previous audits and threat-of-audit letters had a substantial positive impact on self-reported income. Nguyen et al. (2020) showed that voluntary tax compliance was directly affected by three factors: audit probability, corporate reputation and business ownership. It has been suggested that audits have not only a large impact but a persistent one as well (Advani et al. 2017). This effect reaches approximately 26 per cent (on average) in the fourth year after the tax year to which the audit applies.

However, a number of studies reported different and mixed findings, claiming that audit has no significant impact on tax compliance (Graetz et al. 1986; Cowell 1990; Erard and Feinstein 1994), while others (e.g., Ghosh and Crain 1996) claimed the opposite. Mendoza et al. (2017) suggested that the association between auditing level and tax compliance was non-linear. Their findings showed that that there was a level of auditing after which

compliance declined, suggesting that the enforcement strategies might have a certain limit regarding the taxpayers' behaviour.

In their laboratory experiments, Guala and Mittone (2005) presented another interesting phenomenon that should be included in further research of audit probability and economic determinants of tax compliance. They named it the "bomb crater effect" and defined it as a considerable diminution of taxpayer compliance directly after an audit. Later on, the "bomb crater effect" was examined and its significance confirmed by numerous studies (Mittone et al. 2017; Kastlunger et al. 2009; DeBacker et al. 2015; Maciejovsky et al. 2007).

The broad scope of the literature on audit level and probability surely serves as a verification of its importance. However, the problem with audits is that they represent a significant cost to public finance and yet eliminate only a part of tax evasion. In other words, audits should be adequately combined with other tax compliance factors. In addition to this, and more recently, authors proposed that "nudge" mechanisms can be useful during auditing. Some authors propose the self-funding reward system in combination with the traditional auditing process to improve compliance rates (see Fatas et al. 2021).

2.2. Tax Rate

Almost every fundamental theory of tax compliance includes tax rate as one of the most influential factors. Similar to Allingham and Sandmo (1972), Srinivasan (1973) and Fischer et al. (1992) highlighted the role of tax rate in obtaining tax compliance. However, the standard economic model and its expansions do not offer a clear explanation of the relationship between tax rate and tax compliance (or tax evasion).

Generally, studies report mixed findings on the relationship between tax rate and tax compliance. One group of authors argues that higher tax rates reduce effective income and, consequently, make tax evasion lucrative. In other words, they suggest that compliance is lower at high tax rates (Ali et al. 2001; Boylan and Sprinkle 2001; Christian and Gupta 1993; Lang et al. 1997; Collins and Plumlee 1991). Blackwell's (2007) meta-analysis of twenty laboratory experiments, carried out between 1987 and 2006, showed that higher tax rates might lead to less compliance. Similar findings were found in a study by Alm et al. (2012). There are many studies with opposite findings, suggesting that a reduction in effective income leads to an increase in absolute risk aversion, and therefore, tax evasion declines (Alm et al. 1995; Feinstein 1991). A small number of studies show that tax rates have zero impact on tax compliance (Baldry 1987; Porcano 1988; Modugu et al. 2012).

2.3. Tax System Complexity

With the increasing sophistication of tax legislation, the complexity of the tax system has become an ongoing and developing issue (Richardson and Sawyer 2001). Depending on its form, the term "tax complexity" has been differently explained in the literature. Cuccia and Carnes (2001) focus on the complexity of tax rules, while Cox and Eger (2006) emphasise procedural complexity. In another set of studies, researchers are focused on the taxpayers' view, and specifically on the low degree of legibility (Barney et al. 2012; Pau et al. 2007; Saw and Sawyer 2010) as a determinant of tax complexity.

Evans and Tran-Nam (2014) define tax complexity as a multidimensional concept viewed differently by different categories of people in the tax system. They categorised three separate definitions of tax complexity—from the tax accountants', tax advocates' and taxpayers' points of view. Tax preparers undoubtedly play a role in tax system simplification, and in that way, they can often facilitate tax noncompliance. Erard (1993) emphasised the need for a joint analysis of tax preparation and tax compliance levels. Although the author established the connection between certified tax preparation and a higher level of noncompliance, he suggested that some beneficial social outcomes (especially educational) were significant. In addition to this, the motivation to use tax preparers is to reduce incertitude and fill in the data correctly—which suggests that tax system complexity is an important issue (Hite et al. 1992; Niemirowski and Wearing 2003).

Furthermore, numerous other studies link tax system complexity to tax compliance issues (Chau and Leung 2009; Cox and Eger 2006). After examining different determinants of noncompliance across 45 countries, Richardson (2006) concluded that complexity is the most important determinant for a taxpayer's compliance. Kirchler et al. (2006) claimed that when tax laws are perceived as less complex, taxpayers' intention to comply is higher. In their analysis, Saad (2014) recommended that future research should examine the impact of tax complexity on taxpayers' noncompliance. Finally, today there is a tendency to use technology that can both simplify the tax system and help increase its integrity by reducing corruption options (Bird and Zolt 2008).

2.4. Social Norms and Tax Morale

Insights from behavioural economics have been embraced and implemented in two extensive (but partially overlapping) areas of research. One sequel keeps its focus on the individual factor (personal norms), while the other extends to the analysis of group considerations, mainly social norms (Alm 2019).

The concept of "social norms" as a tax compliance factor has been studied by many researchers in this field (Alm et al. 1999; Slemrod 2016; Scholz and Pinney 1995; Wenzel 2004a, 2004b). However, Cialdini and Trost (1998) were the first authors to define the term as "rules and standards that are understood by members of a group, and that guide and/or constrain social behaviour without the force of law" (p. 152). Alm et al. (1995) conducted a study regarding unrecognised inter-country diversities in compliance rates, due to social norms discrepancies. Many other authors followed this example, referring to different societal norms in connection with the taxpaying culture (i.e., Cummings et al. 2006; Torgler 2002). Their results generally suggest that social norms play a role in tax compliance, but also emphasise the need for the precise differentiation of the term. In a large-scale natural field experiment carried out in the United Kingdom on more than 200,000 individuals, Hallsworth et al. (2017) revealed that social norm messages persistently affect tax compliance behaviour. In the research of the determinants of active filing behaviour, the results from Santoro et al. (2021) suggest that social norms could significantly encourage filing. Torgler (2011, p. 5) concludes, by linking social norms and tax morale, that "an increase in social norms increases the moral costs of behaving illegally and, therefore, reduces the incentives to evade taxes".

In analysing tax compliance, numerous studies were found that incorporated and examined the role of attitudes, although they were not always labelled as such. In their analysis of factors beyond the purely economic, Alm et al. (2012) found that attitudes were repeatedly identified as the source of tax morale. This is consistent with the study by Schmölders (1959), which showed that tax morale is reflected in attitudes towards tax compliance and tax evasion. Torgler (2006) defined tax morale as "intrinsic motivation" to meet tax obligations. However, some of the researchers consider tax morale as an umbrella term encompassing all observed tax compliance (Luttmer and Singhal 2014).

Andreoni et al. (1998), Kirchler (2007) and Torgler (2011) empirically demonstrated that incorporating tax morale into tax compliance models was effective. Many other studies showed that taxpayers' attitudes are significantly positively correlated to tax compliance (Ali et al. 2014; Cummings et al. 2009; Kornhauser 2007; Nguyen 2022). They also argue that tax morale should complement, not substitute, other determinants of tax compliance. The OECD (2019) points to complex interactions between tax morale and other drivers of tax compliance while the recent increasing application of behavioural economics in the field of tax compliance shows that tax administrations are seeking to use tax morale knowledge to improve compliance (OECD 2017).

2.5. Fairness

Although defined in the 1980s, as one of Jackson and Milliron's (1986) key variables of compliance behaviour, only later did fairness become the focus of other researchers. As Richardson and Sawyer (2001) pointed out, studies regarding perceptions of fairness

and their linkage to compliance behaviour were on the rise, but their number was still inefficient to lead to conclusive results. The same authors went on to conclude that the importance of the perception of fairness should not be neglected in future research.

It is generally accepted that fairness is a multidimensional determinant that comprises vertical, horizontal, procedural, distributive and retributive dimensions. In this research, the term "general fairness" will be used (see Richardson 2006). Research in the tax compliance field most often deals with distributive fairness and procedural fairness. Researchers agree that if citizens perceive the allocation of tax burdens and benefits as fair, and if they are satisfied with the quality of public services, they consequently show more willingness to obey tax laws and regulations voluntarily (Bosco and Mittone 1997; Braithwaite 2003; Falkinger 1995; Hartner et al. 2008; Kim 2002; Richardson 2005; Verboon and Goslinga 2009; Kirchler et al. 2008; Guzel et al. 2019; Gobena 2021). In their research, which aimed to identify when and why procedural fairness positively influenced voluntary tax compliance, van Dijke and Verboon (2010) found that trust in authorities may be the core prerequisite for this phenomenon. Koumpias et al. (2021) made a significant contribution in examining trust in government organizations and its effects. In their paper, they established differences in the levels of trust based on citizens interactions with organizations. In other words, trust in output government organizations (those ensuring public goods and services) has a stronger and more positive association with tax morale than trust in an input government organization (Koumpias et al. 2021, p. 4).

3. Methodology

Researching and understanding taxpayer compliance has never been straightforward, primarily because those taxpayers who evade or avoid taxes are strongly motivated to cover up that behaviour (Alm and McKee 2006). Research methods in this area can be classified into one of the following groups—historical data, surveys, and experiments (Slemrod 1992). Kirchler and Wahl (2010) suggested combining methods with the aim of broadening the understanding of taxpayers' reasoning. Alm (2019) argued that, regardless of the specificity of the data source or methodology, one should keep in mind that there are disadvantages in using any of the available methods in this field of study. Nevertheless, it must be acknowledged that such methods have provided many important insights. Moreover, one should be aware of the fact that attitudes do not necessarily anticipate behaviour. However, Onu (2016) argues that there are theoretical arguments backing the attitudes and behaviour relationship. Moreover, Ajzen (1991) suggests that by measuring attitudes specifically related to the behaviour (such as tax compliance attitudes) raises the chances of valid results.

Based on the existing literature and established research gaps, the empirical objectives of this paper are to examine the impact of the chosen economic and psychological determinants on the taxpayers' compliance, to examine the impact of the taxpayers' sociodemographic characteristics on tax compliance and to compare the results with previous research.

3.1. Research Design

A questionnaire was chosen as the main method and instrument for data collection in the current study. To better understand taxpayers' attitudes and motivations, a self-administered questionnaire was developed. It consisted of three parts: (1) the economic determinants of tax compliance, (2) the psychological determinants of tax compliance, and (3) the socio-demographic data (gender, education level, employment status, monthly income, seniority). The economic determinants of tax compliance (tax audits and tax rates) were measured with 6 items, as proposed by Tenidou et al. (2015) and van Dijke et al. (2019). Psychological determinants of tax compliance (tax morale, social norms, tax system complexity and fairness perceptions) were assessed with 19 items as suggested by Onu et al. (2018), Kirchler et al. (2006), and Hauptman et al. (2015). The two aforementioned scales were slightly modified due to the specificities of the Croatian tax system. To express their

opinion, respondents were presented with a 5-point Likert scale ranging from "1-Strongly Disagree" to "5-Strongly Agree".

3.2. Data Collection

The study was conducted in Croatia from April to May 2021. It was carried out online and invitations were sent to a random sample of Croatian individual taxpayers (income tax). The sampling was based on the willingness and availability of participants to complete the questionnaires. In order to ensure the content validity of the questionnaire and to test the respondents' understanding of the questions, the questionnaire was piloted with a sample of 40 participants. Some minor issues were identified during the pilot. As a result, wording of some of the questions was changed to ensure that the participants could clearly articulate and answer the questions.

To optimise the scope in this online survey, two sampling strategies were used. Regarding the first subsample, the data was collected by random sms invitations to mobile phones. In a second subsample, social media invitations via paid Facebook and Instagram advertisements were created, targeting specific sociodemographic groups (inspired by Rinken et al. 2020). Only individuals older than 18 years were asked to participate in the survey. A total of 299 were valid and accepted for this study, representing a response rate of 69.5%.

3.3. Data Analysis

The data were analysed in five steps using IBM SPSS Statistics 26. First, a descriptive analysis was carried out to examine the socio-demographic profile of respondents. This was followed by an exploratory factor analysis (EFA) to reduce the number of determinants of tax compliance (31 in total) to a smaller number of factors. The original multi-item constructs were reduced in the first step and also adjusted to the specificities of the tax system. Therefore, the theoretical framework was significantly modified through the EFA.

Principal axis factoring with direct oblimin rotation was used as the factor extraction method. Prior to factor analysis, the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlett's test for sphericity were applied. In addition, only factors with eigenvalues greater than 1 were retained, while items with factor loadings and communalities greater than 0.3 were retained in the final factor matrix. Reliability alphas within each dimension were calculated to best determine the internal consistency of a factor. Third, participants were then divided into segments through cluster analysis using the tax compliance factor scores. In this study, a non-hierarchical clustering method was used, more specifically the K-means clustering method. Fourth, possible statistically significant differences between taxpayer segments in terms of tax compliance factors were explored through ANOVA. This was supported by a subsequent post hoc analysis using the Hochberg GT2 post hoc test in the case of homogeneous/nearly equal variances and the Games–Howell post hoc test in the case of non-homogeneous variances. Finally, possible significant socio-demographic differences between taxpayer segments were tested.

4. Results

Exploratory factor analysis yielded a KMO measure of sampling adequacy of 0.785, a significant Bartlett's test of sphericity with chi-square = 2537.515 (df = 300) and $p = 0.000$, indicating that the covariance matrix was appropriate for conducting factor analysis. Six items with low communalities (less than 0.30) were excluded from further analysis. Finally, EFA with direct oblimin rotation from the 25 perception items yielded six factors with eigenvalues greater than one, which explained 60.23% of the total variance (see Table 1). According to Hair et al.'s (2013) rule of thumb, all standardised factor loadings (except one) were greater than 0.50, which suggests that the sample size of 299 participants was large enough to increase the significance level of the findings. Additionally, three or more items for each factor and the level of communalities indicated moderately good conditions and sufficient sample size (Leandre et al. 2012). Furthermore, all Cronbach's alpha values

were at the acceptable reliability level, i.e., higher than the recommended standard of 0.70 (Cortina 1993). Table 1 shows the results of the exploratory factor analysis, indicating standardised factor loadings, mean values, and standard deviations of all items examined.

Table 1. Results of exploratory factor analysis.

Statement	1	2	3	4	5	6	Mean	Std. Dev.
Tax Morale								
Non-compliance with tax liabilities is never justified.	0.589						3.30	1.040
Non-compliance with tax liabilities is always justified.	0.581					−0.108	3.62	0.973
Non-compliance with tax liabilities is sometimes justified.	0.734					−0.130	2.76	1.024
I believe I should declare my entire income and pay the appropriate income tax according to that.	0.597		0.219				3.47	1.091
I find manipulating tax reliefs acceptable.	0.625					0.100	3.51	0.983
I find the practice of cash-in-hand payments an acceptable way to avoid paying taxes.	0.657						3.16	1.051
The opportunity to pay a smaller amount of tax should be taken, even if it is not legal.	−0.585	0.103	0.114	0.108			3.98	0.788
Tax evasion is justified if the tax rates are too high.	−0.580		0.163	0.112			3.30	1.040
Tax System Complexity								
Tax laws are written in a simple language.		0.604	−0.131				2.19	0.871
It does not take a lot of effort to understand the explanations regarding tax legislation and tax authorities' publications.		0.725					2.48	0.948
I understand the current regulations regarding my tax liabilities.		0.596	0.105			0.115	3.09	1.008
Terms used in tax laws and tax authorities' publications are difficult to understand.		0.706					2.28	0.888
I feel confident and well informed regarding current tax laws.		0.683				0.100	2.43	0.953
Tax Rates								
Income tax rates are too high.			0.679				4.22	0.918
Increasing income tax rates affects the shadow economy growth.			0.779				4.12	0.859
I believe that the total tax burden on labour at rates of 56.5%. or 66.5% is too high.			0.700				4.35	0.858
Tax Audits								

Table 1. *Cont.*

	Factor							
Statement	1	2	3	4	5	6	Mean	Std. Dev.
If a citizen did not declare income for tax purposes, the tax authorities would certainly detect it.				0.548			2.97	1.036
Tax authorities' audits are frequent and profound.				0.751			2.47	0.854
Due to their knowledge and competence, tax authorities can detect quite every act of tax evasion.				0.725			2.31	0.986
Social Norms								
My family expects me to meet my tax obligations in accordance with the laws and regulations.	0.244		0.100		−0.619		3.59	0.998
My friends expect me to meet my tax obligations in accordance with the laws and regulations.					−0.956		3.14	0.986
People in my environment would strongly disapprove if I would not meet my tax obligations.				0.134	−0.576		2.55	0.987
Fairness Perceptions								
The decision processes and tax audits of the tax authorities are executed fairly.	−0.151	0.172		0.260	−0.160	0.363	2.06	0.779
The level of tax I pay is generally fair.	0.147	0.143	−0.218			0.531	2.20	0.885
I receive adequate public services for the taxes I pay.						0.831	1.92	0.891
Eigenvalue	4.896	3.218	2.273	2.196	1.316	1.160		
% of variance	17.542	10.809	7.201	6.836	3.624	2.882		
Cumulative variance	19.583	32.454	41.546	50.330	55.595	60.234		
Cronbach's alpha	0.703	0.797	0.773	0.709	0.768	0.701		
KMO = 0.785								
Bartlett's test of sphericity: $\chi2 = 2537.515$; df = 298;	Sig. = 0.000							

Note. Extraction method: principal axis factoring. Rotation method: oblimin with Kaiser normalisation [a].
[a] Rotation converged in six iterations.

The first factor, "tax morale", comprised eight items related to personal attitudes towards tax liabilities in order to better understand the decision-making process in tax manipulation, particularly in relation to the justification of tax compliance. With an eigenvalue of 4.90, this factor explained 17.54% of the total variance. The second factor, "tax system complexity", is characterised by five items relating to the understanding of tax legislation and a clear understanding of the tax regulation. This factor had an eigenvalue of 3.22 and explained 10.81% of the total variance. The third factor, "tax rates", included three items focusing on attitudes towards the level of tax rates and their impact on the shadow economy and the labour market. This factor had an eigenvalue of 2.27 and explained 7.2% of the total variance. Like the first factor, the third component had a higher mean (4.20) and a reliability alpha of 0.83. The fourth factor, "tax audits", was derived from three items relating to the efficiency of tax audits conducted by the authorities. It yielded an eigenvalue of 2.20 and explained 6.8% of the total variance. The fifth factor, "social norms", was characterised by three items relating to the influence of social groups, namely

family, friends and people from the neighbourhood, on the respondents' tax compliance. This factor yielded an eigenvalue of 1.32 and explained 3.62% of the total variance. The final factor, "perception of fairness", comprised three items reflecting the respondents' perceptions of fairness in tax audits, the level of taxes, and the decision-making processes and public services executed and provided by tax authorities. This factor had an eigenvalue of 1.16 and accounted for about 2.88% of the variance in the data.

Having uncovered the dimensions underlying the tax compliance determinants, the next step in the analysis was to cluster the respondents. The cluster analysis identified different groups of respondents based on their perceptions of the six factors described in the previous analysis. A non-hierarchical K-means clustering method was used as this method is more efficient with larger data sets (n > 200) and is more suitable for grouping cases rather than variables compared to the hierarchical technique (Johnson and Wichern 1998). After checking cluster membership, distance information, and final cluster centres, a four-cluster solution was found to be most appropriate. Furthermore, the mean values of each factor were calculated for the members of each cluster (see Table 2). The resulting ANOVA tests showed that all six factors contributed to the differences between the four clusters (Sig., $p < 0.001$) (Table 2). In addition, post hoc analyses using Hochberg GT2 or Games–Howell tests examined the differences between the clusters on all six tax compliance factors. Comparison of the means showed that the taxpayer segments differ from each other, confirming the statistically significant differences in the means. Finally, four segments were labelled based on the importance of the factors for tax compliance.

Table 2. Clusters and post hoc analysis.

Factors (Overall Mean)	Clusters				F	Sig.	Post Hoc [a]
	Extrinsically Motivated (1)	Morally Committed (2)	Financially Motivated (3)	Socially Committed (4)			
Tax morale (3.27)	3.27	3.53	2.94	3.34	34.689	0.000 ***	1 < 2, 1 > 3, 2 > 4, 3 < 4
Tax system complexity (2.48)	2.78	2.43	2.24	2.58	8.150	0.000 ***	1 > 2, 1 > 3, 3 < 4
Tax rates (4.21)	4.38	4.48	4.62	3.28	91.382	0.000 ***	1 < 3, 1 > 4, 2 > 4. 3 > 4
Tax audits (2.56)	3.26	2.27	2.20	2.75	42.796	0.000 ***	1 > 2, 1 > 3, 1 > 4, 2 < 4, 3 < 4
Social norms (3.07)	3.33	3.30	2.30	3.41	41.719	0.000 ***	1 > 2, 2 > 3, 3 < 4
Perception of Fairness (2.03)	2.61	1.75	1.60	2.41	65.010	0.000 ***	1 > 2, 1 > 3, 2 < 4, 3 < 4
N	67	94	72	64			

Note. Level of significance at * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. [a] Post hoc analysis using Hochberg GT2 or Games–Howell.

The largest number of taxpayers fell into the second (N = 94) and third (N = 72) clusters, while the first (N = 67) and fourth (N = 64) clusters were almost equal according to the number of respondents. Participants gathered in the first cluster perceived the combination of economic and psychological determinants as crucial for their tax compliance, but the dominant ones were tax rates and tax audits (tax rates = 4.38; tax audits = 3.26). Since the taxpayers in this cluster were significantly under the influence of the financial and deterrence factors, it is obvious that external (system) changes could stimulate their tax compliance. The type of taxpayer elicited in this cluster might be defined as "Extrinsically motivated" taxpayers.

The taxpayers in the second cluster were the ones under the influence of the financial factor (tax rates = 4.48) but characterised by strong tax morale (tax morale = 3.53) as well. Respondents from this cluster can be described as the ones who possess an intrinsic motivation in complying with their tax liabilities. Their voluntary tax compliance could be stimulated, with minimum cost to the tax system, by empowering a psychological contract between taxpayers and government. This cluster might be recognizable as "Morally committed" taxpayers.

In the third cluster, taxpayers were highly focused on tax rates, questioning the level of income tax rates and the overall tax burden (rates = 4.62). This group of taxpayers is slightly frustrated with the current tax system (tax system complexity = 2.24) and rates the fairness of the system as very low (perception of fairness = 1.60), while they do not perceive that their family or friends have any expectations regarding their tax compliance (social norms = 2.30). Since psychological factors could not stimulate their compliance, the type of taxpayer described in this cluster could be named "Financially motivated" taxpayers.

Taxpayers in the fourth cluster considered that the opportunity to pay a smaller amount of tax should not be taken and they agreed that people in their surroundings have some expectations regarding their tax compliance (social norms = 3.41). This suggests that they perceived paying taxes as their personal duty, and they might cooperate for the common good. This cluster is named "Socially committed" taxpayers.

The results of the ANOVA post hoc comparisons for the cohorts of taxpayers (Table 2) showed some statistically significant differences between the four groups. Extrinsically motivated taxpayers differ significantly from morally committed taxpayers on perceptions of tax system complexity, tax audits, social norms and perceptions of fairness. Extrinsically motivated taxpayers differ significantly from financially motivated taxpayers regarding tax morality, the complexity of the tax system, tax audits and perceptions of fairness. The comparison between extrinsically motivated taxpayers and the last group of taxpayers, socially committed taxpayers, shows some statistically significant differences in terms of tax rates and tax audits. Morally committed taxpayers differ significantly from extrinsically motivated and socially committed taxpayers in terms of tax morality. Moreover, the same group of taxpayers differs significantly from socially committed taxpayers in terms of tax rates, while social norms distinguish them from financially motivated taxpayers. The third group of taxpayers, financially motivated taxpayers, differs from extrinsically motivated and socially committed taxpayers in terms of tax rates. The last group of taxpayers, namely the socially committed taxpayers, differs significantly from the financially motivated taxpayers in terms of tax morale, complexity of the tax system, social norms and perceptions of fairness. Furthermore, the same cohort's perceptions of tax audits and perceptions of fairness differ significantly from those of morally committed taxpayers.

Table 3 shows the socio-demographic characteristics of the four clusters. All identified homogeneous case clusters averaged between 41 and 44 years of age (with a standard deviation of approximately ±12.3) and were predominantly female. Respondents in all four groups predominantly held master's degrees and worked in the private sector with more than 11 years of professional experience. Possible statistically significant socio-demographic differences between the segments of taxpayers were tested, pointing out one difference—monthly income. It was evident that the majority of the financially motivated cohort came from the highest income range, which was clearly different from the other groups, especially the extrinsically motivated and socially committed cohorts.

Table 3. Differences between taxpayer segments.

Variables	Extrinsically Motivated (1)	Morally Committed (2)	Financially Motivated (3)	Socially Committed (4)	F	Sig.
Taxpayer Segments						
Age in years (avg (SD))	44 (14.6)	43 (11.3)	41 (12.7)	44 (10.5)	0.893	0.473
Gender (%)					0.611	0.609
Male	35.8	34.1	31.9	28.1		
Female	64.2	65.9	68.1	71.9		
Education level					0.561	0.641
High school	14	22	20	18		
Bachelor	10	10	4	12		
Master	35	44	39	29		
MBA; PhD	8	17	9	5		
Employment status					1.148	0.330
Employed public sector	23	21	21	20		
Employed private sector	32	59	35	35		
Unemployed	3	2	4	0		
Retired	8	8	5	5		
Income monthly					3.592	0.014 *
<700 €	19	14	15	14		
701–1000 €	26	38	19	29		
1000–1500 €	16	28	18	14		
1500 € >	6	13	30	7		
Seniority					1.860	0.136
<5	14	9	10	7		
6–10	11	16	20	11		
11–20	20	47	30	27		
20>	22	21	12	19		
N	67	94	72	64		

Note. Level of significance at * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

5. Discussion and Conclusions

This paper focused on identifying taxpayer clusters and examining the factors that shape these clusters using a sample of 299 individual taxpayers. The results followed the well-established idea that taxpayers are not a homogeneous group and that they are stimulated and motivated to meet their tax obligations by very different mechanisms. A factor analysis was conducted that identified the following significant factors: tax audits, tax rates, complexity of the tax system, tax morale, social norms, and perceptions of fairness.

The cluster analysis identified four distinct groups of respondents based on their perceptions of the six factors significant to tax compliance. The clusters were named as follows: "Extrinsically motivated", "Morally committed", "Financially motivated", and "Socially committed" taxpayers. The first and third clusters seemed to be mostly influenced by the economic factors, while second and fourth were significantly under the influence of psychological determinants, which is somewhat similar to the Torgler's (2003) results of the typology of taxpayers. Torgler's (2003) "Intrinsic taxpayer" can be compared to a "Morally committed" taxpayer in this case, since they are driven by their individual emotions and responsibilities. The same author also identified the type of taxpayers who were socially committed (as our fourth cluster) and named them "Social taxpayers". The specificities of these clusters offer a practical solution for tailoring taxation strategies towards them. It is obvious that there are still many taxpayers who fulfil their tax liabilities because of the existence of deterrent factors such as tax audit, or the crucial role for their decision is played by a financial determinant (tax rate). But it should be noted there are also morally and socially committed taxpayers who make their decisions according to their own moral standards or taking into account the social norms in their environment. This is consistent with Braithwaite's (2003) statement about how tax compliance can be improved

by persuading and encouraging taxpayers to cooperate. Thus, the time has come for policy makers to employ such strategies and stimulate voluntary tax compliance. In addition, it needs to be emphasised that such strategies do not necessarily imply a high level of expense to the tax system. After all, researchers have lately offered significant evidence about the fact that enforcement strategies do not always bring efficiency (Mendoza et al. 2017; Kirchler et al. 2008).

This might be an opportunity to analyse and introduce a reward mechanism which, for example, redistributes the collected fines from noncompliant to compliant taxpayers in a form of a symbolic rewards (especially given its positive effects, see Fatas et al. 2021). Combating the tax evasion problem by incorporating this new evidence about taxpayers would surely be a step forward towards service-based and trust-based climates (Kaplanoglou and Rapanos 2015; Gangl et al. 2020) beyond purely enforced interventions.

Jackson and Milliron (1986) were some of the first authors to argue that age, gender and education should always be taken into account when examining tax compliance. According to Fischer et al. (1992), sociodemographic variables have no direct influence on taxpayer compliance. However, they do show that there is a significant indirect influence that is evident in the possibility of tax evasion and attitude. Hofmann et al. (2017) made an important contribution with their meta-analysis of survey studies in 111 countries, demonstrating the importance of sociodemographic factors and arguing that they should not be neglected in future studies. In their study, they focused on age, gender, education, and income in order to estimate the impact on compliance while taking geographical regions into account. A more thorough and nuanced study of the tax compliance by the wealthy taxpayers is of utmost importance for public efficiency (Gangl and Torgler 2020). The results of this study suggest that the clustering procedure statistically differentiates the groups regarding their monthly income. Moreover, it sheds light on a better understanding of the determinants of the tax compliance of wealthy citizens and implies the need for practical solutions that would lead to an optimised and fair tax system for the middle, lower and upper class citizens. The results also point out that although it is very important to rely on an economic framework, evidence strongly suggests that taxpayers are motivated by other factors, many of them beyond purely financial. In the last 20 years of research, a whole range of potential determinants was identified; they should be acknowledged and used to incentivise tax compliance. Therefore, a major challenge for upcoming researchers is to investigate how these emerging determinants shape tax compliance. Understanding and improving tax morale and the fairness of the system as well as analysing the norms surely hold the potential to increase revenue with minimal enforcement mechanisms. This is the reason why regulatory institutions should recognise that there is no one-size-fits-all solution for taxpayers. Above all, it is an important task to initiate a change in the discussion on taxation and replace the traditional frameworks with different strategies that combine economic and socio-psychological factors (Batrancea et al. 2019). In other words, the traditional tax system infrastructure calls for measures that encourage taxpayers' willingness to pay—with or without the tax authority watching over their shoulders (Braithwaite 2003).

The results of this study raise some questions for policy makers and may help them to understand and promote voluntary tax compliance in Croatia, but they may also be a helpful starting point for research in countries with similar economic and fiscal policies. After identifying clusters and the factors behind taxpayer attitudes, these findings can hopefully stimulate future research on taxpayer heterogeneity and optimal strategies to promote tax compliance. Although this work contributes new insights to existing research, it has certain limitations that should be kept in mind. First, it focuses exclusively on income tax. However, it is well known that, in reality, taxpayers often suffer from the overall tax burden. As a result, there may be differences in taxpayer compliance. Second, despite the fact that questionnaires are widely used in the field of tax compliance research, these instruments have their own disadvantages (Alm and Torgler 2011), such as unconscientious and dishonest responses, lack of personalization, difficulties in conveying

feelings and emotions, etc. In this research, the term "general fairness," is used but it is undeniable that this is a multidimensional concept. Therefore, future research calls for more detailed elaboration and differentiation between distributive (horizontal, vertical, exchange), procedural and retributive justice. It would also be quite important to continue the discussion regarding the influence of the presence of third-party reporting (an external, economic factor) in voluntary tax compliance. In this context, in line with present studies such as that by Kleven et al. (2011), taxpayers' employment status information should indicate whether individuals are self-employed or salaried. Finally, the findings are not necessarily generalizable to the context of countries beyond Croatia (and similar countries). Future research could consider other analysis techniques, such as regression analysis or causal inference methods, including instrumental and control variables that can be used to address the potential presence of endogeneity and its impact on the interpretation of results. Moreover, future research should focus on developing this research framework and expanding it to a larger international comparative study. Conducting surveys of taxpayers from other countries could shed light on whether there are differences and similarities that could lead to the assumption that there are common characteristics in taxpayer compliance. In addition, taxpayers' perceptions and attitudes should be observed over time to better understand how fiscal changes affect taxpayer tax compliance. Finally, future studies could use a more comprehensive list of the determinants of tax compliance and extend the findings of the current study.

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Article

Nudges, Boosts, and Sludge: Using New Behavioral Approaches to Improve Tax Compliance

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Abstract: This paper discusses current developments in tax compliance research, with a focus on three aspects. First, we summarize empirical evidence on the traditional deterrence or enforcement approach, suggesting that tax audits and fines for noncompliance are critical in taxpayers' compliance decisions. However, recent research indicates that the effects of deterrence are more nuanced than initially thought, suggesting that other interventions are needed to improve tax compliance. Second, therefore, we discuss research on behavioral approaches to increase tax compliance, starting with research that analyzes the effects of "*nudges*", or interventions that use behavioral economics to alter the ways in which the choice architecture facing individuals is communicated to them by the tax administration. As applied to tax compliance, we conclude that nudges have had mixed effects on increasing tax compliance, suggesting that the specific design and implementation of these interventions determine their effectiveness. Third, we extend our discussion to other behavioral economics interventions that have not yet been studied widely in tax compliance research. These include "*sludge*", or institutional features that complicate compliance, and "*boosts*", or initiatives that target individuals' competencies and thereby help them to make better decisions. Our central argument is that all three of these behavioral interventions should be utilized in the design of tax policies. However, for these methods to effectively complement traditional deterrence approaches, tax administrations should evaluate them before implementing them in the field. Closer cooperation between administrators and academics should thus be facilitated and encouraged.

Keywords: tax compliance; deterrence theory; behavioral economics; nudges; boosts; sludge

1. Introduction

Ensuring that individuals pay their fair share of taxes has long been a challenge for tax agencies, and improving tax compliance continues to be a pertinent issue today. For example, the Internal Revenue Service (IRS) of the United States estimates that in recent years the amount of taxes that should be but are not paid—the so-called "tax gap"—is roughly USD 500 billion annually, or nearly 1/6 of the taxes actually collected (IRS 2022). Indeed, Charles Rettig, a former Commissioner of the IRS, has said in recent testimony that this tax gap may have grown to as much as USD 1 trillion annually, an amount that exceeds 5 percent of the U.S. gross domestic product (GDP) (Rappeport 2021). The U.S. problem is not an isolated one. According to global estimates, tax evasion may account for up to 11.5 percent of the world's total GDP (Zucman 2017).

Given these remarkable figures, a substantial body of research investigates methods to increase compliance. Conventional collection efforts rely on the notion that audits and penalties deter tax evasion (Allingham and Sandmo 1972), and extensive literature has documented that financial sanctions have a strong effect on compliance (Alm 2019; Slemrod 2019). Non-financial, or "collateral" sanctions (Blank 2014), such as the revocation of

driving licenses and the denial of passports to tax evaders, have also been suggested as ways to improve compliance, and a recent study by Organ et al. (2022) for the U.S. estimates that limiting passport access for taxpayers with significant tax debts has a positive effect on compliance. Nevertheless, it is increasingly recognized that more enforcement does not always translate into more tax compliance (Alm and Kasper 2023; Beer et al. 2020; Kasper and Alm 2022; Kasper and Rablen 2023; Lancee et al. 2023). Indeed, much of the recent research indicates that tax compliance cannot be achieved solely with the threat of penalties and sanctions, and in some circumstances, more audits may actually lead to less compliance.

As a result, various alternative approaches for increasing compliance have been proposed in research and implemented in practice. Most notably, several studies have investigated the effects of behavioral interventions, especially the effects of letters sent to taxpayers in which the tax agency tries to "nudge" taxpayers to comply. These letters allow taxpayers to keep their tax compliance decisions unchanged, but the letters also typically increase the salience of audits and fines for noncompliance, and they also sometimes appeal to social norms or moral principles as a way to increase compliance. However, a growing body of work finds somewhat mixed and inconclusive results on the effectiveness of these nudges. While enforcement threats generally tend to increase compliance, there is also work showing that some nudges have a positive effect on compliance in some situations but not in others (Alm 2019; Slemrod 2019).

Given the often inconclusive results for nudges, it seems worthwhile to examine whether there are lessons to be learned from the use of nudges. It also seems important to examine other behavioral-based approaches that have the potential to increase tax compliance but that have not yet been systematically investigated as tools for improving tax compliance.

This is our purpose here. Specifically, we provide an overview of three novel approaches to regulating behavior—"nudges", "boosts", and "sludge"—by making reference to recent and relevant empirical research that has examined these approaches in other fields (e.g., environmental science, finance, health) and in various institutional settings (e.g., developed/developing countries, different tax instruments, diverse empirical methodologies). We then discuss the potential of these approaches in strengthening tax compliance. Broadly, we hope to contribute to a better understanding of the effectiveness of behavioral interventions, along with the development of a richer toolbox for administrators and practitioners to increase compliance.

We proceed as follows. In the next sections, we discuss traditional and behavioral perspectives on tax compliance, where we focus on deterrence. Subsequently, we discuss how behavioral insights are implemented in other fields to induce behavioral change. Specifically, we discuss how "nudges" can affect compliance decisions; we also discuss how "boosts", or providing individuals with tools to make better decisions, and how reducing tax system "sludge" (or complexity) may affect behavior. We then present a set of best practices that administrators and researchers should follow when deciding between implementing nudges and boosts or reducing sludge. Subsequently, we discuss how nudges, boosts, and sludge can be used to increase tax compliance. The last sections conclude.

2. What Motivates Tax Compliance?

2.1. Increasing Tax Compliance Using Audits and Fines

The standard model of tax compliance (Allingham and Sandmo 1972) is based on the economic theory of crime (Becker 1968). The model assumes that taxpayers weigh the certain consequences of compliance against the uncertain benefits of tax evasion and choose the option that gives them the greatest expected income (or utility). The fundamental insight from this approach is that taxpayers comply with tax laws because they fear being detected and punished for non-compliance. As a result, the model predicts that

increasing the frequency of audits and the severity of fines for non-compliance will enhance tax compliance.

There is in fact ample evidence that increasing the perceived risk of audit and imposing greater fines for tax evasion have positive effects on compliance (Alm 2019; Slemrod 2019). For instance, an early field study conducted by Slemrod et al. (2001) discovered that sending a letter to taxpayers threatening "close examination" of their tax returns leads to a minor but statistically significant increase in reported income among low- and middle-income taxpayers relative to a control group that did not receive any letter (but actually decreased reported income for high-income taxpayers). Another study by Kleven et al. (2011) examined the effect of letters announcing either a certain audit or a 50 percent probability of an audit, while a control group did not receive any letter. The study found that the audit probability had a positive impact on reported income; that is, taxpayers who anticipated a 100 percent probability of audit reported higher income than those who expected a 50 percent probability of audit, and both groups reported more income than taxpayers in the control group who did not receive a letter. Meiselman (2018) found that messages that increase the perceived probability of punishment have a positive effect on the filing compliance of delinquent taxpayers and that increasing the salience of penalties also has a positive impact on compliance. There are also numerous studies using naturally occurring field data and data generated from laboratory experiments that provide similar results (Alm 2019).

Overall, then, there is strong evidence that increasing the perceived risk of an audit and raising the fines for noncompliance often lead to greater tax compliance, as suggested by the standard model of tax compliance. In a comprehensive review of the empirical literature, Alm (2019) concludes that a one percentage point increase in the risk of detection generally increases compliance by 0.2 to 0.4 percentage points, while a one percentage point increase in the fine for noncompliance usually increases compliance by around 0.1 percentage points. Therefore, in line with the predictions of the standard theory, tax administrations can improve compliance by increasing either or both the fine on evaded taxes and the audit probability.

Even so, there is also evidence that tax audits can have differential effects and even reduce tax compliance in many settings. For example, field studies show that the effect of tax audits on the post-audit tax compliance of audited taxpayers varies depending on the audit outcome. Taxpayers who were found to owe taxes tend to increase their subsequent compliance compared with a control group of unaudited taxpayers, but those who were found not to owe taxes show the opposite response (Beer et al. 2020; Gemmell and Ratto 2012). This result may be due to ineffective audits or audits that fail to detect a taxpayer's noncompliance, which can reduce post-audit tax compliance (Kasper and Alm 2022). Other studies using laboratory experiments find that randomly selected taxpayers tend to decrease their tax compliance in the subsequent reporting decision, a phenomenon known as the "bomb crater effect" (Guala and Mittone 2005; Mittone 2006), an effect that appears to be driven by the misperception of the risk of a subsequent audit when the audit selection is random (Kasper and Rablen 2023).

In addition to these findings, previous research has explored the effect of collateral sanctions on tax evasion. Some scholars have suggested using non-financial sanctions to discourage noncompliance, such as publishing the names of tax delinquents or limiting access of tax evaders to official documents like passports and licenses, alongside regular financial penalties (Blank 2014). Although there is limited evidence on the effectiveness of these measures, some studies suggest that non-financial sanctions can increase tax compliance. For example, a study conducted in Slovenia found that firms reduced their tax debt in response to the threat of public shaming (Dwenger and Treber 2022), while laboratory experiments conducted by Casal and Mittone (2016) and Alm et al. (2017) showed that public shaming can have a positive effect on tax compliance. Additionally, a recent study by Organ et al. (2022) found that restricting passport access for taxpayers with significant tax debt strongly increased compliance.

Taken together, these results suggest that both financial and non-financial sanctions can deter noncompliance. These results also suggest that a taxpayer's decision to comply with tax obligations may be influenced by factors beyond purely financial incentives. These findings have led to several extensions of the standard model of tax compliance.

2.2. Nonfinancial Determinants of Tax Compliance: The Role of Trust and Other Social Constructs

The expected utility model of tax compliance has been criticized for its inability to provide a compelling explanation for observed levels of compliance (Alm et al. 1992). Given real-world values for audit and fine rates, the model's rational cost–benefit analysis implies that many taxpayers face minimal audit risk and small fines for noncompliance, leading them to underreport income or over-claim deductions to evade taxes. However, such behavior is not commonly observed, despite the model's predictions. This discrepancy suggests that non-financial considerations influence taxpayers' compliance decisions. What other factors are suggested by theory to explain why people pay taxes?

One strand of research stays within the basic framework of the economics-of-crime model by adding a range of potentially relevant considerations (e.g., employer withholding, labor supply decisions, alternative tax and penalty systems, systematic audit selection procedures, complexity and uncertainty, use of paid tax preparers, government services, positive rewards). These many extensions make the basic model more realistic and withholding especially results in predictions of compliance closer to its observed levels. However, these extensions do not alter the fundamental conclusion of the economics-of-crime approach: compliance is driven entirely by financial considerations like detection and punishment. See Alm (2019) for a discussion of these extensions.

Another and more recent strand of research expands the scope of the economics-of-crime model beyond purely economic considerations theory by introducing some aspects of behavior considered explicitly by other social sciences, especially psychology. These aspects change the ways in which an individual makes decisions (e.g., misperceived probabilities of audit, guilt and shame, and "rules of thumb" for decisions), and they also introduce group considerations (e.g., fairness, altruism, and social norms).

The foundation for this other strand of research is behavioral economics. The standard neoclassical economic model of human behavior is based on several main assumptions: individuals are rational, they have unlimited willpower, and they are purely self-interested. While these assumptions may be a useful starting point for the analysis of individual behavior, there is increasing evidence that they are inaccurate and unrealistic depictions of many, perhaps most, individuals. As emphasized by Congdon et al. (2011), these so-called "deviations" from neoclassical assumptions can be classified into two broad areas: imperfect individual optimization (stemming from, say, limited computation abilities or bounded self-control) and non-standard preferences (like other-regarding preferences).

In the context of tax compliance, behavioral economics has been applied in two broad (and somewhat overlapping) dimensions. One extension keeps its focus on *individual* factors, stemming from imperfect optimization; the other extends the analysis to *group* considerations, stemming largely from non-standard preferences. Consider each of these dimensions.

The first aspect of behavioral economics focuses on the ways in which *individual* behaviors diverge from neoclassical predictions. Many of these extensions involve some form of "frame dependence", in which an individual's decision depends upon how the choice is presented. Frame dependence is typically related to some cognitive limitation of the individual in perceiving decision problems and in evaluating the available options. Given these cognitive limitations, many individuals do not maximize expected utility, but instead pursue different strategies, as modeled by *non-expected utility theories*. The most well-known of these alternative theories is likely the prospect theory of Kahneman and Tversky (1979); other theories include rank-dependent expected utility theory (or anticipated utility), first-order and second-order risk aversion, regret/disappointment theory, non-additive probabilities, ambiguity theory, and hyperbolic discounting, among others.

These many applications of non-expected utility theories to tax compliance are discussed in comprehensive surveys by Hashimzade et al. (2013) and Alm (2019); see also Kirchler (2007) and Torgler (2007). Relative to expected utility theory, these models change the "probability" that an individual perceives and the "objective function" that he or she pursues. In doing so, they continue to demonstrate the importance of enforcement on tax compliance. However, these models can also generate predictions that better approximate observed levels, especially if they have overweighting of probabilities. All of this comes at the cost of adding many complications to the analysis of individual behavior.

The other aspect of behavioral economics focuses more on *group* behavior, often summarized as *social interaction theories*. There is abundant evidence that individuals are influenced by the social context in which, and the process by which, decisions are made and that they are motivated not simply by self-interest but also by group notions like social (or group) norms, social capital, social customs, appeals to patriotism or conscience, or feelings of fairness, altruism, reciprocity, empathy, sympathy, trust, guilt, shame, morality, and alienation. Regardless of the specific term that is used, all of this research concludes that one's own *individual* behavior is strongly influenced by the behavior of the *group* to which one identifies, largely via other-regarding preferences.

There are various aspects of these social interactions, but perhaps the most useful approach to social interactions emphasizes that many individual behaviors can be viewed as a "psychological contract" between individuals (and between individuals and government). Central to this contract is the broad notion of a "social norm" of behavior. A social norm represents a pattern of behavior that is judged in a similar way by others and that is sustained in part by social approval or disapproval. Put differently, a social norm is a recognized, customary, and self-reinforcing pattern of behavior in which everyone participates, given the expectation that everyone else will also participate. Put differently, a social norm is an informal rule of behavior that individuals follow for reasons largely distinct from the fear of legal penalties. Consequently, if others behave according to some socially accepted norm of behavior, then an individual will behave appropriately; if others do not so behave, then an individual will respond in kind. The presence of a social norm is also consistent with many other approaches that incorporate similar notions of social interactions, such as those that recognize some form of other-regarding preferences. Indeed, it is hard to think of any type of social interaction that is not governed in some way by a social norm.

As for specific applications of these approaches to tax compliance, again see Hashimzade et al. (2013) and Alm (2019) for surveys. These models maintain the importance of enforcement, but they also introduce many other relevant considerations that go well beyond narrow financial considerations. Notably, they are able to generate realistic predictions about the level of compliance, although at the cost of considerable complexity.

Overall, then, the many theories of tax compliance suggest that enforcement matters, including the ways in which third-party sources of information and tax withholding systems affect the enforcement capabilities of tax administrations. However, theory (especially theory based on behavioral economics) also suggests that an individual does not always behave as assumed in the standard economic approach; that is, an individual may not be able to make all calculations required under expected utility theory, an individual may not be able to determine the true costs of an action, an individual may face limits on his or her self-control, and an individual may be affected by the framing of a decision. Finally, theory (again, theory based on behavioral economics) suggests that an individual is a social creature and may be influenced by group considerations in his or her compliance behavior.

Indeed, a large body of empirical research suggests that trust, social norms, tax morale, fairness considerations, and subjective understanding of the tax system all affect compliance (Alm and Kasper 2023). For instance, prior studies investigate the role of social norms, or the behaviors and shared ethical beliefs attributed to other taxpayers (Wenzel 2004), and studies using laboratory experiments find that social norms have the potential to increase tax compliance (Alm et al. 1999; Bobek et al. 2013). Social norms affect compliance by

increasing the moral cost of noncompliance (Myles and Naylor 1996; Frey and Torgler 2007; Traxler 2010), and they are particularly effective when one identifies with the group in question (Wenzel 2005). Similarly, tax morale, or the intrinsic motivation to pay taxes, affects tax compliance (Alm and Torgler 2006; Frey and Torgler 2007; Kirchler 2007; Torgler 2007; Luttmer and Singhal 2014). Rather than moral costs being increased because of information that the taxpayer has deviated from the behavior of others, here the costs result from deviating from one's own moral standard (Erard and Feinstein 1994; Alm and Torgler 2011). Taxpayers' trust in the tax administration also affects compliance (Kirchler 2007). In particular, compliance levels tend to be higher and enforcement tends to be more effective when individual trust in the government and the tax administration is greater (Kogler et al. 2013; Kasper et al. 2015; Batrancea et al. 2019).

In sum, these results indicate that there are alternative approaches for improving compliance that go well beyond enforcement. These alternative approaches—nudges, boosts, and sludge—are discussed in detail in the following sections.

2.3. Tax System Characteristics: "Sludge" and Other Frictions

Tax system characteristics also seem likely to affect individual compliance decisions. One characteristic of tax systems that are frequently criticized is their complexity, including such features as the length of the tax code, the number of taxes, and the readability of the tax code (Tran-Nam and Evans 2014). Complexity in the tax system can lead to unintentional non-compliance because people may misinterpret rules or make unintentional errors (Cuccia and Carnes 2001). Complexity might also lead some taxpayers to pay more than they should, for instance, by not claiming refunds or credits to which they are entitled (Alm et al. 1993). We discuss the role of complexity later, in the context of "sludge" and other similar frictions in the tax code.

3. Broadening the Scope—Using Insights from Behavioral Economics to Increase Tax Compliance

3.1. Changing Taxpayer Communications to Nudge Taxpayers

While academic work on the effects of tax system design other than audits and fines is scarce, a growing body of work investigates how tax administrations can change taxpayer communications to promote tax compliance (Antinyan and Asatryan 2019). Similar to the "letter" method used by Slemrod et al. (2001) discussed earlier, this research extends the use of messaging well beyond audits, for example, by utilizing it in randomized controlled trials (RCTs) in which the tax administration distributes letters with a variety of different messages to randomly selected groups of taxpayers. This approach aims to nudge taxpayers to comply by subtly changing the environment with the presentation of information that is designed to influence behavior in a specific way without restricting choice or significantly changing incentives (Thaler and Sunstein 2008). Nudges often leverage cognitive biases or heuristics to steer individuals toward choices that are in their best interest. Strictly speaking, the application of "nudges" in the context of tax compliance does not align with the original definition of nudges. While Thaler and Sunstein (2008) highlight that nudges must help decision-makers to decide in *their* best interest, these studies aim at fostering decisions that are in the best interest of *society*. However, individual and social benefits do not necessarily align because free-riding on the contributions of others and thus not paying taxes might be in the taxpayer's best interest, while such behavior would clearly be suboptimal for society as a whole.

Overall, prior work studying these effects suggests that changing taxpayer communication can affect tax compliance, but the evidence is mixed (Hallsworth 2014). Several studies find no effect of behavioral interventions, such as highlighting the social norm of paying taxes or appealing to tax morale (Blumenthal et al. 2001; Torgler 2004; Fellner et al. 2013; Pomeranz 2015; Ortega and Scartascini 2020), while other studies suggest that moral suasion (Hallsworth et al. 2017; Bott et al. 2020; Del Carpio 2013) or simplification (Dwenger et al. 2016) can increase tax compliance in real-world settings. Relatedly, recent

work by List et al. (2023) examines the welfare effects of nudges. In their comprehensive review of the literature on nudges and tax compliance, Antinyan and Asatryan (2019) find that deterrence nudges generally tend to increase compliance. However, compared with non-deterrence nudges, their effects on compliance are moderate. Moreover, Antinyan and Asatryan (2019) find that nudges are more effective on delinquent taxpayers (who have a history of late payments) and also more effective when they are delivered in person (rather than by mail). Finally, they find that the long-term effects of nudges are lower in lower-income countries. Another recent study by Truzka et al. (2022) finds similar results, especially the result that deterrence interventions generally tend to be more effective than other interventions in increasing compliance.

However, it is important to note that most of these studies have investigated the effects of nudges on individual income tax compliance, and most studies have also examined evidence in developed countries. Both practices are now changing. For example, there are now several recent studies on the effects of nudges for other taxes, such as the company income tax (Biddle et al. 2018; Bergolo et al. 2023) or the value-added tax (Pomeranz 2015). Also, researchers have had increasing access to administrative data in developing countries; see Pomeranz (2015) for Chile, Kettle et al. (2017) for Guatemala, Hoy et al. (2020) for Papua New Guinea, and Bergolo et al. (2023) for Uruguay. Much of this newer work was undertaken by The World Bank, in partnership with governments in its client countries and sometimes in partnership with other international organizations; for information on much of this work, see https://www.ictd.ac/theme/tax-administration-and-compliance/ and https://www.worldbank.org/en/topic/macroeconomics/brief/innovations-in-tax-compliance (both accessed on 1 June 2023). These studies have utilized a range of innovative field experiments that test different nudge strategies for improving tax compliance. Importantly, all of these field studies occur at the local government level in developing countries, focusing on local property taxes in Asia (e.g., Pakistan), Latin America (e.g., Argentina, Brazil, Colombia, Costa Rica, Guatemala, Mexico, Peru, Uruguay), and Africa (e.g., Ethiopia, Ghana, Kenya, Liberia, Malawi, Rwanda, Sierra Leone, South Africa, Tanzania, Uganda). The results vary significantly by the specific type of nudge strategy, but they all rely at least in large part on providing more and better information to individuals. A common result is that these strategies often improve individuals' ability to make informed decisions, while also increasing trust in their neighbors and in their local government, and, through these channels, they also improve tax compliance. Indeed, Haushofer and Fehr (2014) argue that the available empirical evidence on the potential for nudges in improving the quality of decision-making in developing and poorer countries is likely to be particularly large.

Even so, these nudge strategies do not always work. One potential explanation for the inconsistent results on the effects of nudges found in prior work is that behavioral interventions are often not comparable across studies because researchers work independently when designing their nudges. For example, "social norm" messages have been designed very differently by different teams of researchers. Blumenthal et al. (2001) find that the phrase "...*people who file tax returns report correctly and pay voluntarily 93 percent of income taxes they owe* [...], *a small number of taxpayers who deliberately cheat owe the bulk of unpaid taxes*" does not affect compliance. In contrast, Hallsworth et al. (2017) find that the phrase "...*nine out of ten people in the United Kingdom remit their tax on time. You are currently in the very small minority of people who have not paid us yet*" is the most effective of several of their letters in making people pay their taxes. Similarly, Bott et al. (2020) use a "societal benefits" treatment that uses the phrase "[*y*]*our tax payment contributes to the funding of publicly financed services in education, health and other important sectors of society*", and they find that this appeal almost doubles the average income reported compared with a baseline letter that did not include such an appeal.

In sum, a growing body of work investigates to what extent tax administrations can change their communication strategies to nudge taxpayers to comply. However, field studies find inconclusive results, and prior work does not investigate why behavioral

interventions increase tax compliance in some settings but not in others. As prior work does not investigate the effectiveness of the many different approaches that have been examined using common instruments and objectively measured outcomes, the reasons for these inconclusive results remain unknown.

3.2. Nudging beyond "Letter Studies"

Studies investigating the effect of nudges on tax compliance focus almost exclusively on the potential of changing taxpayer communications. However, other fields have tested a variety of other behavioral approaches to support individuals in making better decisions. Such approaches are frequently taken in environmental science (e.g., to foster pro-environmental behavior), finance (e.g., to increase savings and contributions to retirement funds as well as improve investment decisions), or health (e.g., to suggest healthy diets, exercise, and inform patients of the risks of certain diseases). Here, we discuss how other fields have used behavioral interventions and how these insights can be used to increase tax compliance. First, we provide an overview of nudges and their use in other fields beyond tax compliance. Second, we discuss "boosts" and outline their applications. Finally, drawing from the insights gained from other fields, we discuss novel ideas for how to use nudges and boosts to increase tax compliance. In a later section, we extend our discussion to "sludge" and its effects on tax compliance.

A recent meta-analysis provides a comprehensive overview of the effectiveness of nudges in different domains (Mertens et al. 2022), reviewing more than 200 articles from various disciplines with regard to the effectiveness of different choice architectures. Prior meta-analyses have pointed out that developing a common nomenclature is crucial in facilitating the evaluation of hypothesized relationships (Szaszi et al. 2018). Only when behavioral sciences use the same terms to describe a specific intervention will there be a chance to reach a consensus on what interventions are effective in which settings. Therefore, our discussion follows the categorization of nudges proposed by Mertens et al. (2022), who categorize behavioral interventions along three dimensions: *decision information*, i.e., the content and style of information presented to the decision-maker; *decision structure*, i.e., the way that the decision is structured (or which, where, and how options are presented); and *decision assistance*, i.e., if and what kind of assistance is offered to decision-makers. The study also identifies nine choice architecture intervention techniques. See Table 1 for a summary of these features.

Table 1. Categorization Of Behavioral Interventions (Mertens et al. 2022).

Intervention Category	Intervention Technique	Description
Decision Information	Translation	Translate a choice's attribute into more meaningful information
	Visibility	Provide relevant information
	Reference points	Give information about the individual's position relative to a peer group's behavior
Decision Structure	Defaults	Change the default option of the choice
	Option-related effort	Modify effort associated with certain choices
	Range and composition of options	Modify how categories are split to facilitate choice
	Option consequences	Modify consequences of choice to prevent present bias
Decision Assistance	Reminders	Increase salience of specific information to reduce information overload
	Commitment	Encourage ex-ante commitment

Since individuals' decision-making is affected by the information that is available to them, modifying this information is likely to affect their decisions. The first set of nudges (Decision information nudges) take this into consideration by altering the information given to decision-makers, for example, by translating choice attributes into information

that is more meaningful to decision-makers. Providing individuals with more meaningful information ensures that they take it into consideration, which in turn saves time and effort. For example, Ungemach et al. (2018) apply a translation nudge to increase the match between consumers' preferences and their choices, aiming to help individuals make choices that are better aligned with their objectives. Ungemach et al. (2018) find that translating information that is relevant to the decision-maker into units that are more informative and readily available increases the quality of decisions, as measured by how well preferences and decisions are aligned.

A second intervention technique under Decision information nudges is to nudge desired actions by increasing the visibility of certain behaviors, i.e., making decisions and their consequences more salient. For instance, giving consumers information on how their choices affect their health or the environment reduces the propensity for decisions with negative externalities. Along these lines, Jessoe and Rapson (2014) investigate how showing consumers their real-time energy consumption affects consumption decisions, and they find that households react with a significant decrease in energy consumption when informed about their energy consumption in real-time compared with when they are informed only at the end of the invoice period. They conclude that the visibility of consumption, rather than consumption itself, affects behavior and that well-designed visibility nudges have the potential to induce more conscientious behavior. Visibility nudges may also work by increasing the visibility of certain attributes of a choice, such as the reciprocity that a certain choice entails. For example, studies have used reciprocity statements such as "If you needed an organ, would you take one?" to test if these affect individuals' propensity to become organ donors themselves (O'Carroll et al. 2017; Han and Wibral 2020).

In a third intervention technique under Decision information nudges, it is well established that individuals adjust their behavior to what their peers are doing. Taking advantage of this mechanism, i.e., giving reference points that refer to peers' "good" behavior, may encourage individuals to change their behavior in order to fit in. Several studies have used this concept to steer individuals' behavior in the desired direction (Köbis et al. 2022; Nolan 2021). In a prominent study, Allcott (2011) investigates the role of social norms in energy consumption, using reference points to alert consumers to their level of energy consumption in comparison to their peer group's consumption. He finds that consumers within the highest decile of pre-treatment energy consumption decrease their consumption the most, while the effect on individuals in the lowest decile is very low. While these results paint a promising picture of the use of reference points, they also raise the issue of heterogeneous effects. Prior work generally highlights the importance of taking individuals' current decisions into account, suggesting that nudges should be tailored to the specific group on which the nudges are used.

Another strand of the literature investigates the effects of Decision structure nudges. Mertens et al. (2022) identify four intervention techniques to perform these nudges. First, changing the default option is a powerful way to affect individuals' choices. For example, Johnson and Goldstein (2003) point out that, in countries where citizens were added to an organ donor list by default and had to actively opt out, the donor rate increases substantially. Second, the desirability of a choice seems to be directly affected by the effort an individual has to undergo when choosing this specific option. Increasing the effort (such as the physical effort or the time that needs to be invested to pursue an option) may severely affect the desirability of a choice. A popular example of such interventions is placing unhealthy food farther away from the consumer to increase the effort that needs to be undertaken to get it. Such interventions indeed lead to more consumption of healthy food options that are placed closer (Kroese et al. 2016). Third, the composition of a choice affects how individuals evaluate its content and its consequences. For example, smoking one package of cigarettes per day may be perceived as having fewer consequences on a smoker's health than smoking 7300 cigarettes per year (Read et al. 2000). Fourth, and in a similar vein, an option is to alter the way in which individuals are informed about the consequences of their decisions. Alerting individuals about certain consequences, whether using micro-incentives or other

means, may attenuate their present bias or loss aversion. For example, Veldwijk et al. (2016) investigate how the presentation of the consequences of cancer affects participants' risk perceptions, and they find that the framing of the consequences, i.e., presenting a probability of surviving versus presenting a probability of dying, significantly affects participants' perceptions of risk, in line with the predictions of prospect theory. A fifth and final method of utilizing option consequences is by placing incremental incentives (or consequences) at different stages in the decision-making process, such as using "gamification" in healthcare contexts (Hare et al. 2021). For example, Mitchell et al. (2018) find that using an app that incentivizes healthy behavior (such as walking) with loyalty points has a significant effect on the increase in mean daily step counts. In this case, the reward for step counts was used as a short-term consequence used to encourage long-term health and well-being.

The last group of nudges pertains to Decision assistance nudges, in which the goal is to assist individuals in making a decision by providing either reminders or commitment devices. Reminders alert individuals of actions that they have not yet undertaken. For example, patients may be more inclined to quit smoking after a family member has died of lung cancer because this reminds them of the dangers of smoking (Hare et al. 2021). Examples that are tangible or closer to one's own life may have a stronger effect on his or her behavior than information about the incidence of lung cancer among the general smoking population. Commitment devices act preventively by asking individuals to commit to certain behaviors in the future that they are less likely to undertake when asked to do so in the present. This may apply to all choices where utility is discounted exponentially or hyperbolically, implying that individuals are less likely to undertake such behavior and commit to it long-term. A popular example is the Save More Tomorrow program (Thaler and Benartzi 2004), which asked a group of employees to commit to a savings plan that tied increases in salary to increases in savings. The study finds a significant and sizeable increase in savings for individuals in the Save More Tomorrow program compared with individuals whose savings were not tied to their income; that is, individuals are more willing to save for retirement when they are told that they will only need to save in the near future rather than now. In line with these considerations, Thaler and Benartzi (2004) find that 78 percent of people who were unwilling to accept a pay cut today were willing to join a program in which they would accept a pay cut in the near future.

3.3. Boosting Desired Behaviors

More recently, another behavioral approach to facilitating better decision-making has gained traction in the social sciences: "Boosting". Boosts are behavioral policy interventions that aim to improve human decision-making in predictable ways by providing individuals with the tools to make good decisions. On a broader level, boosts might include formal educational programs. On a more specific level, boosts may provide individuals with strategies to make better decisions. Boosts have been used in a number of fields, but most examples are in healthcare (Olejniczak et al. 2020). Grüne-Yanoff and Hertwig (2016) categorize boosts into three classes: boost policies that equip individual decision-makers by changing the representation of statistical information to improve competence in decisions under risk; boost policies that teach core competencies; and boost policies that provide decision-makers with efficient cognitive strategies for decisions under uncertainty. Table 2 gives an overview of these uses of boosts.

Table 2. Boosting In Practice (Grüne-Yanoff and Hertwig 2016).

Class of Boost	Aim	Example
Decisions Under Risk and Risk Competence	Educating people and improving their ability to evaluate potentially manipulative information	Designing educational programs to improve the statistical literacy of people
Teaching Core Competences	Identifying key information necessary to make informed decisions and teaching individuals these core competences	Teaching people to check vital signs and to call 911 in case of an emergency
Decisions Under Uncertainty	Designing efficient cognitive strategies that individuals can use	Formulating decision trees and smart rules of thumb

Changing the representation of statistical information has been shown to improve the statistical reasoning of individuals (Garcia-Retamero and Hoffrage 2013). For example, people better understand statistical information presented as natural frequencies than statistical information presented as probabilities. They also understand absolute risks better than relative risks and graphical representations better than numerical representations (Gigerenzer et al. 2007). A nudge approach would use this information to frame information in such a way that decision-makers make choices that suit policymakers' objectives. A boosting approach would encourage individuals to make informed decisions themselves, both by improving the representation of information and educating people to improve their ability to evaluate potentially manipulative information. Proponents of the boosting approach focus on improving the statistical skills of laypeople using educational programs. For example, Gigerenzer (2010) shows that few people have the necessary skills to understand health statistics, suggesting that shared decision-making and informed consent in this context is problematic. A boosting program would entail changing the curricula of schools in order to improve basic statistical knowledge.

The boosting approach also focuses on teaching core competencies and correcting specific skills and knowledge deficits in certain decision domains. Rather than making individuals experts in a certain domain, the goal of such boosting policies is to identify crucial information that people need to be able to make informed decisions that align with their objectives. For example, Van Roekel et al. (2022) suggest that risk literacy boosts can improve compliance with hygiene requirements in hospitals. In their study, nurses were provided information on the risks of inadequate nurse hand hygiene in causing infection in patients. Van Roekel et al. (2022) found that both nudges and boosts were effective in increasing compliance with hygiene requirements. However, the boost effect was more sustainable than the nudge effect. Kirgios et al. (2020) provide another example of effective boosting in the health domain. Their study found that the weekly gym attendance rate of individuals could be increased by teaching people a strategy to overcome self-control problems. Boosts have also been used to help people evaluate online information. For example, Lorenz-Spreen et al. (2021) investigate how boosting can be used to improve people's competencies to detect manipulative strategies online, such as microtargeted advertising. Microtargeted advertising exploits recipients' personal characteristics by sending them messages specifically targeted to them. The study found that prompting participants to reflect on their own personality by completing a short personality questionnaire boosted their ability to identify ads that were targeted at them.

Finally, boosts also come in the form of simple and efficient cognitive strategies that support better decisions. For example, healthcare workers can use decision trees to streamline decision-making in complex situations that require speedy decisions. Gigerenzer and Kurzenhaeuser (2005) found that healthcare staff can respond to a series of yes–no questions to help them make the best choice. Similarly, Jenny et al. (2013) investigate the use of fast, concise, and frugal decision trees by doctors in detecting depression, and found that it offered simple and accurate screening. Also using a decision tree, Fischer et al. (2002) develop a clinical prescription rule, a scoring system, and a short decision tree, all of which help doctors in the prescription of antibiotics to children. McGrew et al. (2019) showed that

teaching students a small number of flexible heuristics that can be applied across a range of digital contexts improved their evaluation of digital sources. Such rules of thumb have also been studied among employees in the financial sector. Drexler et al. (2014) showed that training firms with simple rules of thumb improved firms' financial practices more than formal accounting training, and Amberger et al. (2023) found that trained tax professionals are more rationally inattentive than students in tax-related decision-making.

3.4. Nudges, Boosts, or Both?

Although the difference between nudges and boosts is not always clear-cut in the literature, they can nonetheless be clearly distinguished (Wilkinson 2013; Grüne-Yanoff and Hertwig 2016; Grüne-Yanoff 2018; Grüne-Yanoff et al. 2018; Congiu and Moscati 2022). While nudges aim to affect behavior by changing the decision context, boosts aim to affect behavior by teaching people how to use decision tools to make informed decisions. Moreover, nudges target specific circumstances, while boosts have a reach beyond the particular circumstance. For example, a boost in statistical literacy will not only increase a decision-maker's capabilities in one circumstance but in any situation that requires an understanding of financial matters. In contrast, a nudge that changes the wording of a message will only affect the specific situation in which the message is relevant.

To determine whether a nudge or a boost is best suited to induce the desired behavior, Hertwig (2017) suggests the following guidelines:

- If individuals lack the cognitive ability or motivation to acquire new skills or competencies, then nudging is likely to be more efficient.
- If policymakers are uncertain about people's goals, if there is marked heterogeneity in goals across the population, or if an individual has conflicting goals, then boosting will be the less error-prone intervention.
- If the working of a nudge requires it to be non-transparent or even invisible to the person being nudged, then it fails the easy-reversibility test and is a paternalistic intervention.
- If governments do not (always) act benevolently or if they permit the private sector to create 'toxic' choice architectures, then boosting will provide better protection for individuals.
- If policymakers aim to foster generalizable and lasting behaviors, boosting seems to be more expedient, ceteris paribus.
- If there is substantial danger of unanticipated, unpredictable, and undesired consequences of nudging or boosting interventions, then consider the respective alternative.

It seems clear that boosts lend decision-makers a type of autonomy that nudges do not (Wilkinson 2013; Grüne-Yanoff and Hertwig 2016), even though some scholars argue that nudges (and sludges as well) differ with regard to their effects on well-being but not with regard to their effects on autonomy (Hortal and Segoviano Contreras 2023). The nudge approach takes a libertarian paternalistic approach by assuming that individuals' cognitive and motivational deficiencies can be used by policymakers to the benefit of these individuals themselves. This has led to a normative debate surrounding the use of nudges. Critics of nudges argue that nudge policies undermine the autonomy of decision-makers by manipulating them. Boosts, on the other hand, focus on individuals' cognitive abilities and strategies, and they aim at equipping individuals with the skills to make the best decisions themselves. Therefore, in using boosts, there is no need to justify libertarian paternalism.

3.5. Tax System Design and "Sludge"

Behavioral research has more recently identified another consideration that affects individual decisions: "Sludge". Thaler and Sunstein (2008), Sunstein (2021), and Newall (2023) all argue that, if a decision environment is opaque, confusing, or misleading, then the environment can in fact reduce the set of options from which the decision-maker can choose, thereby making it difficult for individuals to opt out of a default option and to identify the option that improves the welfare of the decision-maker. Sunstein (2021) refers to this

type of decision environment as "sludge" or "nudges for the bad". Instead of making good decisions easier, sludge makes it more difficult for decision-makers to make decisions in their best interest. Another definition suggests that sludge has two particular characteristics: "frictions" and "bad intentions" (Goldhill 2019). For example, people applying for a visa are often required to visit a website that does not function properly or to go through an unclear and complicated process during their visa application that might frustrate them and discourage them from completing their visa application.

In the context of tax compliance, all of this work suggests that tax system design features can cause frictions that hinder tax compliance or make people pay more (and also sometimes less) than they should. Indeed, as noted earlier, tax systems are frequently criticized for their complexity, such as the length of the tax code, the number of taxes, and the readability of the tax code (Evans and Tran-Nam 2014). Complexity is a striking and obvious example of sludge. This sludge can push people toward behaviors that are not in their best interest.

Perhaps surprisingly, the actual impacts of tax system complexity on taxpayer compliance are difficult to determine, and thus far academic research has not produced much evidence on these issues. Some exceptions here include research by Alm et al. (1993, 2010), McKee et al. (2018) and Vossler and Gilpatric (2018), all of whom find, using laboratory experiments, that subjects who are uncertain about their true liabilities increase their compliance when they receive information from the tax authority. Also, the National Taxpayer Advocate (2022) in the U.S. regularly identifies aspects of the tax code that cause problems for taxpayers, including:

- Complexity of the tax code;
- Processing delays;
- Inadequate IRS hiring and training;
- Erratic telephone and in-person service;
- Difficulties in online access for taxpayers and tax professionals;
- Absence of E-Filing and Free Filing;
- Inadequate IRS transparency;
- Poor tax return preparer oversight;
- Long appeals;
- Challenges for overseas taxpayers.

It seems plausible that tax administrations can increase acceptance of the tax system and strengthen taxpayer compliance by eliminating existing sludge and avoiding new sludge when implementing policy reform. However, other than the evidence from laboratory experiments noted earlier, the empirical evidence on the causal effect of sludge in the tax system on taxpayer behavior remains largely nonexistent.

4. Using Insights from Nudges, Boosts, and Sludge to Improve Tax Compliance

In this section, we discuss how notions from nudges, boosts, and sludge can be used to improve tax compliance. First, using the categorization proposed by Mertens et al. (2022), we propose nudge interventions for tax compliance. Second, we look at how boosts might be applied within a tax compliance framework, structuring our discussion along the lines of the class of boosts suggested by Grüne-Yanoff and Hertwig (2016). It is important to note that any given intervention might affect different groups of individuals in different ways. Therefore, we emphasize the need to consider the heterogeneous effects of any proposed interventions. It is also important to note that these interventions may work in part by reducing tax complexity sludge, even though we emphasize the effects of these interventions using nudges and boosts. In particular, we believe that reducing the complexity of the tax code, simplifying tax filing, and improving taxpayer services all offer opportunities to reduce sludge in the tax system. Again, however, there is little evidence of the causal effects on taxpayer compliance of addressing these issues, other than from laboratory experiments. The effects of sludge on compliance—and of reducing sludge—clearly represent a useful area for future research.

Prior work studying the effect of nudges on tax compliance has relied almost exclusively on assessing the effects of changing taxpayer communications (Alm 2019; Slemrod 2019; Antinyan and Asatryan 2019). However, there are various other ways in which nudging can be used to increase compliance.

One intervention technique for nudges is to increase the visibility of relevant information using several avenues. First, tax administrations should aim to simplify tax filing by reducing the complexity of tax forms and the information provided to complete them. More broadly, relevant information should be easily accessible to all taxpayers and provided in a way that is better aligned with the knowledge and capabilities of the average taxpayer. Second, tax authorities or governments may consider drawing taxpayers' attention to where their tax money is put to use. This increases the visibility of the state's effort to convert tax money into public goods and reminds individuals of what their tax money provides to society. Third, tax authorities may try to evoke a feeling of reciprocity among taxpayers. Increasing the visibility of what the government is providing in the form of public goods or drawing taxpayers' attention to what fellow taxpayers are contributing to public goods may increase taxpayers' feeling of reciprocity and increase their willingness to pay their taxes. Such campaigns could work on either the individual level or the aggregate level. On the individual level, an example might be sending taxpayers letters. On the aggregate level, policymakers could highlight the trade-off between tax payment and public goods in public campaigns, especially when the introduction of new public goods is discussed. Moreover, a "public goods clock" could be established, working similarly to the "public debt clock" provided in such cities as New York and Berlin. Such a clock might display how much tax revenue has been collected to date and how far along the state treasuries are to reaching their budget requirements for the current fiscal year. Knowledge about these variables may raise tax morale and a collective sense of responsibility for the public budget.

In a similar vein, *translation* may increase taxpayers' recognition of their contribution to public goods. Interventions that are based on translation are usefully targeted toward individual taxpayers. Such interventions could entail expressing taxpayers' contributions as a public good. For example, after having turned in their annual income tax declaration, taxpayers could be informed about what their tax payments helped to finance, and they could be informed that, due to their tax payments, a playground could be remodeled. These translations could evoke in taxpayers a sense of contributing to the community by clearly displaying the share of a public good that they helped to finance.

Research on tax evasion has already seen some applications of displaying social norm information or information about reference points to increase tax compliance (Lefebvre et al. 2015; Antinyan and Asatryan 2019; Burgstaller and Pfeil 2022; Besley et al. 2023). Most studies present peers' average compliance rates (empirical/descriptive norms) as a reference point for taxpayers. The results of this research suggest that giving information about social norms does not increase tax compliance in all taxpayers by the same degree but rather that the effectiveness of social norms depends on the compliance levels of the taxpayers. For example, the effectiveness of nudges for late-paying taxpayers is higher than for the average taxpayer (Antinyan and Asatryan 2019). This is especially important since alerting individuals to a reference point may also backfire (De Neve et al. 2021) and thus decrease compliance among the most compliant taxpayers. Therefore, to increase the likelihood of timely filing, taxpayers with a history of late filing could be approached with information about their peers' filing behavior, such as the share of taxpayers that file well before the filing deadline.

Regarding Decision structure nudges, default nudges could be used in a number of areas related to tax compliance. For example, a substantial number of taxpayers, especially those who are self-employed, do not file taxes regularly (Alm et al. 2016). Those who have not filed consistently for a number of years may view not filing as the default. Changing this default, by providing automatic substitutes for returns based on third-party or prior tax return information, might strongly affect the commitment of non-filers. More broadly, tax administrations could facilitate filing by offering pre-filled tax returns that list income

and expenses from the prior tax year, so that taxpayers would not have to start preparing their return "from scratch". Changing the default option could also be used as a tool to reduce collaborative tax evasion. When taxpayers perceive high levels of non-compliance to be the norm, changing this default could increase tax compliance (Erard 2018; Enste 2019; OECD 2021). For example, a norm nudge could inform taxpayers about descriptive norms, such as compliance levels in other domains or in other countries.

A different set of nudges may alert decision-makers to the consequences of the different choice options of their tax compliance decisions; these could also be emphasized on an individual level. When considering undeclared work, for example, suppliers of such work may be unaware of their losses from retirement savings. In capital-based retirement systems, workers who do not pay into their pension scheme forego not only their contributions but also the interest rate on it; in pay-as-you-go pension schemes, they do not gain pension entitlement for the time worked undeclared. Making such a consequence more salient to suppliers may discourage them from providing undeclared services. In this case, a consequence nudge may be combined with a loss-framing nudge to have a greater effect. To this end, individuals may be reminded that a lack of contribution would result in deteriorating infrastructure and social services.

Decision-assistance nudges such as reminders or commitments may also help individuals to better understand their tax obligations. Reminding taxpayers not only of the relevant deadlines but also their responsibility to the public good can be achieved in different ways. For example, studies have shown that public figures have a large influence on individuals, especially when such figures are celebrities and are perceived as possessing extraordinary abilities (Parmelee and Bichard 2012; Moraes et al. 2019). This relationship may be explored from a tax compliance perspective, for instance, by running public marketing campaigns with well-known individuals who are perceived as role models.

Finally, policymakers and researchers who implement nudges and evaluate their effectiveness should be aware of how they measure decision quality. Ungemach et al. (2018) test the alignment of attitudes and decisions to infer whether individuals choose in a way that fits their preferences. This way of measuring the quality of a decision requires less normative predispositions, allows the assessment of subjective decision quality, and should thus be reflected in the evaluation of nudges.

To determine how to apply boosts in increasing tax compliance, we refer back to Hertwig's (2017) rules described in Section 3.4. According to Hertwig (2017), boosts should be applied when there is heterogeneity in individuals' goals or when the government does not act benevolently. Behaviors that are usually nudged or boosted include, for example, environmentally friendly consumption or specific eating habits. Tax compliance is different because not complying with the tax law is illegal and so is not simply a behavior deemed "bad" by an external observer. However, even the most skeptical taxpayer would most likely not advocate for a complete abolishment of the entire tax system, and, with the exception of a few countries considered dictatorships, it is difficult to envision a government that actively acts against its citizens. Therefore, the necessity of using boosts (instead of nudges) to increase tax compliance appears unwarranted, following these arguments.

However, filing taxes is a more complicated process than behaviors usually encouraged using nudging or boosting. Boosts may assist in increasing the knowledge of the tax code in general and the specifics of handling the filing process in particular. Such boosts may in turn reduce non-compliance that results from poor understanding of the tax code and its administrative processes; therefore, boosts may contribute to the establishment of tax compliance in the long term. This approach is reflected in the fifth rule for using boosts put forward by Hertwig (2017). However, such educational measures to increase tax compliance have received very limited attention in the literature. For example, Alm and Torgler (2011) propose a "service" paradigm in tax administration (in addition to "enforcement" and "trust" paradigms) in which the tax authority educates taxpayers and provides services to help them comply with tax laws. This approach is aimed at taxpayers who are willing to pay taxes but have trouble complying with tax laws. Increasing the quality of taxpayer

services reduces compliance costs and might thereby increase tax compliance. As noted earlier, while several studies have argued that providing administrative services that make it easier for individuals to pay taxes improves compliance (Alm et al. 1993, 2010; McKee et al. 2018; Vossler and Gilpatric 2018), empirical evidence on this issue remains limited. As boosts have the main goal of educating individuals and enabling them to make informed decisions, boost interventions seem to be a promising tool in implementing a service-orientated approach by tax authorities; such interventions are also of course consistent with reducing tax system sludge.

Educational programs to improve the financial, fiscal, and tax-related knowledge of taxpayers appear to be a particularly important approach for increasing compliance. The knowledge that taxpayers have about the tax system affects compliance, yet taxpayers do often not know what they should pay in taxes (Alm and Kasper 2023). For example, a better understanding of the tax code likely affects how individuals perceive the tax authority and increase the perceived fairness of their actions. Indeed, Feld and Frey (2007) show that taxpayers are more likely to pay their fair share of taxes if they believe that they are being treated in a fair and legitimate way. This psychological tax contract between taxpayers and tax authorities encourages tax compliance. Similarly, taxpayers are more likely to comply when they trust the tax authority (Kirchler et al. 2008).

Therefore, boost—and sludge-reducing—interventions aimed at improving taxpayers' understanding of the tax system might be a particularly promising approach. Individuals who have the knowledge, skills, and confidence to make responsible tax decisions are considered tax literate (Godbout et al. 2017), and tax literacy has been found to be related to individuals' compliance decisions (Cvrlje 2015; Nichita et al. 2019). Tax compliance might thus be boosted by including information about the fiscal system, the tax system, and the role taxes play in society in school curricula and educational programs. For example, prior work finds that financial education programs have positive effects on financial knowledge and downstream financial behaviors (Kaiser et al. 2022). Future research should investigate the effectiveness of similar programs on tax literacy.

Teaching individuals core competencies for filling in tax returns may also improve compliance. Many taxpayers find navigating the tax system difficult (Pham et al. 2020; Alm et al. 2023), which contributes to unintentional noncompliance. The vast use of paid tax preparers indicates that many taxpayers find it difficult to comply with their filing requirements on their own. Teaching individuals core competencies, such as filing a tax return and overcoming self-control problems that lead to procrastination, might thus also boost tax compliance.

In addition to these key competencies, tax authorities can make use of decision trees to facilitate filing. The effectiveness of fast, concise, and frugal decision trees in complex decisions has been documented for health practitioners. Applying this approach to tax compliance, such decision trees could help taxpayers determine their taxable income and thus boost tax compliance. For example, taxpayers could receive a list of yes–no questions before filing their tax return in an online system to determine which forms they need to complete, which sources of income they need to indicate, and which exemptions and credits they may use. Tax return software that is designed to facilitate tax filing already incorporates such decision trees, and tax agencies should aim to provide similar programs.

In sum, behavioral insights have generated a variety of measures that can help tax administrations increase compliance. The implementation of these measures should be guided by political demands, administrative capacities, and country-specific experiences. In particular, we believe that joint efforts between policymakers, administrators, and researchers are best suited to identify and implement behaviorally informed administrative strategies to increase compliance.

5. Conclusions

Prior work in the behavioral sciences provides valuable insights into determinants of compliance and regulatory approaches that are not reflected in standard economic theory.

Broadly speaking, this line of research suggests that governments and tax authorities can affect taxpayers' compliance decisions in several fundamentally different ways.

First, governments and tax administrations may implement specific changes in the environment in which taxpayers file their returns to facilitate compliance. These nudge interventions typically do not require taxpayers to learn new skills or exert substantial amounts of mental effort. As nudges follow the concept of libertarian paternalism, nudging is sometimes criticized for restricting individual autonomy. This argument is particularly relevant with regard to tax compliance because, per their definition, nudges are a valid policy instrument only when they lead to the desired outcome as judged by the decision-maker. Behavioral interventions, such as letters nudging taxpayers toward more compliance, typically aim to achieve an outcome that is desirable from a societal, but not necessarily from an individual, perspective. This obvious inconsistency has rarely been addressed in prior work. Nevertheless, we see great potential in nudges that simplify tax reporting decisions, provide better taxpayer services such as presenting tax-related information in a more intuitive way, and change default options to facilitate compliance.

Second, governments and tax authorities may invest in citizens' education to improve their fiscal literacy to increase tax compliance. This boosting approach requires a more long-term investment and a higher degree of mental effort and engagement of the decision-maker; it is also consistent with a sludge-reducing approach. Due to their more long-term effects, boosts might not be as cost-effective as several choice-specific nudge interventions. However, boosting may help improve economic education more broadly and might therefore foster tax morale. The effects of boosts might thus extend well beyond the effects of nudges. For instance, boosts that enhance individuals' tax morale might not only increase tax compliance but might also reduce the propensity to avoid taxes (Kemme et al. 2020). To the best of our knowledge, the effect of behavioral interventions on tax avoidance (versus tax evasion) has not been investigated in prior work. Boosting fiscal literacy might have the additional benefit of facilitating voting decisions that align more closely with individuals' true preferences and thus result in tax systems that more closely reflect citizens' preferences. In sum, boosts might increase willingness to pay taxes outside the narrow decision framework that is affected by nudges. Boosts might also improve compliance by reducing sludge.

Finally, boosts to increase tax compliance (or to reduce sludge) should complement but not replace nudges. Neither nudges nor boosts nor sludge should be expected by themselves to close the compliance gap. Instead, it is important to remember that taxpayers' compliance decisions are made within an institutional framework, and policy reform should first and foremost aim to establish effective, transparent, and fair tax systems. However, prior work suggests that all three behavioral approaches offer valuable additions to the toolbox of measures that tax administrations use to build better tax systems and promote tax compliance. To effectively implement these insights in practice, it is critical that tax administrations be open to the idea of partnering with researchers to systematically evaluate the potential of novel behavioral approaches to increase tax compliance. This way, successful administrative strategies can be scaled up and implemented permanently and effectively based on actual field evidence.

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Economic Determinants Concerning Corporate Tax Revenue

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Abstract: This study quantifies the impact of selected economic determinants on corporate tax revenues. The methodology applies a panel regression method with the 27 EU Member States considered for 2004–2020. This paper used a panel regression model with fixed effects, and the Arellano adjustment was used to achieve robust standard deviations. Source data were obtained from the European Commission, Eurostat, World Bank and Transparency International databases. Based on this hypothesis, we wanted to prove that the nominal tax rate, which is legislatively determined based on political consensus, is a decisive determinant of the amount of tax revenue. However, the analysis results reject this hypothesis, although the model showed it as positive but statistically insignificant. On the other hand, an interesting research result is that the analysis confirmed the effective tax rate as a significant determinant of tax revenues. From this, we can conclude that policies should be aimed at an effective tax rate or a better harmonisation of the nominal tax rate towards the effective rate.

Keywords: corporate tax revenues; trade openness; macroeconomic determinants; effective tax rate

1. Introduction

Corporate tax revenue is a key source of government revenue that provides financing for public goods and services such as education, infrastructure, defence and others. Differences in tax revenues between member countries are currently a highly debated topic, as it is necessary to correctly determine the factors usually included in the specifications. Before we confirm or refute the evidence from professional studies in the empirical part, it is necessary to define why we started the discussion on the given issue. As mentioned, it is important to note that several factors influence the amount of corporate tax revenue governments collect. Studies on this issue have included several variables such as the specification of the tax base, the profitability of enterprises and the size of the enterprise sector in the economy, GDP per capita, the ratio of foreign direct investment to GDP, the ratio of total debt to GDP, and institutional factors such as the degree of political stability and corruption. We aim to explore and expand the given base with other factors that explain the differences in resource mobilisation in EU countries. At the same time, we expand the data set with a longer time horizon. More specifically, we will look at the determinants of tax revenues such as nominal and effective tax rate, foreign direct investment as the ratio of inflow and outflow of direct foreign investment, public debt as the ratio of debt to GDP, the inflation rate measured based on the harmonised index of consumer prices and the employment rate as the share of working-age employees, and we analyse to what extent these factors affect tax revenues. We solve potential econometric problems with the help of selected econometric models, which provide us with a detailed analysis of the investigated issue.

The main objective of this study is to analyse and evaluate the economic determinants of corporate tax revenues. Following this objective, this study is divided into six parts. The

introductory part follows a literature review focusing on the most important determinants. In the literature review, in addition to corporate taxation and corporate tax revenues, individual determinants and their impact on corporate tax revenues are dis-cussed. The third part is dedicated to describing the data and methodology of the work, which will be used in the empirical research. It is a descriptive and comparative analysis and mainly a panel regression. There is also a description of the individual variables used. The fourth part describes the results of the analysis of the determinants of corporate taxation. The evaluation is processed in the discussion section, where our results are com-pared with those of other authors, and the study is closed with a conclusion.

2. Literature Review

The level of a country's corporate income is influenced by a combination of macroe-conomic and other determinants that reflect the ever-changing economic situation in that country. Studies by Andrejovská (2019), Tahlova and Banociova (2019), Karpowicz and Majewska (2018), Cung and Son (2020) and Cozmei (2015) were focused on tracing the impact of economic determinants on tax revenues in different countries or country groupings at various time intervals around the world. Determinants influencing the level of corporate tax revenue include domestic and foreign tax policy. The simplest and most accessible fiscal instrument of this policy can be considered to be the nominal tax rate, which each country has set in its legislation.

It is the inappropriateness of using nominal rates as an objective indicator in tracking and then comparing corporate taxation rates that have led to the derivation of the effective tax rate, which has substantially better predictive power, note Baker and McKenzie (1999), Barrios et al. (2009) and Inkabova et al. (2021). The level of the tax rate, which substantially affects the tax burden in the form of nominal, effective and average tax rates, is essential information not only for investors but also for policymakers and economists (Banociova and Tahlova 2019). The correlation results of Kawano and Slemrod (2016), expressing the relationship between corporate tax rates and tax revenues for OECD countries between 1980 and 2004, suggest that an increase in implicit tax rates maximises corporate profits. The relationship between tax rate and tax revenue has also been discussed by Clausing (2007), Devereux (2007), Devereux and Griffith (1998, 2003). In their results, the authors conclude that a higher tax rate increases tax revenue, while a negative reciprocal relationship between tax rate and tax revenue can be established. In relation to investment, the tax rate has a negative dependence. The negative effect on tax revenue has also been confirmed for inflation. Cung and Son (2020) found that if inflation rises above a certain level, it will cause a decline in consumption, purchasing power of money, investment and production, which will have a negative impact on tax revenues but also on overall economic growth. The results confirmed that a 1% increase in inflation would cause a reduction of VND 540.1337 billion (Vietnamese dong) in corporate tax revenue.

The impact of inflation on corporate tax revenues could be complex and depends on several factors. In general, however, inflation may negatively rather than positively affect corporate tax revenues (Balzer et al. 2020). The negative effect was confirmed by Tahlova and Banociova (2019) when examining tax revenues and unemployment rates. The authors assume that the higher the unemployment rate, the greater the corporate sector's profitability decline, ultimately resulting in lower corporate tax revenues. In the case of the new Member States of the European Union, the unemployment rate also has a decisive negative impact. A 1% increase in this variable causes a EUR 128.921 million decrease in corporate tax revenue (Andrejovská 2019). Further evidence of a negative impact on tax revenues also applies to the determinant of corruption.

Cung and Son's observation results (Cung and Son 2020) suggest that corruption can reduce the efficiency of tax systems by reducing taxpayers' trust in the government, reducing tax compliance, and increasing tax evasion. The results also indicate that countries with high levels of corruption tend to have lower tax revenue collection relative to GDP. On the other hand, a positive reciprocal relationship has been found between tax revenue and

GDP (Kubátová and Říhová 2009; Bánociová and Pavliková 2013). This interdependence was investigated by Vasiliauskaite and Stankevicius (2009) using Spearman's correlation coefficient and cluster analysis on a sample of EU Member State data. Their results also showed that the level of the GDP indicator is positively influenced mainly by tax revenue effects. The relationship between foreign investment, tax rates and corporate tax revenues has been considered by Gropp and Kostial (2000) and Bènassy-Quéré et al. (2000). Both analyses prove that FDI is sensitive to differences in tax rates. Gropp and Kostial (2000) also find that this effect is more statistically significant for countries that exempt foreign income from taxation. Camara (2023) notes that FDI inflows can contribute to revenue mobilisation by broadening the taxpayer base and generating higher tax revenues by promoting investment and employment opportunities. Clausing (2007) proved the positive impact of GDP and FDI on corporate tax revenues based on regression analyses. However, a sharper parabolic relationship between tax revenues and rates has also been demonstrated in the case of FDI. The author explains this through a larger increase in tax revenue at low rates and, conversely, a larger decrease in tax revenue at high rates. Cozmei (2015) concludes that higher net FDI inflows relative to GDP increase countries' corporate tax revenues. Trade openness was included as an indicator variable in the analysis by Tahlova and Banociova (2019). The authors hypothesised that trade openness has the potential to achieve higher corporate tax revenues. This assumption was subsequently confirmed via the analysis performed. Also, Cozmei (2015) concluded that the industry turnover index positively affects the ratio of corporate tax revenue to GDP. Clausing (2007) uses the industry turnover index as a proxy for a company's financial performance in his research. His results show that this index and the GDP variable have a positive and statistically significant effect on corporate tax revenue.

While an increase in corporate income taxes may generate more revenue for the government, it could also have far-reaching consequences on various aspects of the economy, including production across different sectors, income distribution among households, prices of goods and services, and overall welfare. According to a study by Bhattarai et al. (2019), the impacts of direct and indirect tax reforms on the economy are quite interesting. The authors analyse how corporate taxes affect revenue collection and the economy. In a separate study, Bhattarai et al. (2017) also examine the implications of corporate taxes in an advanced economy.

According to the studies reviewed, the economic determinants examined negatively or positively affect corporate tax revenues. Our objective was to quantify this impact and determine whether the nominal rate, as an objective indicator for monitoring and comparing the level of business taxation, is a decisive factor in determining the level of tax revenue.

3. Methodology

This paper aimed to empirically verify the impact of selected economic determinants of corporate taxation, which significantly affect corporate tax revenues in the European Union countries for the period of 2004–2020, and then use selected econometric models to investigate the impact of selected variables on the size of corporate tax revenues. The analysis of the determinants of corporate taxation in the European Union countries was performed in 27 countries for the period of 2004–2020. The first part describes the evolution of the dependent variable corporate tax revenue as a percentage of each country's GDP over the observation period. The second part consists of creating a model using the regression analysis method. Three methods are used to generate the model estimation: Pooled OLS regression, fixed effect method and random effect method.

To investigate the impact of economic variables in relation to corporate tax revenue, we set the following research hypothesis in this paper:

H0: *The statutory (nominal) tax rate is a crucial variable that significantly affects the level of corporate tax revenue.*

The selected economic determinants affecting corporate taxation were divided into tax rates, macroeconomic indicators, and business performance indicators. Their selection was conditioned by the theoretical findings of Andrejovská (2019), Cung and Son (2020), Teera and Hudson (2004), Tanzi and Davoodi (2012), Wigger and Wartha (2004), Tosun and Abizadeh (2005), who have studied a considerable number of determinants affecting corporate tax revenues in different countries and periods. The first area includes the nominal and effective and the personal income tax rate, since, according to the authors, this rate also impacts corporate tax revenues. We have decided to include the difference between this and corporate tax rates in the analysis.

The second group of observations consisted of our selected macroeconomic indicators: GDP, inflation, FDI, unemployment, government debt, and trade openness. Although these variables do not directly affect corporate tax revenue (such as the tax rate), their values ultimately affect the level of our explanatory variable. In addition to these variables, we will consider a less traditional indicator, the Corruption Perceptions Index. The last group of variables represents enterprises' performance in the countries concerned. Specifically, these are the Industry Turnover Index and Business value added by industry. We have included mining, quarrying and production turnover in the analysis to ensure that these indicators cover all companies. For value-added, we also include all industries or all activities according to the NACE classification. Table 1 shows and further characterises the definitions of each variable under study.

Table 1. Overview and description of variables.

Variable	Unit	Source	Description
Response Variable			
Corporate tax revenues	% GDP	The European Commission	Taxes on corporate income or profits, including holding gains (as a percentage of GDP).
Explanatory Variable			
Nominal tax rate	%	The European Commission	Highest statutory rates of corporation tax (including surcharges).
Effective average tax rate	%	The European Commission	Effective average tax rates of large corporations in the non-financial sector calculated using the Devereux/Griffith methodology.
Gross domestic product per capita	EUR per capita	Eurostat	Ratio of real GDP to average population in a particular year at constant prices (2010).
Harmonised Index of Consumer Prices	%	Eurostat	Harmonised Consumer Price Index, for international comparison of consumer price inflation, measured as an annual average index and rate of change.

Table 1. *Cont*.

Variable	Unit	Source	Description
Foreign direct investment	% GDP	The World Bank	Net inflows of foreign direct investment coming from non-resident investors expressed as a ratio to GDP.
Unemployment	%	Eurostat	Annual unemployment rate by gender (male and female) and age (15–74 years), measured as a percentage of the population in the labour force.
Public debt	% GDP	Eurostat	Ratio of outstanding public debt at year-end to gross domestic product at current market prices.
Individual tax rate—Corporate tax rate	%	The European Commission	The difference between the maximum individual and corporate income tax rates.
Trade openness	% GDP	The World Bank	The sum of exports and imports of goods and services measured as a share of gross domestic product.
Corruption Perception Index	Score	Transparency International	Corruption Perception Index on a scale from 0 (highly corrupt country) to 100 (very clean country).
Industrial Turnover Index	Score	Eurostat	Annual data for sales of own-account services and goods in mining, quarrying, and manufacturing (calendar-adjusted, not seasonally adjusted, index 2015 = 100).
Value added	% GDP	Eurostat	Gross value added and income by industry (all activities according to NACE classification).

Source: Own elaboration.

Before conducting the actual panel regression analysis, we initially assessed the presence of stationarity, heteroskedasticity, serial autocorrelation, and cross-sectional dependence in the model. We performed the tests at a significance level of $\alpha = 0.05$. Based on the Augmented Dickey–Fuller Test and the Phillips–Perron Unit Root Test, which were

used to test the stationarity of the data from 2004 to 2020, the variables under examination were found to be non-stationary during this period. This may indicate a strong trend and seasonality in the data. Therefore, we decided to transform the variables using the natural logarithm and repeat the tests. After the transformation, we can observe that the only variable that remains non-stationary in the model is trade openness. We conducted the heteroskedasticity test using the Breusch–Pagan test, which confirmed our assumption of constant variance of residuals in the model, indicating the presence of heteroskedasticity. Furthermore, in the model, we identified the presence of serial autocorrelation using the Breusch–Godfrey/Wooldridge test. The Pesaran CD test did not confirm the presence of cross-sectional dependence.

The model form we chose to use in our panel analysis is as in Equation (1). Table 2 defines our expected effects of variables on corporate tax revenues.

$$
\begin{aligned}
CITREV_{it} = {}& \beta_1 TR_{it} + \beta_2 ETR_{it} + \beta_3 GDPpc_{it} + \beta_4 HICP_{it} + \beta_5 FDI_{it} + \beta_6 U_{it} \\
& + \beta_7 GD_{it} + \beta_8 ITR_{it} + \beta_9 TO_{it} + \beta_{10} CI_{it} + \beta_{11} ITI_{it} \\
& + \beta_{12} VA_{it} + u_{it}
\end{aligned}
\tag{1}
$$

Table 2. Variable and expected effect.

Name	Determinant	Expected Effect
Response Variable		
Corporate tax revenues	CITREV	
Explanatory Variable		
Nominal tax rate	TR	+
Effective average tax rate	ETR	+
Gross domestic product per capita	GDPpc	+
Harmonised Index of Consumer Prices	HICP	+
Foreign direct investment	FDI	+
Unemployment	U	−
Public debt	PD	−
Individual tax rate—Corporate tax rate	ITR	+
Trade openness	TO	+
Corruption Perception Index	CI	+
Industrial Turnover Index	ITI	+
Value added	VA	+

Source: Own elaboration.

4. Results

4.1. Evolution of Corporate Tax Revenues over Time

For the sake of clarity in the graphical representation of the data, we have chosen to display them for both the old and new member states of the European Union as a whole. We will consider 'old countries' those that became members before 2004, and conversely, those that joined the EU after 2004 will be regarded as 'new countries'. The categorisation of countries will thus be as follows:

Old EU member states: Belgium, Denmark, Finland, France, Greece, Netherlands, Ireland, Luxembourg, Germany, Portugal, Austria, Spain, Sweden, Italy.
New EU member states: Bulgaria, Cyprus, Czech Republic, Estonia, Croatia, Lithuania, Latvia, Hungary, Malta, Poland, Romania, Slovakia, Slovenia.

Regarding the evolution of corporate tax revenues, we will first examine the development of the heterogeneity of this variable (Figure 1). Average corporate tax revenues for all EU countries remained around 3% of GDP during the observed time horizon, with the variance ranging between 2% and 5% of GDP throughout the entire observed period. Before the crisis year of 2008, we observed an increase in the average value, as well as in the heterogeneity of the variable. After this year, there was a decline in the tax revenues

of countries, and the variance of values remained wide. Between the years 2010 and 2014, the values and their variances remained at approximately constant levels. Subsequently, from 2015 onwards, there was a slight increase in corporate tax revenues, followed by a slight decline.
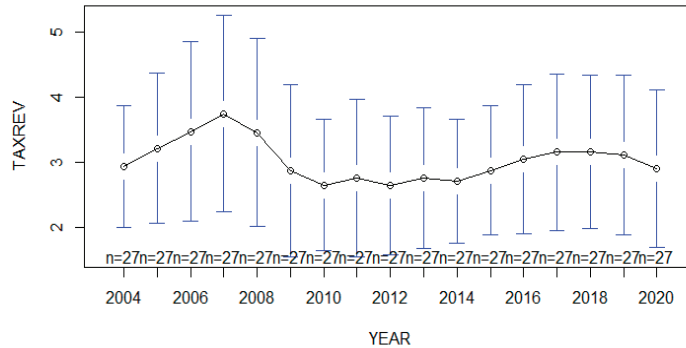

Figure 1. Heterogeneity of corporate tax revenues (% of GDP) in EU countries from 2004 to 2020. Source: own elaboration.

In addition to average values, we will also examine the values of individual countries. For better visualisation, we will focus on the percentage representation of corporate tax revenues for the years 2004 and 2020 (Figure 2). In this comparison, Croatia stands out significantly in both years, where they have corporate tax revenues accounting for 13.57% (in 2004) and 17.06% (in 2020) as a share of this country's total tax revenues, calculated as a percentage of GDP. In addition to being 3–8 times higher than in other EU countries, we also observe a growth over time. One possible explanation for significantly higher corporate tax revenues in Croatia compared to other EU countries could be Croatia's tax policy. Although the tax rate in this country was at 18% in 2020 (which is lower than the EU average of 21.5%), it is offset by a relatively broad tax base, resulting in more companies being subject to taxation. Another factor could be the economic structure of Croatia. In this country, there is a relatively high share of state-owned companies, which tend to generate higher profits and, consequently, higher taxes. Additionally, one of the most significant sectors is tourism, which, during the main season, can also contribute to higher corporate income tax revenues. Since this indicator is constructed as the ratio of corporate tax revenues to GDP, it is important to note that Croatia does not achieve a high GDP per capita compared to other EU countries. Thus, the fact that the observed indicator is at a high level may still mean that the actual amount of generated corporate tax revenues could be lower than in wealthier countries. The second country with the highest share is Luxembourg, where the values are already around 5% of GDP, but there has been a decrease of nearly one percentage point over time. The most significant decline in values occurred in the cases of Finland, Hungary, Greece, and Spain, where we observed a decrease of around 1.5% of GDP. In the case of the other EU countries, there were no significant changes observed over the years; there were only slight increases or decreases, with corporate tax revenues remaining around 2–3% of GDP. If we were to focus on countries with the lowest corporate tax revenues as a percentage of GDP, these would be Romania, Latvia, and Germany. In the case of Latvia and Germany, values of 0.71% of GDP and 0.72% of GDP were observed in 2020, respectively. Throughout the entire observed period, Romania had the lowest tax revenues, and there was also a decline over time. In 2004, it was at a level of 0.07% of GDP, and in 2020, it was at 0.01% of GDP. Compared to Croatia, these values are significantly different. This is very interesting, especially considering that in 2020, the tax rates in these countries were not very different (18% in Croatia and 16% in Romania). However, the difference in corporate tax revenues as a percentage of GDP is substantial. We assume that the low corporate tax revenues in Romania may be due to its smaller and less developed economy

compared to that of other EU countries. The size of the corporate sector in this country is smaller, and even the most widespread industries are not among the most profitable, which can result in lower tax revenues. Another issue could be the country's level of compliance with tax regulations and a history of corruption. Despite efforts to improve tax collection and reduce tax evasion, Romania still has a relatively high level of tax evasion, which can lead to lower tax revenues because some companies may not pay their fair share of taxes. Additionally, the level of the Corruption Perceptions Index was at 44 in 2020, whereas for comparison, the EU average stands at 64.
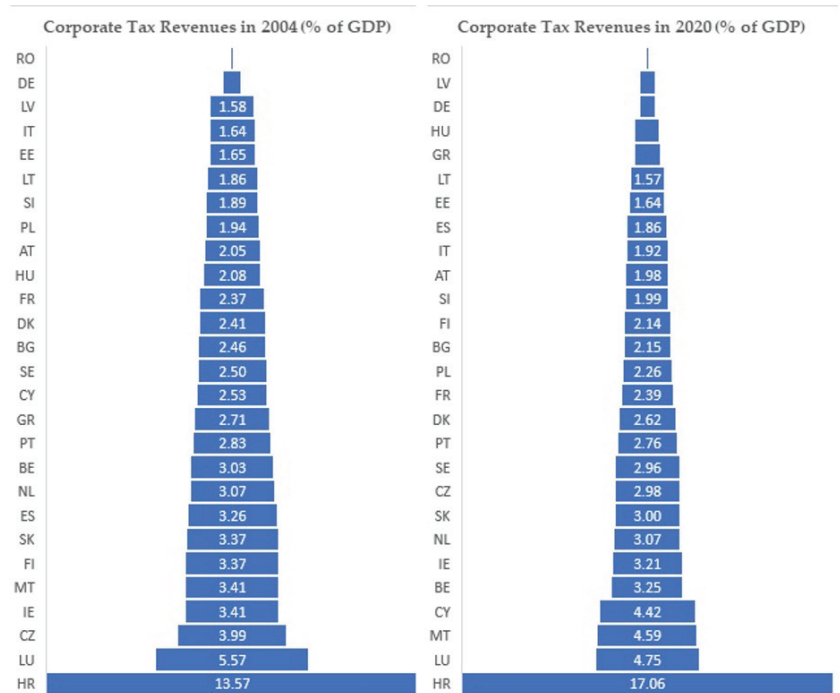
Figure 2. Corporate tax revenues (% of GDP) in EU countries in 2004 and 2020. Source: own elaboration.

4.2. Regression Analysis

In the framework of the panel regression model, we examined the influence of seven determinants, which, according to economic theory and prior research, are believed to impact the level of corporate tax revenues. These determinants include the effective tax rate, GDP per capita, inflation, public debt, the difference between nominal tax rates on individual and corporate incomes, trade openness, and the corruption perception index. To ensure that our model effectively captures the studied issue, we verified several tested assumptions. The presence of heteroskedasticity was tested using the Breusch–Pagan test, which indicated that the assumption of constant variance and the absence of variable autocorrelation may not hold in the model. Using the Arellano method, we adjusted the model and obtained robust standard errors. An overview of the test results conducted in our modified model is presented in Table 3.

Table 3. The modified model, estimated using the fixed effects method following the Arellano adjustment. The level of statistical significance is indicated as follows with symbols * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Determinants	β Coefficient	Robust Standard Deviation	Significance Level	
ETR	0.062	0.020	0.002	**
GDPpc	−0.00002	0.000	0.036	*
HICP	0.047	0.024	0.048	*
PD	−0.019	0.005	<0.001	***
ITR	0.024	0.011	0.031	*
ln(TO)	1.345	0.669	0.045	*
CI	−0.008	0.005	0.122	

Source: own elaboration.

To determine whether the fixed effects model remains the most appropriate even after removing statistically insignificant variables, we used the same tests as in the original model:

OLS vs. RE

We used the Lagrange Multiplier test to decide between the OLS model and the RE model. We evaluated it based on the *p*-value, which is of less than 0.001 and, consequently, lower than the significance level of 0.05. This implies that we reject the null hypothesis (H0) and consider the random effects model as more suitable.

OLS vs. FE

We used an F test for these two models to determine the better one. Once again, we compared the *p*-value (<0.001) with the significance level (0.05). Since the *p*-value is of less than α, we reject the null hypothesis (H0) in favour of H1—fixed time effects are significant in panel data models. Therefore, the fixed effects (FE) model is more appropriate.

RE vs. FE

We used the Hausman test to choose between the random effects (RE) and fixed effects (FE) models, which had performed better in previous tests compared to the ordinary least squares (OLS) model. Since the *p*-value level is 0.027, which is less than α = 0.05, we reject the null hypothesis in favour of the alternative. In conclusion, it is suggested that the most suitable model for determining the determinants of corporate tax revenues is the fixed effects model. The results of the final (adjusted) panel regression model testing are presented in Table 4, below.

Table 4. Results of the testing statistics.

Testing	Test	*p*-Value	Result
Stationarity	Augmented Dickey–Fuller test	0.121 (TO)	Only the TO variable is
	Phillips–Perron Unit Root test	0.054 (TO)	non-stationary
Choice between models	Lagrange Multiplier test	<0.001	The fixed effects model
	F test	<0.001	is the most appropriate
	Hausman test	0.027	
Heteroskedasticity	Breusch-Pagan test	<0.001	Present
Serial autocorrelation	Breusch-Godfrey/Wooldridge test	<0.001	Present
Cross-sectional dependence	Pesaran CD test	0.688	Absent

Source: Own elaboration.

5. Discussion

Evaluation of panel regression results

Based on the analysis and testing, our model has the following form:

$$CITREV_{it} = 0.062 \times ETR_{it} - 0.00002 \times GDPpc_{it} + 0.047 \times HICP_{it}$$
$$-0.019 \times PD_{it} + 0.024 \times ITR_{it} + 1.345 \times \ln(TO_{it}) \qquad (2)$$
$$-0.008 \times CI_{it} + \alpha_i + u_{it}$$

After conducting statistical tests, we can consider the regression model to be statistically significant at a significance level of $\alpha = 0.05$ (the *p*-value of the model is lower than α). If the model was statistically insignificant, there would be doubts about the validity of the resulting coefficients. We assume that the individual relationships between corporate tax revenues and their determinants are not random but are valid based on the estimated coefficients. The coefficient of determination (R^2) represents the proportion of variance in the dependent variable that is explained by the independent variables in the regression model. In our model, this coefficient is at the level of 0.1349, indicating that the model can explain 13.49% of the total variability. This value is lower than our initial assumption. Based on previous empirical studies, we expected the model to include all significant factors influencing the level of corporate tax revenues.

The results below describe which variables analysed are statistically significant at the $\alpha = 0.05$ level of significance. The ETR variable is statistically significant at the $\alpha = 0.01$ level, and the PD variable is statistically significant at the $\alpha = 0.1$ level. The results of these variables could be interpreted as follows:

Effective tax rate: regression coefficient $\beta 1 = 0.062$. This represents the positive effect of ETR on corporate tax revenue. Specifically, if the effective tax rate was increased by 1%, this would induce an increase in corporate tax revenue of 0.062% of GDP.

GDP per capita: In contrast, the GDP per capita has a slight negative impact on corporate tax revenues. If GDP per capita was to increase by EUR 1 per capita, corporate tax revenues should fall by 0.00002% of GDP.

Inflation: We can evaluate that the correlation between HICP and corporate tax revenues is positive. The regression coefficient is 0.047. This means that a 1% increase in HICP is related to a 0.047% increase in corporate tax revenue.

Public debt: As we expected, public debt is another variable that has a negative impact on corporate tax revenues. Specifically, a 1% increase in public debt leads to a 0.019% decline in corporate tax revenues.

Difference between individual tax rate and corporate tax rate: The regression coefficient $\beta 5$ is associated with the variable expressing the difference between the nominal income tax rates for individuals and legal entities (corporations). Therefore, from a certain perspective, we observe the impact of the income tax rate on individuals. The effect induced by this difference in tax rates is positive. An increase in corporate tax revenues of 0.024% of GDP is associated with a 1% increase in individual tax rate variables.

Trade openness: Due to the non-stationarity of the data, we had to transform the trade openness indicator using the natural logarithm. Consequently, the interpretation of this variable will be different from that of the others. Specifically, we will not interpret the regression coefficient in the original units of corporate tax revenues and trade openness (% of GDP), but as percentage changes. Therefore, a 1% increase in trade openness is associated with a 1.345% increase in corporate tax revenues. In the case of reversing the logarithm values using the natural logarithm base exponentiation for the value $\beta 6$ ($e^{1.345}$), the interpretation would be as follows: a 1% increase in trade openness is associated with a 3.896% increase in corporate tax revenues as a percentage of GDP.

To better illustrate the impact of individual variables on corporate taxation, we will compare the values of the obtained regression coefficients with the average values of corporate tax revenues. The average value for all observed countries over the entire time horizon is 3.03% of GDP. This means that in the case of the variable with the highest regression coefficient (ETR), the average value of corporate tax revenues would increase to 3.09% of GDP when ETR increases by 1%. Conversely, at first glance, GDP per capita has

the smallest impact. However, this is also because it represents a change when increasing by EUR 1 per capita. For example, if we were to calculate it based on the average year-on-year change across all observed countries over the entire time horizon (EUR 240 per capita), the impact would not be as low. In fact, if GDP per capita was to increase by EUR 240 per capita, corporate tax revenues would decrease by 0.005% of GDP. Since a significant impact on corporate tax revenues was only observed for six variables, namely ETR, GDP, HICP, PD, ITR, and TO, we will not evaluate all regression coefficients. However, it is important to note that even though, in our model, the remaining variables (i.e., nominal tax rate, foreign direct investment, unemployment, corruption perception index, industry turnover index, and value-added) did not exhibit any significant influence, when compared to the findings of other authors, their positive or negative effects have been demonstrated.

The evaluation of the results obtained from the analyses is defined through responses to a pre-established research question described in the *null hypothesis*. From *that* perspective, the null hypothesis is rejected.

The results of the conducted analysis, along with our expectations and the findings of other empirical studies, are presented in Table 5. One significant difference between our research and that of other authors is the fact that the statistically significant impact of certain determinants on corporate tax revenues was not confirmed in our case. These variables include the nominal tax rate, foreign direct investment, unemployment, corruption perception index, industry turnover index, and value-added. We can conclude that the specified research question was not confirmed, not only in terms of the statutory tax rate being a decisive variable significantly affecting corporate tax revenues but also because it was statistically insignificant and, therefore, had to be removed from the model. Among the remaining six determinants, a statistically significant impact was observed. However, the results were not consistent with expectations or the findings of other authors in some cases. In the case of the impact of the effective tax rate, a positive effect on corporate tax revenues was confirmed. Apart from this variable, the results of all authors aligned with our expected and confirmed outcomes concerning the indicator representing the difference between the income tax rate for individuals and the income tax rate for legal entities. For this determinant as well, a positive effect was observed. Furthermore, a positive relationship was confirmed between corporate tax revenues and both inflation and trade openness. While the opinions of various authors differed regarding both variables, our results align with the findings of Tahlova and Banociova (2019). In our research, both GDP per capita and public debt had a negative effect on corporate tax revenues (CITREV). Regarding the variable PD, we arrived at the same results as authors Konečna and Andrejovská (2020). The most surprising finding is the negative effect of GDP per capita, as it does not align with the opinions of other authors, including our own expectations.

Table 5. Evaluation of our results and results from other empirical research.

Determinant	Authors	Correlation between the Determinant and Corporate Tax Revenues			Interpretation
		According to the Author	Our Own Expected	Our Own Identified	
TR	Konečna and Andrejovská (2020)	+	+	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Tahlova and Banociova (2019)	+			
	Clausing (2007)	+			
	Karpowicz and Majewska (2018)	+			
ETR	Andrejovská (2019)	+	+	+	An increase in the effective tax rate leads to an increase in corporate tax revenues.
	Cozmei (2015)	+			
GDPpc	Clausing (2007)	+	+	−	An increase in GDP per capita leads to a decrease in corporate tax revenues.
	Konečna and Andrejovská (2020)	+			
	Cozmei (2015)	+			

Table 5. *Cont.*

Determinant	Authors	Correlation between the Determinant and Corporate Tax Revenues			
		According to the Author	Our Own Expected	Our Own Identified	Interpretation
HICP	Cung and Son (2020)	−	+	+	An increase in inflation leads to an increase in corporate tax revenues.
	Tahlova and Banociova (2019)	+			
FDI	Clausing (2007)	+	+	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Cozmei (2015)	+			
U	Tahlova and Banociova (2019)	−	−	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Andrejovská (2019)	−			
	Kennedy et al. (2015)	−			
PD	Konečna and Andrejovská (2020)	−	−	−	An increase in public debt leads to a decrease in corporate tax revenues.
	Krogstrup (2002)	+			
ITR	Cozmei (2015)	+	+	+	A higher income tax rate for individuals leads to an increase in corporate tax revenues.
	Tahlova and Banociova (2019)	+			
TO	Cozmei (2015)	−	+	+	An increase in trade openness leads to an increase in corporate tax revenues.
	Tahlova and Banociova (2019)	+			
CI	Tanzi and Davoodi (2012)	+	+	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Cung and Son (2020) Mihokova et al. (2016)	+			
ITI	Clausing (2007)	+	+	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Cozmei (2015)	+			
VA	Tahlova and Banociova (2019)	+	+	X	The determinant does not have a statistically significant impact on corporate tax revenues.
	Clausing (2007)	+			

Source: own elaboration.

6. Conclusions

To analyse the determinants of corporate tax revenues, we applied panel regression, where we constructed a pooled regression model, fixed effects (FE) model, and random-effects (RE) model. Based on our testing, we subsequently concluded that the most suitable model was the fixed effects model after the Arellano adjustment. The Arellano adjustment was necessary due to the presence of heteroskedasticity and serial correlation. Out of the initial twelve determinants, the statistically significant impact on corporate tax revenues was not confirmed for six, despite being confirmed in empirical studies by other authors. These variables included the nominal tax rate, foreign direct investments, unemployment, corruption perception index, industrial turnover index, and value-added. After adjusting the model by excluding statistically insignificant variables, we arrived at the final form of the fixed effects model following the Arellano adjustment. Based on this model, we can interpret that a significant impact was confirmed for the remaining determinants, with a positive effect on corporate tax revenues observed for the following variables: effective tax rate, the difference between individual tax rate and corporate tax rate, inflation, and trade openness. An increase in their values leads to increased corporate tax revenues for these variables. In contrast, the indicators of GDP per capita and public debt had a negative impact. Therefore, an increase in these variables would lead to a decrease in corporate tax revenues.

Interestingly, the analysis results reject this hypothesis, although the model showed it to be positive but statistically insignificant. On the other hand, an interesting research result is that the analysis confirmed the effective tax rate as a significant determinant of tax revenues. From this, we can conclude that policies should be aimed at an effective tax rate or a better harmonisation of the nominal tax rate towards the effective rate.

Future studies need to run some scenarios where corporate taxes are raised when economies become less liberal and stringent. Then, such a scenario should be compared with a case where the global markets become more flexible. Such an analysis will help determine the net impact a corporation tax can make in these economies. That will answer

the question of what aspects of changes in the design of corporate tax are possible to arrive at those ideal scenarios.

The current study has certain limitations, and future research should aim to address them. For instance, the study only considered a limited set of macroeconomic determinants of corporate tax revenues. Also, microeconomic determinants still need to be included. Therefore, it could be beneficial for future studies to include additional determinants, such as total firm assets, ROA, sector size, sector profitability, or sector value added, to gain a more comprehensive understanding of the issue.

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Article

Cryptocurrencies, Tax Ignorance and Tax Noncompliance in Direct Taxation: Spanish Empirical Evidence

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Abstract: This article highlights the complexity of taxation surrounding cryptocurrency transactions due to the lack of uniform regulation, creating uncertainty for both taxpayers and tax authorities. After determining the tax obligations of individuals in taxation, a survey has been conducted to assess the level of knowledge and compliance with tax obligations related to cryptocurrencies. The survey, in which 103 people participated, reveals the confusion and errors that prevail in perceptions of the tax obligations for cryptocurrencies, particularly in transactions such as swapping and staking in personal income tax. This results in almost half of the respondents (49.5%) not declaring any of their operations with cryptocurrencies. The reasons for this include the fact that the majority of respondents (66%) find the regulation of cryptocurrencies in Spain confusing and difficult to understand. Additionally, 87.4% believe that tax agencies should provide more information and resources on the taxation of cryptocurrencies and digital assets, and that there should be clearer and more comprehensive regulation. However, it should be noted that 41.7% also consider that tax regulation discourages investment in cryptocurrencies.

Keywords: taxation; cryptocurrencies; tax evasion; personal income tax; wealth tax; tax obligations; tax compliance

1. Introduction

The rise of cryptocurrencies has been one of the most impactful phenomena of the last decade. In 2008, a certain Satoshi Nakamoto openly published a paper entitled "Bitcoin: A Peer-to-Peer Electronic Cash System", which presented an economic–financial alternative based on the creation and widespread use of electronic currencies that, with the support of cryptographic techniques, guaranteed payments in economic transactions (Nakamoto 2008). The code enabling operations, however, was released in 2009. In this way, cryptocurrencies, since those years, have been conceived as a new possibility within innovative payment mechanisms and their growth within the virtual payment market has been such that it has generated a previously unknown financial dilemma, in which banks and other types of intermediaries no longer have within their reach the total control of the payment flow market (Álvarez-Díaz 2019; Almeida and Gonçalves 2023). As virtual, decentralized, and independent currencies, they have presented a progressive growth but been very volatile in terms of value as a consequence of the effect caused by speculations (Vučinić and Luburić 2022; Portugal Duarte et al. 2023). Currently, the supply market for such assets is composed of about 9953 varieties of digital currencies (CoinMarketCap 2023).

Bitcoin, being the pioneer currency, has always shown a growth in its monetary value considerably higher than its followers. However, like the rest, it is not recognized as a financial asset to be listed on stock exchanges as it does not enjoy a controlling body that supports it and fulfills a role similar to central banks, nor a legal regulatory framework

that guarantees its free circulation within the world's economic markets (Cunha et al. 2021; Vučinić and Luburić 2022; Náñez Alonso et al. 2024). Bitcoin, throughout its trajectory, has suffered different liquidity and legal crises in the financial markets, to the point of surprising the world economy due to the rapid growth and valorization experienced (Akins et al. 2015; Chohan 2017). Its price went from USD 1 in February 2011 to a peak of USD 69,000 in November 2021, and the number of users, estimated at around 5 million in 2016, has been approximately 220 million in 2022 (Auer et al. 2023). In addition, it is the cryptocurrency with the largest market capitalization, valued at more than USD 580 billion (CoinMarketCap 2023). After Bitcoin, many other cryptocurrencies appeared, such as Ether, Ripple or Litecoin, to name a few. So, in the last 15 years, cryptocurrencies have transformed from being a peer-to-peer-oriented technology (payments without supervision by a centralized authority) to become mainly financial assets traded by millions of users worldwide (Corbet et al. 2019; Kyriazis 2021; Kaygin et al. 2021). Therefore, it can be stated that there is some interest in determining the degree of adoption of cryptocurrencies. However, its determination remains a complicated task today (Al-Amri et al. 2019; Alonso et al. 2023b). The reason for this is that there is no homogeneous or reliable data to draw on, since different methodologies are used to calculate them: in some cases, estimates are based on transactions, while in others, they are based on surveys and market sources, interviews, and app downloads. This implies that, both globally and nationally, there is no precise comparable data for each country and cryptocurrency.

Globally and nationally, the outlook for cryptocurrency adoption in 2023 is not very promising, similar to what happened in 2022, but quite the opposite of 2021. Regulatory uncertainty and problems with companies such as FTX have caused such a situation. While some slowdown began to manifest itself in the market in 2022, the turmoil and uncertainty about the future of these assets still persist in 2023 (Vučinić 2020). The high risk involved in cryptocurrencies due to their remarkable volatility always makes one wonder how the person is willing to invest in something so risky (Portugal Duarte et al. 2023).

Various studies (Arias-Oliva et al. 2019; Gil-Cordero et al. 2020; Alonso et al. 2023a; Gasiorowska et al. 2023) indicate that the typical cryptocurrency investor is an individual who frequently uses information technologies, holds a university education, and typically allocates 5% of their capital to this type of asset. Some 9% of investors do so on a regular basis, 23% invest in falls in value, 26% do so when available and the remaining 41% invested in the past and consider cryptocurrency their long-term investment (García 2023). Attending to gender, current habitual investors are men (74%) compared to women (26%). The objective of this study is to analyze the behavior of people who operate with cryptocurrencies, and specifically why they do not declare their profits on their tax returns. Currently, the adoption of cryptocurrencies worldwide (led by Bitcoin) has not stopped growing. Not only has the growth of its price been exponential but also the number of users, which was estimated at 5 million in 2016 and, in 2021, hovered around 220 million (Auer et al. 2023). Some authors estimate that there are 300 million users worldwide and more than 10,000 cryptocurrencies (García-Corral et al. 2022). This implies that, globally, its possession reaches 14% of the population (Finder 2024), although its use among population strata is not homogeneous and is especially concentrated in men between 18 and 35 years of age with a medium–high economic level (Alonso 2023). The motivations of these people when operating with digital assets are diverse, although, in most cases, the scientific literature points to speculation (Auer and Tercero-Lucas 2022; Balutel et al. 2023). Companies should also take this volatility into account when calculating and establishing their financial risk profiles (Kaczmarek et al. 2021).

In short, cryptocurrencies have become an accepted method of virtual payment as well as speculation, the rise of which has forced authorities to strive to understand blockchain technology and its applications in e-commerce. In fact, as stated in 2021 by the Bank of Spain and the National Securities Market Commission in the European Union, there was still no "framework that regulates cryptocurrencies such as BTC and provides guarantees and protection similar to those applicable to financial products". For some time, a regu-

lation known as the "Markets in Crypto Assets" (hereinafter MiCA), aiming to establish a regulatory framework for the issuance of cryptoassets and service providers, has been under negotiation and study at the European level. On 31 May 2023, the European Parliament approved the "MiCA Regulation", related to the cryptocurrency market. Therefore, the regulation of this market is a reality, enacting the first harmonized regulation on this matter, and it will have an impact on all market players in all EU Member States, both on cryptocurrency issuers and related service providers, but, in any case, a staggered application of the Regulation is foreseen (Bofill et al. 2023).

Our article proposes five fundamental hypotheses that seek to shed light on the following. (1) The taxation of cryptocurrencies in Spain is neither clear nor easy to understand. (2) There is insufficient knowledge regarding the taxation of cryptocurrency transactions in personal income tax and wealth tax. (3) There is widespread non-compliance in terms of the taxation of cryptocurrency transactions. (4) Despite widespread non-compliance, those operating with cryptocurrencies have not experienced negative consequences, such as the opening of tax proceedings or penalties. (5) There is a widespread belief that more information and resources are needed from the Treasury regarding the taxation of cryptocurrencies.

To address these hypotheses, we designed a questionnaire that included questions of different types, such as closed, semi-closed, evaluation questions with several options and only one correct answer (test type), as well as questions with semantic differential scales. We used the Google Forms tool for the dissemination of the questionnaire. The collection of responses was carried out using the Snowball Sampling method, which is based on the dissemination of the questionnaire through various social networks. In this way, the individuals reached were able to disseminate it in turn among their own contacts. To verify the normality of the sample, we applied the Kolmogorov–Smirnov test. We performed the Kruskal–Wallis nonparametric test to assess the homogeneity of the response groups for each variable and to determine whether there were statistical differences between them. In addition, we performed an analysis of independence between the variables addressed in the hypotheses using the Chi-square test.

Our article is structured as follows. It starts with an introduction that sets out the context and importance of the topic: the taxation of cryptocurrencies in Spain for individuals. It highlights the lack of clarity in tax regulations and the need to address this problem. This is followed by five research hypotheses that address different aspects of cryptocurrency taxation, from the lack of knowledge to the perceived effectiveness of enforcement measures. The Materials and Methodology section describes in detail how the research was conducted, highlighting the questionnaire design and the use of the Google Forms tool. The Snowball Sampling method to obtain representative responses is explained and the statistical tests used, such as the Kolmogorov–Smirnov test and the Kruskal–Wallis analysis, are detailed. In the Results section, the findings obtained from the analysis of the data collected are presented. The answers to the hypotheses raised are highlighted and an overview of the results is provided. The Discussion of Results delves into the interpretation of the findings, relating them to the existing literature and highlighting their relevance in the context of cryptocurrency taxation in Spain. Possible implications are addressed and the contribution of the study to the knowledge on the subject is highlighted.

Finally, the Conclusions section synthesizes the key results and responds to the hypotheses raised.

2. Taxation of Cryptocurrencies in Spain for Individuals

Cryptocurrencies are assets mostly used for speculative purposes (Auer and Tercero-Lucas 2022). Cryptocurrency buying and selling, also known as trading, refers to the process of buying and selling digital assets such as Bitcoin, Ethereum or other cryptocurrencies on exchange platforms (Aspris et al. 2021; Fang et al. 2022). This activity can generate capital gains or losses, depending on whether the value of cryptocurrencies increases or decreases between the time of purchase and sale. In personal income tax (IRPF), these gains or losses are considered as capital variations and must be declared. For its part, swapping

or cryptocurrency exchange refers to the process of exchanging one cryptocurrency for another, generally through exchange platforms or third-party services (Woebbeking 2021; Cipollini 2024). This exchange can generate income from movable capital in personal income tax, especially if profits are obtained from the difference between the value of the cryptocurrency at the time of acquiring it and the value at the time of exchange (Cipollini 2024). Finally, staking is an activity that involves participating in the validation of transactions and the security of a blockchain network by holding and blocking a certain number of cryptocurrencies in a digital wallet (Murugappan et al. 2023; Riposo and Gupta 2024). In exchange for holding these locked cryptocurrencies, participants receive rewards in the form of new cryptocurrencies or interest (Murugappan et al. 2023; Riposo and Gupta 2024). In the context of personal income tax, income obtained through staking is considered income from movable capital and is subject to declaration.

Undoubtedly, operations with cryptocurrencies have tax implications, as business transactions with virtual currencies manifest economic capacity—an essential element of tax requirements (Baer 2023; Náñez Alonso 2019). The uses of cryptocurrencies are not always legitimate, and despite the apparent security they offer, fraudulent use exists. This has led to the adaptation of legislation (Teichmann and Falker 2020; Issah et al. 2022; Watters 2023; Lucero and Muslera 2022). This type of asset faces an additional difficulty because, in addition to being a means of payment, it can represent any good that its creators have intended it to symbolize. Regarding their legal definition, some authors have pointed out that cryptocurrencies represent a "true legal disruption" (Pastor Sempere 2017, 2018), going so far as to firmly state that we are faced with a "multifunctional cryptoasset of a heteroclite nature, that is, in a virtual asset that has a heterogeneous structure that allows it to adapt at each moment to the utility that is intended of it" (Pastor Sempere 2017; Villaroig Moya and Pastor Sempere 2018).

At the European level, various entities have expressed opinions on cryptocurrencies, often to warn of their risks and associate them with possible fraud. The only positive regulation is the recent Directive (EU) 2018/843 of the European Parliament and of the Council, dated 30 May 2018, known as the "Fifth Directive". This directive focuses on preventing the use of the financial system for money laundering purposes and establishes concepts related to virtual currencies, guiding countries on how national regulations should be.

As per Alm (2021) or Noked (2018), the problems arising from tax evasion related to the operation of cryptocurrencies (buying, selling, staking) generate inequality. However, they also view blockchain technology positively as a means to increase revenue collection in the future.

Consequently, tax evasion resulting from these operations has been studied and identified as a problem in various countries. For example, in the United States of America by Alm (2021) and Nguyen (2022), in South Korea by Jeong (2022), in Turkey (Zengin and Kocoglu 2022), in the Caribbean (Marcelino et al. 2023), in Europe (Solodan 2019) and (Ferreira and Sandner 2021). All these authors agree on highlighting the problem and the need for adequate regulation. Therefore, given this situation, our study focuses on the field of the direct taxation of individuals, where the Spanish tax system considers four major figures: the personal income tax (hereafter IRPF), the wealth tax (hereinafter IP), and the inheritance and gift tax (hereinafter ISD). Additionally, as a novelty, a new figure will be added in 2022: the solidarity tax on large fortunes (hereinafter ISGF). The latter, along with the gift tax (ISD), is excluded from this study. Table 1 provides a summary of the tax obligations and regulations applicable to cryptocurrency transactions.

The personal income tax in Spain, regulated by Law 35/2006 (LIRPF hereafter), is the reference tax for resident individuals. This tax, which covers the general and savings tax base, is governed by rates that fluctuate according to the Autonomous Community. In the context of cryptocurrencies, whose obtaining through the "mining" process is subject to personal income tax, the qualification of this income is determined by the particular conditions of the activity (Náñez Alonso 2019). The taxation of cryptocurrencies is ana-

lyzed in three categories: income from work, income from economic activities and capital gains and losses. The distinction between carrying out the activity professionally or for entertainment, as well as being self-employed or employed, influences the qualification of the income obtained. In relation to employment income, it is considered as such when the "miner" renders services in an employed and dependent regime (Náñez Alonso 2019). However, the identification of the employer is complicated due to the anonymity inherent in the cryptocurrency system, posing challenges in the application of this qualification. Income from economic activities applies when the activity is carried out in a professional and self-employed manner (Peláez-Repiso et al. 2021). In this case, the income must be included in the general personal income tax taxable base, allowing the deduction of expenses necessary for the exercise of the activity, such as the amortization of computer equipment or the rental of premises. As for the income from movable capital, those who carry out "staking" must be taxed in the personal income tax as a transfer to third parties of their own capital. Cryptocurrencies are valued at their market value in EUR at the time they are received.

Table 1. Tax obligations and regulations applicable to operations with cryptocurrencies in the personal income tax and wealth tax.

Tax	Action	Tax Obligation	Regulation/Consultation
Personal Income Tax	Buy	Without obligation [1] Recommended to keep a proper record of purchases, including the amount in EUR and the acquisition date, as these may be necessary data to calculate gains or losses at the time of sale or exchange	Personal Income Tax Law (LIRPF) and Binding Consultation DGT V2616-22 [2]
	Sell	Capital gains or losses (difference between the selling value in EUR and the acquisition value in EUR)	LIRPF Arts. 14-1-c, 33-1, 34, and Binding Consultation V0808-2018 [3]
	Swap	Capital gains or losses (the market value of the cryptocurrencies involved is considered in EUR)	LIRPF Arts. 2, 14-1-c, 33-1, 34-1-a, 35, 37-1-h, 49-1-b. Binding Consultation DGT V2005-22 and V2520-22. [4]
	Staking	Capital gains	LIRPF 25-2, 46, 49; D 439/2007 arts. 75, 76; and Binding Consultation DGT V1766-22 [5]
		Income from economic activity	Art. 27.1 LIS, in analog application to individuals.
Wealth Tax	Holding	Include in the declaration along with the rest of the assets and rights	LIP arts. 1, 3, 24, and 29; Binding Consultation DGT V0250-18, Binding Consultation V0590-18, and Binding Consultation V2289-18 [6]

Source: Own elaboration based on data obtained from LPERSONAL INCOME TAX, LIS, LIP, LISD and binding consultations of the DGT.

Capital gains and losses come into play when the "miner" performs the activity for entertainment. The transfer of cryptocurrencies and their variation in the value of the taxpayer's assets determine the qualification of this income, and its valuation can be based on the market price on the day of the transaction (Náñez Alonso 2019).

Regarding wealth tax (IP), cryptocurrencies must be included in the taxable base due to their nature as assets or rights with economic content (Pastor Sempere 2018). The obligation to declare them and the amount to be paid are subject to the regulation of each region, and in the absence of this regulation, the minimum exempt amount is EUR 700,000. The DGT has confirmed that cryptocurrencies are considered part of the assets and must

be valued at market price at the date of accrual, i.e., 31 December of each year. Table 1 provides a guide to the regulations applicable in each situation.

In addition to the tax complexity of complying with personal income tax and wealth tax obligations, new obligations have been added. As of 1 January 2024, residents in Spain, both individuals and legal entities, will have to declare to the Tax Agency their holdings in cryptocurrencies abroad. The obligation starts with a balance equivalent to EUR 50,000 in cryptoassets, and holders must report the amount in digital assets on foreign platforms. The deadline to comply with this tax obligation is until the end of March 2024, using the new form designated by the Tax Agency, known as model 721. The obligation includes both "hot wallets" connected to the internet and "cold wallets" without network connection. The balance in EUR of all offshore digital currencies must be indicated, using the quote as of 31 December provided by trading platforms or price-tracking websites, or a reasonable estimate of the market value in euros. In addition, users of cryptocurrencies in Spain must include on the income tax return the capital gains and losses related to transactions carried out with these digital currencies. Entities offering services with cryptoassets in Spain must also declare balances and transactions, using forms 173 and 172 for different types of services, respectively.

3. Research Hypothesis

Having analyzed in the previous section the tax complexity affecting transactions with cryptocurrencies in direct taxation, and the existence of tax evasion in this area of taxation, we propose the following hypothesis.

1. The taxation of cryptocurrencies in Spain is neither clear nor easy to understand.
2. There is a general lack of knowledge when it comes to taxing transactions with cryptocurrencies in the personal income tax and wealth tax.
3. There is a general lack of compliance in terms of the taxation of cryptocurrency transactions.
4. Despite the generalized non-compliance, those who operate with cryptocurrencies have not had any negative experience (opening of tax proceedings or penalties).
5. There is a widespread belief that more information, training, and resources are needed from the Treasury regarding the taxation of cryptocurrencies.

4. Materials and Methodology

4.1. Materials

The material used to obtain the information was the survey, created from scratch based on the previous assumptions and hypotheses. The survey questions were of different types: closed, semi-closed, evaluation questions with several options and only one correct answer (test), and finally, questions with semantic differential scales included.

For the dissemination of the survey, which is available as Supplementary Materials S1. Questionnaire, the Google Forms tool was used.

4.2. Methodology

The method used to obtain the responses was the so-called "snowball", Parker et al. (2020), based on the dissemination of the survey through different social networks, so that the individuals reached could in turn disseminate it to their own contacts. This method has been proposed and validated in the field of social sciences by various authors, such as Johnson (2014), Mejía Navarrete (2014), Handcock and Gile (2011), García-Estévez (2022) and Gautam and Kumar (2023).

In order to check the normality of the sample, the Kolmogorov–Smirnov test was applied (Kozarić and Dželihodžić 2020):

$$D = \max |Fn(x) - F(x)| \tag{1}$$

where:

- D is the test statistic.
- Fn(x) is the empirical cumulative sample distribution function.
- F(x) is the theoretical cumulative distribution function under the null hypothesis.

The Kruskal–Wallis nonparametric test, where we tested the homogeneity of the response groups for each variable and determined whether there are statistical differences between them (Kumar et al. 2019; Nain and Kamaiah 2020):

$$H = 12/N(N + 1) \sum (R_i^2/n_i) - 3(N + 1) \tag{2}$$

where:

- H is the Kruskal–Wallis test statistic.
- N is the total number of observations in all the groups.
- R_i is the sum of ranks for group i.
- n_i is the size of group i.

In addition, an analysis of independence between the variables addressed in the hypotheses was performed using the Chi-square test (Judith et al. 2022):

$$\chi^2 = \sum (O_i - E_i)2/E_i \tag{3}$$

where:

- χ^2 is the Chi-square statistic.
- O_i represents the observed frequency in each category.
- E_i is the expected frequency in each category if there were no association between the variables.

5. Results

Following the application of the snowball method, the study obtained a sample of 103 responses. The answers are accessible as Supplementary Materials S2. Survey Results. The sample indicates a tendency toward a relatively mature population, ranging from 25 to 60 years of age, with evident economic resources and an acceptable personal criterion considering their level of education. In fact, this observation is further confirmed by the fact that over 90% of the surveyed individuals reside in municipalities with 50,000 inhabitants or more.

Hence, the sample appears to have been appropriately targeted. This aligns with findings from various studies in Spain, indicating that the primary users of cryptocurrencies are men aged between 18 and 35, residing in urban areas, with a medium–high level of education and high-income levels (Arias-Oliva et al. 2019; Gil-Cordero et al. 2020; Alonso et al. 2023a).

The data suggest that the majority of respondents possess some level of knowledge about cryptocurrencies and their tax implications, although a significant portion still has limited knowledge. Additionally, perceptions of tax obligations vary among respondents, with differences in responses to how to meet these obligations depending on the specific circumstances of cryptocurrency transactions. All these details are presented in Tables 2–4.

Regarding knowledge of cryptocurrencies, the majority (33.0%) have limited knowledge, and only 3.9% have very high knowledge.

Regarding tax obligations related to cryptocurrencies in Spain, 38.8% have no knowledge at all, 26.2% have limited knowledge, and only 1.0% have very high knowledge on this topic.

Nearly half (49.5%) of the respondents consider it necessary to declare ownership of cryptocurrencies in the income tax (personal income tax). The obligation to calculate and declare the value as of 31 December is answered by 31.1% of investors, highlighting the need to assess the value of cryptocurrencies at the end of the fiscal year. In other words, 87.4% of the respondents would act incorrectly when declaring ownership of cryptocurrencies in

the personal income tax. On the other hand, a low percentage (12.6%) believe that there is no tax obligation in the personal income tax for acquiring and holding cryptocurrencies, which is the correct answer. This indicates some confusion or misinformation about tax obligations related to cryptocurrencies for buying and holding them and their impact on the personal income tax.

Table 2. Experience and degree of knowledge of cryptocurrencies.

My knowledge regarding the operation of cryptocurrencies is on a scale from 0 (no knowledge) to 5 (very high knowledge).	Frequency	Percentage
0	9	8.7
1	8	7.8
2	34	33
3	31	30.1
4	17	16.5
5	4	3.9
Are you aware of the tax obligations associated with cryptocurrencies in Spain? Scale from 0 (no knowledge) to 5 (very high knowledge).		
0	40	38.8
1	27	26.2
2	25	24.3
3	10	9.7
4	1	1
5	0	0

Source: Own elaboration through data obtained via the survey and SPSS.

Table 3. Knowledge of the taxation of transactions with cryptocurrencies in personal income tax.

As a cryptocurrency investor during this year, which of the following tax obligations must you fulfill in relation to the personal income tax (personal income tax)?	Frequency	Percentage
Declare ownership of the cryptocurrency	51	49.5
Calculate and declare the value as of 31 December	32	31.1
Calculate and declare the value of the cryptocurrency based on the last quarter's quotation	7	6.8
There is no tax obligation in the personal income tax for acquiring and holding cryptocurrencies	13	12.6
If, as a cryptocurrency investor, during this fiscal year, you have made a sale of cryptocurrencies, what tax obligations must you fulfill regarding the personal income tax?		
I don't have to do anything, as there is no tax obligation in the personal income tax for acquiring and selling cryptocurrencies	2	1.9
Calculate and declare the value of the cryptocurrency at the market price as of 31 December	37	35.9
Calculate and declare the value of the cryptocurrency based on the average quotation of the last quarter	2	1.9
I must include the gain from the sale of the cryptocurrency in my personal income tax declaration as a capital gain, calculating the difference between the acquisition value and the selling value	62	60.2
If, as an individual, in this fiscal year, I have performed a cryptocurrency swap for others, for personal income tax purposes, I must...		
Calculate the gain or loss from the swap and include it in my personal income tax declaration as a capital gain or loss	49	47.6
Calculate and declare the value of the new cryptocurrency received in the swap at the market price as of 31 December	25	24.3
Calculate and declare the value of the new cryptocurrency received in the swap, based on the average quotation of the last quarter	7	6.8
There is no tax obligation in the personal income tax for the cryptocurrency swap, as it is an internal change within my portfolio	22	21.4

Table 3. *Cont.*

If, as a cryptocurrency investor, in this fiscal year, I have engaged in staking, how should I manage the returns for personal income tax purposes?		
The generated returns must be declared in the personal income tax as a capital gain in the savings base, either as a gain or loss	29	28.2
The generated returns must be declared in the personal income tax as income from movable capital in the savings base	9	8.7
I must calculate and declare the value of the cryptocurrency at the market price as of 31 December	40	38.8
There is no tax obligation in the personal income tax for staking cryptocurrencies, as I am keeping my portfolio unchanged	25	24.3

Source: Own elaboration through data obtained via the survey and SPSS.

Table 4. Knowledge about the taxation of cryptocurrency transactions in the wealth tax (IP).

What are the tax obligations I must fulfill as an individual if I have acquired and held cryptocurrencies in my digital portfolio during the current fiscal year in relation to the wealth tax (IP)?	Frequency	Percentage
Calculate the gain or loss obtained and include it in my wealth tax declaration with the rest of the assets and rights	59	53.7
If the value of cryptocurrencies, along with the rest of the assets, exceeds EUR 700,000, I am obligated to file the wealth tax declaration, including the balance of each different virtual currency of which I am the owner as of 31 December of each year, at its market value	27	26.2
If the value of cryptocurrencies, along with the rest of the assets, exceeds EUR 700,000, I am obligated to file the wealth tax declaration, including the balance of each different virtual currency of which I am the owner as of 31 December of each year, at its purchase value	7	6.8
There is no tax obligation in the wealth tax for the acquisition and holding of cryptocurrencies	10	9.7

Source: Own elaboration through data obtained via the survey and SPSS.

The majority of investors (60.2%) recognize the obligation to include the gains from the sale of cryptocurrencies in their personal income tax declaration as a capital gain, calculating the difference between the acquisition and sale values. While this result reflects a proper understanding of the tax obligations associated with cryptocurrency transactions, it should be noted that almost 40% indicate tax options that are not the correct answer.

Less than half of the respondents (47.6%) recognize the need to calculate the gain or loss suffered in the exchange (swapping) of one cryptocurrency for another and include it in the personal income tax return as a capital gain or loss.

Regarding staking, it should be classified as income from movable capital obtained by the transfer to third parties of one's own capital (article 25.2 of the Personal Income Tax Law). Table 3 reflects that only 8.7% of respondents choose to declare staking-derived income as income from movable capital in the base of savings, which is the correct answer. Therefore, the majority (91.3%) of respondents would be incorrectly taxing the benefits received from staking.

As we can observe in Table 4, only 26.2% of respondents would correctly declare their cryptocurrencies in the wealth tax. The majority response (53.7%) incorrectly suggests that one should calculate the gain or loss from cryptocurrencies and include it in the wealth tax (IP) declaration along with other assets and rights. Moreover, 9.7% mistakenly believe that there is no tax obligation in the wealth tax for acquiring and holding cryptocurrencies, which is incorrect according to the correct answer provided. Additionally, 6.8% confuse market value with purchase value. Thus, the majority (70.2%) of respondents would incorrectly declare their cryptocurrencies in the wealth tax.

The data presented in Table 5 indicate a general lack of understanding and clarity regarding cryptocurrency tax regulations in Spain. Moreover, a significant proportion of individuals appears to be non-compliant with the tax obligations associated with cryp-

tocurrencies, possibly due to a lack of comprehension or confusion surrounding existing regulations. Nearly half of the respondents (49.5%) have not declared any of their cryptocurrency investments, and the majority (66%) find cryptocurrency regulation in Spain confusing and difficult to understand, reflecting a lack of clarity in tax laws related to cryptocurrencies, likely leading to the aforementioned non-compliance. Only about 9.7% of respondents have had negative experiences, suggesting potential issues with the application of tax regulations or difficulties in compliance.

Table 5. Ease/difficulty of taxation, regulatory clarity, and information needs regarding cryptocurrencies and their taxation.

		Frequency	Percentage
Have you declared your cryptocurrency investments during the last fiscal year when you have carried out any of the operations described above?	Yes, I have declared all my cryptocurrency investments	5	4.9
	I have declared some	30	29.1
	I have not declared any of my cryptocurrency investments	51	49.5
	I prefer not to answer	17	16.5
Do you think the taxation of cryptocurrencies in Spain is clear and easy to understand?	Yes, I find the regulation clear and easy to understand	4	3.9
	Some parts of the regulation are clear, but others are not	31	30.1
	No, the regulation is confusing and difficult to understand	68	66
Have you had any negative experiences related to the taxation of cryptocurrencies?	Yes, I have had a negative experience	10	9.7
	No, I have not had any negative experiences	69	67
	I am not sure	24	23.3
Do you think that the tax regulation encourages or discourages investment in cryptocurrencies in Spain?	The tax regulation encourages investment in cryptocurrencies	12	11.7
	The tax regulation discourages investment in cryptocurrencies	43	41.7
	The tax regulation neither encourages nor discourages investment in cryptocurrencies	25	24.3
	I am not sure	23	22.3
Do you think the AEAT (Spanish tax agency) should provide more training and resources on the taxation of cryptocurrencies and other digital assets?	Yes, it is necessary to receive more information and resources	90	87.4
	No, it is not necessary to receive more information and resources	1	0.9
	I am indifferent; I will continue investing based on the knowledge I have	12	11.7

Source: Own elaboration through data obtained via the survey and SPSS.

The majority of respondents in Spain (41.7%) believe that cryptocurrency tax regulation discourages investment, while only 11.7% think it encourages it. About 24.3% believe that the regulation neither encourages nor discourages investment, and 22.3% are unsure. The reason for this is that, as previously stated, most people use cryptoassets for speculation. So further tax regulation means having to pay tax on these possible gains. And that means less profit. Regarding the need for education, an overwhelming 87.4% believe that the AEAT (Spanish tax agency) should provide more information and resources on the taxation of cryptocurrencies and digital assets, while only 0.9% believe that more information is not necessary. Moreover, 11.7% are indifferent.

As observed in Appendix A Table A1, all the variables show significance values lower than 0.005 (working with a confidence level of 99%), indicating that, according to the null hypothesis of the normality test based on Kolmogorov–Smirnov, the variables analyzed in the survey do not follow a normal or Gaussian probability distribution.

In Appendix A Table A2, the significant results of the Kruskal–Wallis test are evident, analyzing statistical differences between the response groups of variables that address the

proposed hypotheses, meaning the responses vary widely among the response modes of the variables.

The taxation and regulation on cryptocurrencies are considered confusing and challenging across all the variables, far exceeding those who find it easy and clear. This is coupled with a low level of interest in taxation. Additionally, a significant number of people who find it difficult and confusing incorrectly believe that they should calculate and declare the value of the cryptocurrency at the market price as of 31 December. Most do not declare their cryptocurrency investments, and there is a perception that taxation may discourage cryptocurrency investment (Aldeia et al. 2023).

Concerning knowledge about tax obligations for cryptocurrency investors, there is a notable lack of understanding, with only 12.6% answering the question correctly. Based on this premise of ignorance, there appears to be a relationship with the variables related to cryptocurrency tax obligations in sales, exchanges, staking, acquisition, and maintenance, as well as whether respondents have invested in cryptocurrencies and their level of household income. In other words, all the variables are related to managing money and the obligations associated with it in cryptocurrencies.

Regarding tax obligations on the sale of cryptocurrencies, it is observed that 60.2% of respondents correctly state that they should include the gains from the sale of the cryptocurrency in the personal income tax declaration as a capital gain, calculating the difference between the acquisition and sale values. Therefore, knowledge about cryptocurrency obligations appears to be well-known among cryptocurrency investors in Spain, although there are differences in responses among other variables associated with cryptocurrency investments in the database.

Concerning tax obligations for performing a cryptocurrency swap in Spain, there is not particularly clear knowledge about these obligations. Only 47.6% of respondents have correctly answered that they should calculate the gain or loss from the swap and include it in the personal income tax declaration as a capital gain or loss. What seemed clearer in terms of the responses is that there is no need to calculate and declare the value of the new cryptocurrency received from the swap according to the average quotation of the last quarter; only 6.8% of survey participants provided this response.

As previously mentioned, the level of knowledge about managing returns for personal income tax purposes when staking has been carried out during the economic year is low. Only 8.7% of respondents correctly answered that the generated returns should be declared in the personal income tax as income from movable capital in the savings base. When combining the responses for various variables, this percentage is significantly reduced, indicating a widespread lack of understanding about returns as cryptocurrency investors.

In general terms, the responses to the variable analyzed regarding tax obligations in terms of the wealth tax (IP) show that 26.2% of respondents know that the tax obligations to be fulfilled as an individual who has acquired and held cryptocurrencies in the digital portfolio during the economic year include filing the wealth tax declaration and paying the corresponding taxes if the value of the cryptocurrencies exceeds the established threshold.

Regarding the declaration of investments, in overall terms, almost 50% have not declared any of the investments made in cryptocurrencies, while less than 5% have declared all the investments made. Therefore, there is non-compliance regarding taxes on cryptocurrency transactions. Non-negative experiences related to cryptocurrency taxation account for 67% of respondents, of which 70% are men. In other words, only 9.7% have had negative experiences. There is a significant difference in responses between those who have had negative experiences and those who have not. This discrepancy in the data is also evident in the gender variable, where 72.8% are men and only 25.2% are women.

Moreover, 87.4% of participants believe that it is necessary to receive more information and resources from the Spanish tax agency (AEAT). Table 6 presents the results of the Chi-square test of the independence of variables.

Table 6. Chi-square test of the independence of the variables.

p-Value Chi-Square Test of Independence	17. Taxation and Taxation of Cryptocurrencies Is Clear and Easy to Understand	11. Tax Obligations as an Investor (PERSONAL INCOME TAX)	12. Tax Obligations, I Have Made a Sale of Cryptocurrencies (PERSONAL INCOME TAX)	13. I Have Exchanged Cryptocurrencies for Other Currencies for Personal (PERSONAL INCOME TAX)	14. I Have Made Staking; How Should I Manage the Income for PERSONAL INCOME TAX?	15. Wealth Tax Obligations (WEALTH TAX)	16. Declaration of Investments in Cryptocurrencies	18. Negative Tax-Related Experience	20. Information and Resources on Taxation and Taxation of Cryptocurrencies
1. Gender	0.6499	0.1961	0.1123	0.7868	0.00779	0.6238	0.8432	0.06699	0.2848
2. Age	0.5535	0.5846	0.5566	0.6743	0.02161	0.08812	0.1068	0.7103	0.7244
3. Level of education	0.9527	0.6743	0.1040	0.8345	0.09331	0.6057	0.9114	0.4778	0.9971
4. Main occupation	0.7586	0.5649	0.9847	0.2352	0.6949	0.6075	0.6543	0.5079	0.9839
5. Household economy	0.8598	0.06853	0.6144	0.5269	0.5925	0.5555	0.2396	0.6422	0.2804
6. Inhabitants of the municipality wealth tax	0.8240	0.1928	0.5067	0.1799	0.03144	0.4394	0.8753	0.7556	0.5467
7. Personal financial situation	0.4289	0.1890	0.8814	0.1784	0.4026	0.2000	0.09728	0.6212	0.5454
8. Cryptocurrency trading	0.7244	0.01367	0.00885	0.6157	0.1546	0.1723	0.00004	0.1337	0.6019
9. My knowledge of how cryptocurrencies work	0.4951	0.7007	0.00233	0.01316	0.2154	0.3498	0.01185	0.3225	0.00973
10. Tax obligations associated with cryptocurrencies	0.00442	0.3504	0.01774	0.1403	0.2391	0.09188	0.00008	0.7362	0.00818
11. Tax obligations (PERSONAL INCOME TAX) as an investor	0.5636		0.00226	0.00024	0.01154	0.00000	0.03630	0.3571	0.7981
12. Tax obligations (PERSONAL INCOME TAX), I have made a sale of cryptocurrencies	0.01197	0.00226		0.00355	0.09841	0.00008	0.00437	0.8284	0.9691
13. I have exchanged cryptocurrencies for other currencies for personal income tax purposes.	0.1399	0.00024	0.00355		0.00133	0.00002	0.2358	0.6789	0.2164

Table 6. *Cont.*

p-Value Chi-Square Test of Independence	17. Taxation and Taxation of Cryptocurrencies Is Clear and Easy to Understand	11. Tax Obligations as an Investor (PERSONAL INCOME TAX)	12. Tax Obligations, I Have Made a Sale of Cryptocurrencies (PERSONAL INCOME TAX)	13. I Have Exchanged Cryptocurrencies for Other Currencies for Personal (PERSONAL INCOME TAX)	14. I Have Made Staking; How Should I Manage the Income for PERSONAL INCOME TAX?	15. Wealth Tax Obligations (WEALTH TAX)	16. Declaration of Investments in Cryptocurrencies	18. Negative Tax-Related Experience	20. Information and Resources on Taxation and Taxation of Cryptocurrencies
14. I have carried out staking, how should I manage the income for personal income tax purposes?	0.03310	0.01154	0.09841	0.00133		0.00019	0.5368	0.6851	0.1535
15. IP tax obligations	0.03451	0.00000	0.00008	0.00002	0.00019		0.1034	0.2092	0.4105
16. Declaration of investments in cryptocurrencies	0.00000	0.03630	0.00437	0.2358	0.5368	0.1034		0.1814	0.3343
17. Taxation and taxation of cryptocurrencies is clear and easy to understand.		0.5636	0.01197	0.1399	0.03310	0.03451	0.00000	0.4003	0.5085
18. Negative experience related to taxation	0.4003	0.3571	0.828407322	0.6789	0.6851	0.2092	0.1814		0.1244
19. Tax regulation is conducive to or discourages investment	0.00017	0.4913	0.08490	0.8308	0.2041	0.05461	0.00027	0.8057	0.9285
20. Information and resources on taxation and taxation of cryptocurrencies	0.5085	0.7981	0.9691	0.2164	0.1535	0.4105	0.3343	0.1244	

Source: Own elaboration through data obtained via the survey and SPSS.

The cells highlighted in green in Table 6 pertain to the variables that have demonstrated significance in the Chi-square test of independence. This implies a connection between these variables, signifying that the responses are not independent across all the survey variables. A distinct relationship exists among the responses to various variables, particularly those concerning tax obligations. Notably, negative experiences are associated solely with gender. The inclination to seek additional information from the Spanish tax agency (AEAT) is linked to variables concerning the level of knowledge of cryptocurrencies and associated tax obligations. An association between age and tax obligations in the wealth tax (IP) is also evident. In the context of managing returns in the personal income tax related to staking, associations are found with gender, age, level of education, and the population size of the municipality where the individual engaged in staking resides. Family income is connected to the understanding of tax obligations among cryptocurrency investors.

6. Discussion of Results

The rapid rise of cryptocurrencies has been remarkable in recent years, attracting mostly young adults between 18 and 35 years old, residing in urban areas, with a medium–high educational level and high income (Arias-Oliva et al. 2019; Gil-Cordero et al. 2020; Alonso et al. 2023a). This trend has become a global phenomenon, challenging not only traditional notions of investment but also presenting new challenges for tax agencies around the world (Solodan 2019; Yalaman and Yıldırım 2019). The ease of access through digital platforms and the attractiveness of potentially high returns due to speculation (Auer and Tercero-Lucas 2022; Alonso 2023) have contributed to this massive growth. However, this boom has not gone unnoticed by tax agencies and public finances, which now face the challenge of adapting their regulatory frameworks to this new financial reality (Baer et al. 2023; Caliskan 2022; Tyc and Siuciński 2020; Ozili 2020).

The decentralized and pseudonymous nature of cryptocurrency transactions poses significant obstacles to the effective identification and taxation of gains (Kaygin et al. 2021; Peláez-Repiso et al. 2021). Tax compliance is emerging as a key piece of this puzzle. It is essential that cryptocurrency users understand and comply with their tax responsibilities to avoid penalties, ensure state revenue collection, and maintain fairness in the distribution of the tax burden (Náñez Alonso 2019; Sanz-Bas et al. 2021; Caliskan 2022; Ozili 2020).

Tax compliance in the field of cryptocurrencies is not only crucial for maintaining the legitimacy and stability of the financial market but also reflects the fundamental principles of economic capacity and generality, ensuring that all citizens contribute equitably to support state functions (Cumming et al. 2019; Sanz-Bas et al. 2021; Caliskan 2022; Paleka and Vitezić 2023).

In our study, we found that most individuals who engage in cryptocurrency transactions face high or very high difficulties in correctly reporting these transactions for direct taxation. For example, in terms of personal income tax, 87.4% of respondents would act incorrectly when declaring ownership of cryptocurrencies. In addition, almost 40% indicate tax choices that are not the correct answer in terms of the obligation to include gains from the sale of cryptocurrencies in their personal income tax return as capital gains. Less than half of the respondents (47.6%) recognize the need to calculate the gain or loss from cryptocurrency swaps. As for gambling, the majority, 91.3% of respondents, would incorrectly declare profits received from gambling. As for wealth tax, the majority (70.2%) of respondents would incorrectly declare their cryptocurrencies for this tax.

Possible reasons for this situation have been identified. First, almost 50% of respondents admit to having low or very low knowledge about cryptocurrencies, which creates a barrier and an increased risk of tax non-compliance when dealing with them, aligning with the findings of studies such as Arli et al. (2020) or Smutny et al. (2021). Moreover, 89.3% of respondents claim to have no or very low knowledge of cryptocurrency taxation, despite actively engaging in cryptocurrency transactions (Fabris 2019; Fabris and Ješić 2023). As a result, 49.5% of respondents did not declare any of their cryptocurrency investments in the previous tax year, a result similar to that reported in the study by Hoopes et al. (2022).

Despite this, a majority of 67% of respondents have not had any negative experiences with tax authorities, indicating a loss of revenue and a niche for tax evasion that tax agencies need to combat.

The current state of tax non-compliance in cryptocurrency transactions is also explained by 66% of respondents stating that tax regulations are confusing and difficult to understand, aligning with the findings of studies such as Yalaman and Yıldırım (2019) or Solodan (2019). This poses a fundamental barrier to achieving "voluntary compliance" with tax obligations (Paleka and Vitezić 2023). A possible solution to this issue is suggested by the majority of respondents (87.4%), who express that tax authorities should provide more education and resources on the taxation of cryptocurrencies and other digital assets. This proposal is also echoed by Caliskan (2022). Cong et al. (2023) indicate that increased tax scrutiny leads crypto investors to use conventional tax planning with tax loss harvesting as an alternative to non-compliance. Now, one may wonder whether respondents have really been entirely truthful in answering the questionnaire. Respondents have no incentive to disclose illicit behavior related to tax evasion; which may lead them to rely on the argument that tax regulations are confusing and difficult to understand (Gonzálvez-Gallego and Pérez-Cárceles 2021; Martinčević et al. 2022).

It is important to keep in mind that more regulation, bringing more information and tax clarity, may pose a challenge for the emerging decentralized finance industry, as 41.7% believe that tax regulation discourages investment in cryptocurrencies, a potential problem highlighted by Auer and Claessens (2021), Chokor and Alfieri (2021) or Grennan (2022). In addition, it is also worth asking whether more regulation would be efficient in ensuring greater tax compliance. The reason is that, as previously indicated, the majority motive for using cryptocurrencies is speculative (Auer and Tercero-Lucas 2022; Alonso 2023). Can we convince to pay the taxes derived from trading those people who seek the highest possible profit and who see the payment of taxes as an expense (and a lower income)? Authors such as Hampl (2020), Meider (2023) or Reiners (2020) present serious doubts in this respect.

At this point, it is clear that states must act, but how? Some states, such as El Salvador, have opted to establish a cryptocurrency (in this case, Bitcoin) as legal tender (Alonso et al. 2024), although most states do not contemplate it and see these assets not as money but as assets used for speculation. Other countries and monetary areas are betting on the implementation of CBDCs as an alternative to cryptocurrencies, although their success and acceptance is not homogeneous (Ozili and Alonso 2024). Through a combination of strong regulations, international cooperation and advanced technologies, states can strengthen their capabilities to collect taxes derived from cryptocurrency transactions and ensure that taxpayers comply with their tax obligations in this emerging area.

1. Implement specific regulations: States can strengthen their regulatory framework for cryptocurrencies by establishing clear and specific regulations addressing the taxation of transactions with these digital assets (Garcia and Garcia 2019; Marian 2021; Ylönen et al. 2023). These regulations could include precise definitions on how to tax capital gains, exchange transactions and other aspects related to cryptocurrencies. By having clear rules, taxpayers would be more informed about their tax obligations, making collection easier for the state.

2. International cooperation: Given the global nature of cryptocurrencies, states can promote international cooperation to share information on relevant transactions. Agreements between countries to exchange tax data could help track transactions and profits generated by citizens in different jurisdictions (Emelianova and Dementyev 2020; Peláez-Repiso et al. 2021). This collaboration could close potential tax loopholes and increase the efficiency of tax collection related to cryptoassets.

3. Develop advanced monitoring technologies: States can invest in advanced monitoring and data analytics technologies to track cryptocurrency transactions (Scarcella 2019). The implementation of artificial intelligence and blockchain tools could facilitate the identification of fraudulent activities, tax evasion and the tracking of cryptoasset

ownership (Faúndez-Ugalde et al. 2020). This would allow tax authorities to have a more complete view of transactions and ensure more accurate and efficient collection.

The challenge is to strike a balance between financial innovation and the need to establish a clear and enforceable tax framework. International collaboration is also essential to address the cross-border nature of cryptocurrencies and ensure consistent taxation on a global scale.

Our study closes an existing gap in the academic literature. Firstly, because, although there are previous studies on this issue, such as the Czech Republic study conducted by Hampl (2020), the Ukraine study conducted by Bondarenko et al. (2019), Malaysia (Ter Ji-Xi et al. 2021) or Germany (Steinmetz et al. 2021), ours has focused on Spain. Secondly, although in Spain the phenomenon of Bitcoin and other cryptocurrencies adoption has been previously studied in general terms by Arias-Oliva et al. (2019), or the factors affecting the unequal adoption between men and women (Alonso et al. 2023a) or its adoption as a financial instrument (Gil-Cordero et al. 2020), our research is different from the previous ones. It is the first research that studies the reasons why Spanish cryptocurrency investors do not comply with their tax obligations when they engage in activities such as staking, trading or cryptocurrency swaps.

As to the limitations of our study, it should be noted that it is a survey carried out at a specific time, with specific social and economic circumstances. Therefore, the generalization of the results may be conditioned by the temporal and situational context in which the research was conducted. In addition, the changing nature of the cryptocurrency market and evolving regulations may influence tax compliance behaviors in the future. Consequently, further research is required to delve deeper into the reasons for voluntary or involuntary non-compliance with tax obligations related to cryptocurrency transactions, considering different temporal and situational contexts, as well as the analysis of additional factors that may influence such behavior.

7. Conclusions

This article underscores the lack of clarity in cryptocurrency regulation and the absence of consistent tax criteria, causing uncertainty for both taxpayers and tax authorities. It emphasizes the necessity for governments and international supervisory bodies to establish a specific regulatory framework to ensure more effective and precise taxation of cryptocurrencies. In terms of the survey's statistical analysis, the sample predominantly falls within the 26 to 35 age range, reflecting the typical profile of cryptocurrency users according to various studies. Notably, there is a gender disparity in the responses, with men constituting the majority, which aligns with the predominant user demographic of cryptocurrencies.

Regarding tax obligations, opinions are muddled and often incorrect. While most respondents understand the necessity of declaring capital gains from cryptocurrency sales, there are discrepancies in how to fulfill these obligations, particularly concerning swap operations and staking. Additionally, a notable portion of respondents appear to disregard tax obligations, likely due to the ambiguity in cryptocurrency-related tax laws. The overall perception is that current tax regulations deter investment in cryptocurrencies, attributable to confusion and lack of clarity in existing regulations. The majority of respondents express a clear need for enhanced education and resources from tax agencies to better grasp the tax implications of cryptocurrencies.

Hence, the data indicate an urgent need for clearer tax regulations concerning cryptocurrencies in Spain, alongside more comprehensive and accessible education for citizens. This initiative aims to foster understanding and ensure proper compliance with tax obligations in this dynamically evolving field driven by innovation. The latter statement can be achieved in three possible ways: by implementing specific regulations, international cooperation and through the development of advanced monitoring technologies.

Appendix A

Table A1. Normality according to the Kolmogorov–Smirnov test.

	N	Normal Parameters [a,b]		Maximum Extreme Differences			Test Statistic	Significance (Bilateral) [c]
		Mean	Standard Deviation	Absolute	Positive	Negative		
1. Gender	103	1.29	0.498	0.449	0.449	−0.279	0.449	0.000
2. What is your age?	103	35.84	9.974	0.107	0.107	−0.083	0.107	0.005
2.1. Age coded in ranges	103	2.31	0.767	0.252	0.220	−0.252	0.252	0.000
3. What is your level of education?	103	2.93	0.582	0.405	0.405	−0.401	0.405	0.000
4. What is your current main occupation?	103	1.43	0.736	0.409	0.409	−0.281	0.409	0.000
5. In which of the following ranges would you situate your household economy?	103	3.38	1.077	0.201	0.201	−0.188	0.201	0.000
6. How many inhabitants does the municipality in which you live have?	103	3.64	0.969	0.251	0.251	−0.196	0.251	0.000
7. If you had to define your personal financial situation, this would be:	103	2.47	0.539	0.325	0.321	−0.325	0.325	0.000
8. Have you made any transactions with cryptocurrencies (buying, selling, swapping…) to date?	103	1.63	1.129	0.411	0.411	−0.288	0.411	0.000
9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	103	2.50	1.228	0.178	0.152	−0.178	0.178	0.000

Table A1. *Cont.*

	N	Normal Parameters [a,b]		Maximum Extreme Differences			Test Statistic	Significance (Bilateral) [c]
		Mean	Standard Deviation	Absolute	Positive	Negative		
10. Are you aware of the tax obligations associated with cryptocurrencies in Spain?	103	1.08	1.054	0.235	0.235	−0.159	0.235	0.000
11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations do you have to comply with in relation to personal income tax (PERSONAL INCOME TAX)?	103	2.44	1.063	0.323	0.222	−0.323	0.323	0.000
12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	103	2.28	0.984	0.389	0.263	−0.389	0.389	0.000
13. If as an individual, during this financial year, I have exchanged cryptocurrencies for other cryptocurrencies, for personal income tax purposes, must I...	103	2.66	1.071	0.314	0.182	−0.314	0.314	0.000
14. If as an investor in cryptocurrencies, in this financial year, I have carried out staking, how should I manage the income for personal income tax purposes?	103	2.18	1.194	0.231	0.231	−0.178	0.231	0.000
15. What are the tax obligations that I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	103	1.88	1.105	0.361	0.361	−0.212	0.361	0.000
16. Have you declared your investments in cryptocurrencies during the last tax year when you have carried out any of the transactions described above?	103	2.78	0.779	0.273	0.222	−0.273	0.273	0.000
17. Do you think that the taxation of cryptocurrencies in Spain is clear and easy to understand?	103	2.62	0.562	0.410	0.250	−0.410	0.410	0.000
18. Have you had any negative experiences related to the taxation of cryptocurrencies?	103	2.14	0.561	0.363	0.363	−0.307	0.363	0.000
19. Do you think that tax regulation favors or discourages investment in cryptocurrencies in Spain?	103	2.57	0.966	0.257	0.257	−0.160	0.257	0.000
20. Do you think that the AEAT should provide more information and resources on taxation and taxation of cryptocurrencies and other digital assets?	103	1.24	0.649	0.520	0.520	−0.354	0.520	0.000

Source: Own elaboration through data obtained via the survey and SPSS. [a] The test distribution is normal. [b] It is calculated from data. [c] Lilliefors significance correction.

Table A2. Significant results of the Kruskal–Wallis test.

Variable	Grouping Variable	H de Kruskal-Wallis	gl	Sig. Asin.
17. Do you think that the taxation of cryptocurrencies in Spain is clear and easy to understand?	10. Are you aware of the tax obligations associated with cryptocurrencies in Spain?	18.181	4	0.0011
	12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	15.931	3	0.0012
	16. Have you declared your investments in cryptocurrencies during the last tax year when you have made any of the transactions described above?	22.822	3	0.000044
	19. Do you think that tax regulation favors or discourages investment in cryptocurrencies in Spain?	18.294	3	0.00038
11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	11.250	3	0.0104
	13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must. . .	11.202	3	0.0107
	15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	18.220	3	0.00040
12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	8. Have you carried out any transaction with cryptocurrencies (purchase, sale, swap. . .) to date?	14.338	4	0.0063
	9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	13.438	5	0.0196
	10. Are you aware of the tax obligations associated with cryptocurrencies in Spain?	18.361	4	0.0010
	11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	12.205	3	0.007
	13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must. . .	7.579	3	0.0556
	15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	14.799	3	0.0020
	16. Have you declared your investments in cryptocurrencies during the last tax year when you have made any of the transactions described above?	8.291	3	0.0404
	17. Do you think that the taxation of cryptocurrencies in Spain is clear and easy to understand?	11.370	2	0.0034

Table A2. *Cont.*

Variable	Grouping Variable	H de Kruskal-Wallis	gl	Sig. Asin.
13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must…	6. How many inhabitants does the municipality in which you live have?	13.640	4	0.009
	9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	11.754	5	0.038
	11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	11.211	3	0.011
	14. If as an investor in cryptocurrencies, in this financial year, I have carried out staking, how should I manage the income for personal income tax purposes?	11.786	3	0.008
	15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	16.982	3	0.001
	20. Do you think the AEAT should provide more information and resources on taxation and taxation of cryptocurrencies and other digital assets?	4.986	2	0.083
14. If as an investor in cryptocurrencies, in this financial year, I have carried out staking, how should I manage the income for personal income tax purposes?	1. Gender:	11.455	2	0.003
	9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	9.287	5	0.098
	11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	10.855	3	0.013
	13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must…	9.596	3	0.022
	15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	17.461	3	0.001
15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	18.277	3	0.00039
	12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	12.406	3	0.0061
	13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must…	11.451	3	0.0095
	14. If as an investor in cryptocurrencies, in this financial year, I have carried out staking, how should I manage the income for personal income tax purposes?	16.883	3	0.0007
	16. Have you declared your investments in cryptocurrencies during the last tax year when you have made any of the transactions described above?	11.236	3	0.0105

Table A2. *Cont.*

Variable	Grouping Variable	H de Kruskal-Wallis	gl	Sig. Asin.
16. Have you declared your investments in cryptocurrencies during the last tax year when you have made any of the transactions described above?	2.1. Age coded in intervals	6.679	3	0.0829
	8. Have you carried out any transaction with cryptocurrencies (purchase, sale, swap…) to date?	30.494	4	0.0000039
	9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	18.228	5	0.0027
	10. Are you aware of the tax obligations associated with cryptocurrencies in Spain?	17.833	4	0.0013
	11. As an investor in cryptocurrencies during this financial year, which of the following tax obligations must you comply with in relation to personal income tax (PERSONAL INCOME TAX)?	9.035	3	0.0288
	12. If, as an investor in cryptocurrencies, I have made a sale of cryptocurrencies during this financial year, what tax obligations do I have to comply with regard to personal income tax?	9.741	3	0.021
	15. What are the tax obligations I must comply with as an individual if I have acquired and held cryptocurrencies in my digital wallet during the current financial year in relation to wealth tax (IP)?	10.178	3	0.017
	17. Do you think that the taxation of cryptocurrencies in Spain is clear and easy to understand?	10.823	2	0.0045
	19. Do you think that tax regulation favors or discourages investment in cryptocurrencies in Spain?	7.190	3	0.0661
18. Have you had any negative experiences related to the taxation of cryptocurrencies?	1. Gender:	6.872	2	0.0322
20. Do you think the AEAT should provide more information and resources on taxation and taxation of cryptocurrencies and other digital assets?	1. Gender:	4.626	2	0.0990
	9. My knowledge of how cryptocurrencies work is from 0 (not at all) to 5 (very much):	17.442	5	0.0037
	10. Are you aware of the tax obligations associated with cryptocurrencies in Spain?	12.346	4	0.0150
	13. If, as a natural person, in this financial year, I have exchanged cryptocurrencies for other currencies, for personal income tax purposes I must…	6.353	3	0.0956
	14. If as an investor in cryptocurrencies, in this financial year, I have carried out staking, how should I manage the income for personal income tax purposes?	6.858	3	0.077

Source: Own elaboration through data obtained via the survey and SPSS.

Notes

[1] While, for income tax purposes, the purchase and holding of cryptocurrency do not entail any obligation, according to RD 249/2023, it is stated that it will not be mandatory to report via form 721 on cryptocurrencies abroad if the total balance of all cryptocurrencies as of 31 December (quantifying their value in euros) does not exceed EUR 50,000.

[2] Binding Consultation DGT V2616-22, dated 23 December 2022. "Information on the obligation to declare the possession of cryptocurrency without having been sold".

[3] Binding Consultation DGT V0808-2018, dated 22 March 2018. "The inquirer buys and sells different virtual currencies, such as 'bitcoin', 'litecoin', and 'ripple'".

[4] Binding Consultation DGT V2520-22, dated 7 September 2022. "Taxation of gains obtained in virtual currency exchange operations".

[5] Binding Consultation DGT V1766-22, dated 27 July 2022. "Taxation of rewards obtained in crypto-assets through 'staking'".

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Asymmetric Analysis of Causal Relations in the Informality–Globalisation Nexus in Africa

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Abstract: This study examines the causal relationship between informality and globalisation in 30 African countries. It deviates from traditional research by adopting a bi-directional framework to address reverse causality. By applying the DH causality method in both linear and nonlinear frameworks, this research challenges the assumption of a linear relationship and finds that the causal structure is better explained within a nonlinear asymmetric context. This paper provides recommendations based on the identified causal relationships. For countries in which globalisation leads to informality, such as Angola, Congo, Guinea, Gambia, Mozambique, Sierra Leone, Tunisia, Tanzania, Uganda, Zambia, and Zimbabwe, the paper suggests policy measures to integrate the informal sector into the formal economy. These measures include designing programmes to facilitate transition, implementing skill development initiatives, and establishing support mechanisms for entrepreneurship and small businesses. Additionally, this paper advises the development of social safety nets, improved market access, effective monitoring and regulation mechanisms, education on the benefits of globalisation, and international cooperation. For countries experiencing positive shocks from informality to globalisation, this paper recommends targeted support programs for entrepreneurship, initiatives to formalize the sector, the enhancement of market access, and skill development tailored to the needs of the informal sector. These policy recommendations aim to capitalize on the positive shocks in informality by fostering entrepreneurship, formalization, market access, and skill development. In the case of negative shocks in globalisation leading to positive shocks in informality, the paper suggests implementing resilience-building policies for the informal sector during economic downturns, establishing social safety nets, and adopting flexible labour policies.

Keywords: informal sector; globalization; Africa; asymmetric causality

1. Introduction

In recent years, scholars in developing economies have dedicated significant attention to examining the intricate connection between informality and globalisation (Ajide and Dada 2023; Bolarinwa and Simatele 2024). The scholarly discourse surrounding globalisation primarily revolves around its impact on economic development. Proponents of globalisation argue that it stimulates economic growth by expanding market reach, attracting foreign direct investment (FDI), and facilitating the transfer of knowledge and technology. Enhanced trade and investment create job opportunities, improve productivity, and contribute to overall economic advancement (Gorodnichenko et al. 2010; Dau et al. 2017; Bolarinwa and Simatele 2024). Advocates also contend that globalisation plays a role in reducing poverty by generating employment and elevating living standards through specialization in areas of comparative advantage (Nguyen Canh et al. 2021). Nevertheless, critics assert that the benefits of globalisation are unevenly distributed, resulting in heightened income inequality within developing countries (Andreas 2011; Hopper et al. 2017). Furthermore, they highlight the potential for labour and resource exploitation, as well as the vulnerability of developing economies to global economic fluctuations. Additionally, critics argue that globalisation can exacerbate poverty, particularly when

traditional industries are displaced or when benefits are concentrated in specific sectors, thereby marginalizing others, especially in the informal sector.

Conversely, the informal sector has elicited a range of perspectives in the development literature. Supporters emphasize the substantial employment opportunities provided by informality in developing countries, serving as a coping mechanism for individuals lacking access to formal employment (Bellakhal et al. 2024; OECD 2023; Canh et al. 2021). Informal businesses often demonstrate entrepreneurialism and dynamism, promoting innovation and filling gaps in the formal sector. Informal employment also serves as a crucial avenue for the inclusion of marginalized groups, such as women, youth, and migrants, in the labour force (Galdino et al. 2023). However, detractors argue that informal employment is characterized by low wages, job insecurity, and limited access to social protection, providing individuals with meagre incomes and unstable livelihoods. They contend that informality poses obstacles to broader economic development efforts by evading regulations and taxes, and informal businesses encounter barriers in expanding operations and accessing formal financial systems, thereby constraining their potential contributions to the overall economy (Bolarinwa and Simatele 2024; Chletsos and Sintos 2021; Bellakhal et al. 2024).

Consequently, the informal sector is widely regarded as a significant obstacle to economic development. Furthermore, the existing body of literature on the relationship between globalisation and informality has primarily concentrated on the effects of globalisation on informality, as evidenced in Hanh (2011 previous studies (See Todaro 1992; Verick 2006; Carr and Chen 2002; Hanh 2011; Meagher et al. 2016; Siggel 2010; Pham 2017; Berdiev and Saunoris 2019; Bellakhal et al. 2024)). Employing a theoretical framework, numerous studies have explored the relationship between globalization and informality. Hanh (2011) utilized Bayesian Model Averaging and focused on 34 developing economies, concluding that globalization correlates positively with informality. Notably, various components of globalization—such as trade integration, trade reforms, de jure financial openness, and social globalization—are influential in determining the size of the informal sector. Carr and Chen (2002) investigated the linkages between globalization and informality, with a particular focus on women workers and producers in the developing world, especially within African economies. Their research determined that globalization enlarges the informal sector, disproportionately affecting women workers and producers.

Similarly, Verick (2006) examined this relationship, placing a special emphasis on African economies and the plight of women workers. The study recommended that African policymakers implement measures to provide social and employment security for women to shield them from the adverse effects of globalization. Meanwhile, Meagher et al. (2016) analysed the repercussions of COVID-19 on the informal sector, paying close attention to institutional, infrastructural complexities, and the dynamics of contemporary market economies. Similarly, Siggel (2010) explored the failures of the formal market that drive labour towards the informal sector, thereby elevating poverty levels. Analysing Indian economic reforms in the 1990s, Siggel concluded that the existing theoretical model does not fully apply in India, as the growth of the informal sector there is driven by an increase in both labour demand and supply—through outsourcing, skill transfer, and the emergence of new enterprises.

A recent work by Bellakhal et al. (2024) evaluated both formal and informal markets within autarkic and open economic frameworks. The study hypothesized that, depending on the level of social contributions, globalization could both increase and decrease the size of informality. Specifically, globalization is posited to increase informality at low and high levels of social contributions but decrease it at intermediate levels.

Few recent empirical studies have also addressed this nexus. Berdiev and Saunoris (2019) examined informal entrepreneurship using cross-sectional data, OLS, and instrumental variable techniques across 60 developed and developing economies. Their findings suggest that globalization substantially reduces informal entrepreneurship. Pham (2017) utilized Bayesian Model Averaging to investigate the nexus within a sample of 50 developing countries from Latin America, Africa, Asia, and Central and Eastern Europe between 1990 and 2010. The

results identified a set of potential covariates and a subset of globalization indicators with high inclusion probabilities in the informality model. One major observation from this literature review is that research on the nexus between globalization and informality is nascent, with most studies focusing predominantly on the effects of globalization and largely overlooking the reciprocal impact of informality on globalization. This study employed a dynamic causal framework to provide a balanced analysis of the nexus.

Asides from the literature, the connection between globalisation and informality is intricate and multifaceted, characterized by mutual influence and interdependence. To obtain a more comprehensive understanding of this connection, it is crucial to analyse the nexus within a causal framework, considering the complex interconnectedness that underlies it. Specifically, the question arises as to whether globalisation impacts informality. Conversely, can informality, in turn, affect globalisation? Addressing the former question reveals that globalisation can exacerbate the vulnerabilities inherent in the informal sector. This exacerbation can arise from the erosion of labour standards, increased competition, or exposure to global shocks. African economies experiencing economic restructuring due to a decline in comparative advantage often face job displacement and a rise in informal employment as individuals seek alternative sources of income (Bolarinwa and Simatele 2024; Bellakhal et al. 2024).

Consequently, individuals often turn to the informal sector to sustain their livelihoods when confronted with economic challenges or unemployment resulting from globalisation. The informal sector provides expeditious and adaptable employment opportunities, particularly in regions with limited formal job prospects. As a result, structural changes often lead to the expansion of the informal sector due to labour market dysfunction. Furthermore, globalisation presents opportunities for regulatory arbitrage, where businesses exploit discrepancies in labour regulations and standards between countries. This practice can result in increased informal employment, as companies seek to evade compliance with formal labour market regulations. Moreover, globalisation frequently coincides with technological advancements that disrupt and surpass local technologies, leading to automation and technological changes that displace workers from formal sectors and direct them towards informal work, which is typically less impacted by these transformations.

Additionally, policy responses to globalisation can inadvertently foster the growth and expansion of the informal sector. For instance, recent austerity measures and labour market reforms in African economies, aimed at enhancing competitiveness, may undermine labour protections and potentially stimulate a surge in informal employment. Furthermore, globalisation often exacerbates income inequality, with certain population segments benefiting more than others. As formal employment opportunities become concentrated in specific sectors or regions, those excluded may turn to informal work as a means of subsistence.

Conversely, globalisation can engender new opportunities for informal workers and spur the growth of informal labour demand. This can occur through participation in global value chains, such as subcontracting, outsourcing, or digital platforms. In certain cases, formal businesses may outsource specific tasks to informal or unregulated entities to reduce costs. Consequently, this can result in informal employment arrangements and a lack of job security for workers in the formal sector. Conversely, the prevalence of the informal sector in developing countries reflects the absorption level of globalisation in African economies. Developing countries with a substantial informal sector may offer lower labour costs compared to countries with a more formalized labour market. This cost advantage can make these countries appealing to multinational corporations seeking to reduce production expenses, thereby intensifying globalisation and the outsourcing of certain activities to regions with lower labour costs. Can informality play a role in explaining the absorption of globalisation in African economies? Indeed, informal sectors can contribute in various ways. First and foremost, informal sectors often demonstrate a higher level of adaptability and flexibility compared to formal sectors. This allows businesses operating in the informal sector to easily adjust to the changing conditions of the global industry. This adaptability can attract global players who are seeking agile partners or suppliers, particularly in

African economies with low costs. As a result, this enhances the absorption of globalisation. Furthermore, African economies with a significant informal sector may also play a role in global value chains, especially in industries where informal activities are prevalent. This further contributes to the attraction of globalisation.

Moreover, globalisation involves the integration of various production stages across different countries. In some cases, informal sectors can function as integral components of these global value chains. Informality may also arise due to market dynamics and the presence of a substantial informal consumer base. This captures the interest of global enterprises who are seeking to explore local consumer markets. Therefore, the degree of informality in an economy can greatly influence the attraction of global enterprises, ultimately leading to a higher level of globalisation. There is evidence to suggest a bidirectional causal relationship between globalisation and informality (Pham 2017; Petrova 2019). The nature and direction of this relationship, however, depend on various factors and contexts. As a result, a more nuanced and comprehensive analysis is required to fully understand the dynamics and implications of the relationship between globalisation and informality in different sectors and regions within the realm of economic development.

In African economies, this relationship may be influenced by the stage of economic development and income level. Middle–high-income African economies, such as South Africa, Gabon, and Namibia, demonstrate a noticeable absorption of globalisation and a low level of informality (Blanton et al. 2018). This can be attributed to factors such as diverse economies, high levels of industrialisation, extensive access to global markets, and policies and initiatives aimed at formalising and regulating economic activities. Consequently, government efforts to enhance labour market regulations and standards may result in a reduction in the size of the informal sector. The relationship between the size of the informal sector and income level plays a significant role in understanding this phenomenon. In high-income African economies, specialisation in specific industries and participation in global value chains lead to the close integration of the formal sectors with the global economy (Elgin and Oztunali 2012; Bolarinwa and Simatele 2022). On the other hand, areas that are less affected by globalisation tend to have a higher prevalence of informal sectors. As a result, the size of the informal sector, its regulation, and its connection to globalisation may exhibit distinct characteristics in high-income economies. Additionally, high-income African economies are better equipped to adopt and adapt to advanced technologies, potentially reducing the prevalence of informal labour in certain sectors.

Conversely, low-income African economies encounter unique challenges regarding the interplay between globalisation and informality. These challenges stem from limited access to global markets, infrastructure constraints, and trade barriers. These circumstances result in the dominance of the informal sector, as low levels of participation in global trade prevail. Subsistence agriculture and informal activities in rural areas play a substantial role in these economies. Globalisation indirectly impacts these sectors, and informality persists due to a scarcity of alternative opportunities. Within these economies, the informal sector serves as a vital survival strategy for individuals facing limited prospects for formal employment. Consequently, the relationship between globalisation and informality in African economies varies in accordance with different contextual factors. Such factors include economic development, governmental policies, and the nature of economic activities, all of which contribute to shaping this relationship.

Therefore, it is imperative to consider the specific circumstances and challenges faced by each individual country when studying the interaction between globalisation and informality. This comprehensive understanding is necessary to grasp the dynamic and multifaceted nature of this phenomenon. The present study primarily focused on a country-specific analysis of the globalisation–informality nexus, with particular emphasis on policy responses to shocks within this relationship. This analysis encompasses examining the impact of increases or decreases in the size of the informal sector (indicating positive or negative shocks) and increases or decreases in the absorption of globalisation in individual economies. Following the Introduction, Section 2 provides a literature review that encom-

passes theoretical and empirical perspectives. Section 2 elucidates the methodology, while Section 3 presents the empirical results. Finally, the study concludes with Section 4, which offers recommendations and conclusions.

2. Methods and Data

2.1. Empirical Model

This subsection is dedicated to discussing the models utilized for the preliminary analyses. These tests play a crucial role in revealing the characteristics of the data and guiding the selection of suitable estimation techniques. Specifically, the paper adopts cross-sectional dependence, the slope homogeneity test, the panel unit root, test and the causality test. Also, it employs the Granger non-causality test (Dumitrescu and Hurlin 2012), following extant studies (Hatemi-J 2020a; Hatemi-J and El-Khatib 2016, 2020; Hatemi-J et al. 2017; Ikhsan et al. 2022; Olaniyi 2020; Olaniyi and Olayeni 2020). This panel causality test uses a block bootstrapping method to generate robust critical values that consider both cross-sectional dependence and individual variations among countries. The causality model is specified as follows:

$$glob_{i,t}^+ = \propto_{1i} + \sum_{k=1}^{K} \pi_{1i}^{(k)} glob_{i,t-k}^+ + \sum_{k=1}^{K} \beta_{1i}^{(k)} inf_{i,t-k}^+ + \mu_{1i,t}^+ \tag{1}$$

$$inf_{i,t}^+ = \propto_{2i} + \sum_{k=1}^{K} \pi_{2i}^{(k)} inf_{i,t-k}^+ + \sum_{k=1}^{K} \beta_{2i}^{(k)} glob_{i,t-k}^+ + \mu_{2i,t}^+ \tag{2}$$

where $i = 1, \ldots, N$ is the number of cross-sectional units, and $t = 1, \ldots, T$ stands for the time covered in the study. $glob_{i,0}$ and $inf_{i,0}$ are the initial values of both globalisation and informality, respectively. Error terms are defined as $\varepsilon_{1i,j}$ and $\varepsilon_{2i,j}$. The positive shocks' components of globalisation and informality are defined as $\varepsilon_{1i,t}^+ = \max(\varepsilon_{1i,t}, 0)$, and $\varepsilon_{1i,t}^+ = \max(\varepsilon_{2i,t}, 0)$, respectively. Also, the negative shocks' components of these variables are defined as follows: $\varepsilon_{1i,t}^- = \min(\varepsilon_{1i,t}^-, 0)$, $\varepsilon_{1i,t}^- = \min(\varepsilon_{1i,t}^-, 0)$. Thus, $\varepsilon_{1i,t} = \varepsilon_{1i,t}^+ + \varepsilon_{1i,t}^-$, and $\varepsilon_{2i,t} = \varepsilon_{2i,t}^+ + \varepsilon_{2i,t}^-$. Consistent with these definitions are the partial cumulative sums of the positive shocks of the variables. For a further description of process of DH causality within the asymmetric framework, please see (Hatemi-J 2020a, 2020b; Olaniyi 2020; Olaniyi and Olayeni 2020; Olaniyi and Ologunudu 2022; Olaniyi and Odhiambo 2024).

2.2. Data, Measurements, and Sources

This study utilized data obtained from 30 sub-Saharan African countries during the period from 1990 to 2018, considering data availability, as only these countries have data. The countries included in the analysis were categorized into three groups based on the income classifications established by the United Nations: high–middle-income countries (USD 3896–USD 12,055), lower–middle-income countries (USD 996–USD 3896), and lower-income countries (USD 996 or lower). For a comprehensive list of the countries included in the study and the data sources utilized, please refer to Tables 1 and 2.

Table 1. Countries adopted in the study.

High–Middle-Income Countries (USD 3896–USD 12,055)	Lower-Middle-Income Countries (USD 996–USD 3896)	Lower-Income Countries (USD 996 or Lower)
Gabon, Namibia, Tunisia, and South Africa.	Angola, Cameroon, Congo, Cote d'Ivoire, Ghana, Kenya, Nigeria, Madagascar, Guinea-Bissau, and Zambia.	Burkina Faso, Democratic Republic of Congo, Ethiopia, Gambia, Liberia, Malawi, Mali, Mozambique, Niger, Senegal, Tanzania, Togo, Sierra Leone, Uganda, and Zimbabwe.

Source: UN Economic Grouping (2023).

Variables	Measurement	Sources
KOF Globalisation Index	Aggregate measure of globalisation covers all attributes of globalisation: economic, social, information, cultural, and political globalisation. The index varies between 1 and 100. The higher the globalisation, the closer to 100.	Gygli et al. (2019)
KOF Economic Globalisation Index	Economic globalisation covers two major areas: trade globalisation; involving trade in goods, services, and trade partner diversity; and financial globalisation, including foreign direct investment, portfolio investment, international debt, international reserve, and international income payments. The index varies between 1 and 100.	Gygli et al. (2019)
KOF Trade Globalisation index	This measure comprises trade in goods, trade in services, and trade partner diversity. The index varies between 1 and 100. The higher the globalisation, the close to 100.	Gygli et al. (2019)
Informality	Based on Multiple Indicators–Multiple Causes (MIMIC) model-based estimates of informal output.	Elgin and Oztunali (2012)

3. Empirical Results and Discussion

3.1. Descriptive Statistics, Correlation, Unit Root Cross-Sectional Dependence, and Homogeneity Tests

The empirical analysis begins with a comprehensive examination of the descriptive statistics concerning the key variables within the findings. These descriptive statistics are presented in Table 3. It is evident from the data that the average informality rate in sub-Saharan African countries is approximately 40% and 42% when measured using the DGE and MIMIC approaches to informality, respectively. This indicates that around 40% and 42% of economic activities within the region occur within the informal sector. Additionally, it is worth noting that the African economy with the highest level of informality exhibits 65% of its economic activities happening informally, whereas the economy with the least informality demonstrates a substantially lower percentage, with only 23% of economic activities occurring within the informal sector. Therefore, the analysis reveals a significant disparity between highly informal and least informal economies in Africa. Figure 1 further demonstrates that economies characterized by higher degrees of globalization and lower levels of informal economic activity generally exhibit greater prosperity. Conversely, those with lower levels of globalization and higher informality tend to experience lesser economic success.

Regarding the measures of globalisation, this study examined three measures of KOF globalisation (refer to Table 3 for specific details). The first measure is aggregate globalisation, which encompasses economic, political, social, and informational aspects. The second measure is economic globalisation, focusing specifically on trade in goods, services, and trade partner diversity. Using the measure of aggregate globalisation, Table 3 demonstrates that the average African country has a 45% level of globalisation absorption. In contrast, the country most affected by globalisation shows absorption rates of 71%, 83%, and 90% for overall globalisation, economic globalisation, and trade globalisation, respectively. Similarly, the average rates for economic and trade globalisation in Africa are 47% and 46%, respectively, indicating a deeper integration of economic and trade globalisation compared to other measures in Africa. The presented figure indicates a strong presence of economic and trade globalisation on the continent, as evidenced by foreign direct investment and trade in goods and services with other nations.

Table 3. Descriptive statistics.

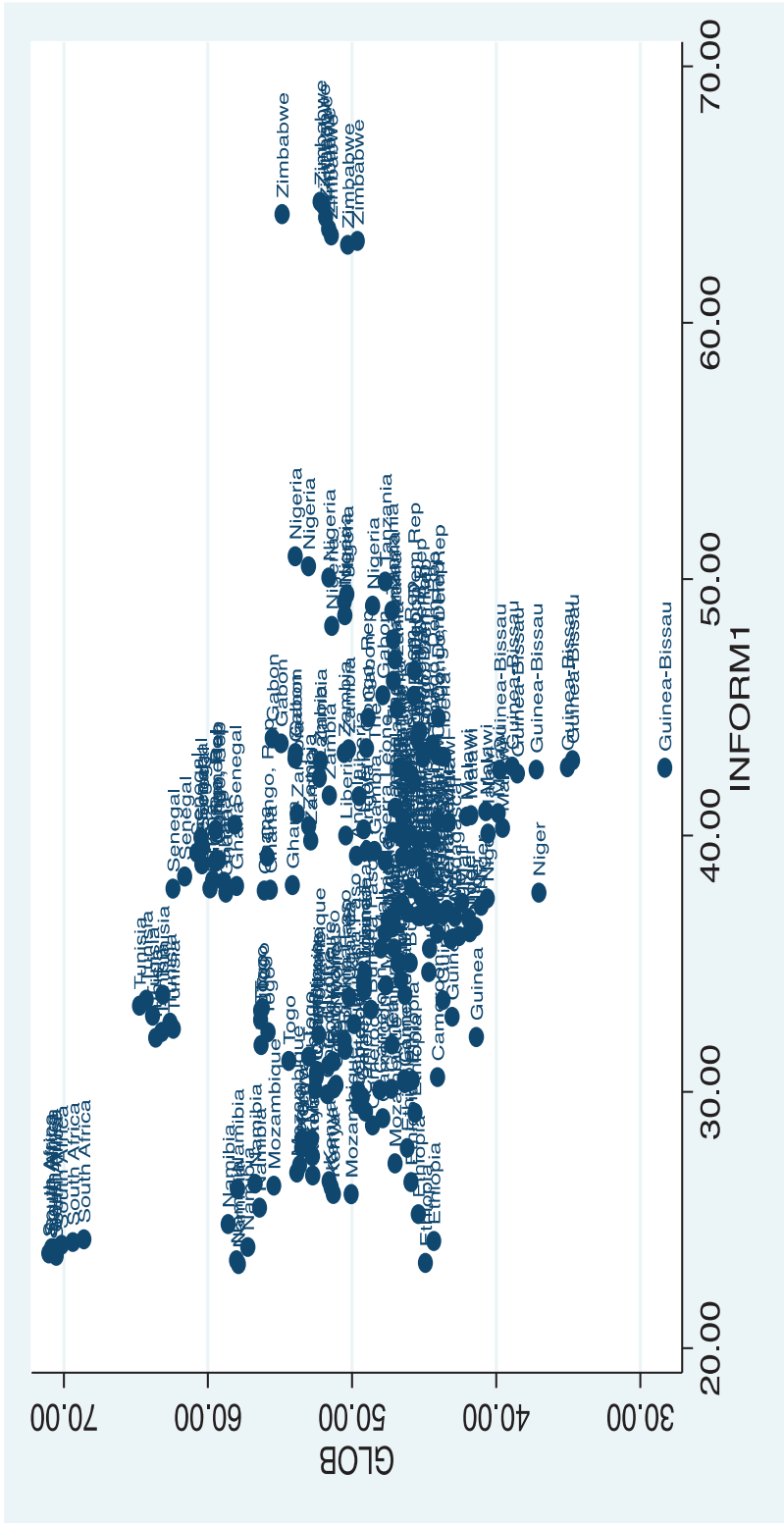| Variables	Mean	Std. Dev.	Min.	Max
Overall globalisation	44.5286	9.6951	21.0029	71.0436
Economic globalisation	47.0586	13.3819	14.4378	83.3227
Trade globalisation	45.7554	15.1234	13.7771	89.9983
Informality	42.2631	7.5779	26.4107	63.2959

Figure 1. Informality and globalisation in Africa. GLOB on *y*-axis and INFORM1 on *x*-axis represent overall globalisation and informality, respectively, expressed in percentage.

Economically, the descriptive statistics show that the liberalization and deregulation policies implemented by Bretton Wood's institutions in the 1980s have contributed to the integration of the African economy into the global economy. The significant level of inequality in the continent serves as evidence of the high level of informality. On average, countries demonstrate a wide wealth gap of approximately 54%, as shown in Table 3. Considering the high inflation rate prevalent on the African continent, the average African country experiences an inflation rate of 65%. This indicates that even meagre incomes in Africa are significantly eroded by the high inflation rate. The country with the highest inflation rate reports a staggering 23.773%. However, despite the weak social-development indicators mentioned, economic growth in Africa exceeds that of Western and several Asian economies. From 1980 to 2020, the average African population grew by 7%. The low standard deviation suggests that most African countries fall within this range. A major contributing factor to this phenomenon is the weak quality of institutions prevalent on the continent.

As shown in Table 3, the average African country scores poorly in corruption, bureaucracy, democracy, law and order, and political stability. Considering the maximal values attainable, it becomes evident that most African countries have poor institutional quality. Consequently, a significant obstacle to African countries benefiting from globalisation is the substandard quality of institutions on the continent. Additionally, this study aimed to analyse the correlation between the variables under investigation. Moreover, this study examined the unit root properties of the variables. Furthermore, the presence of cross-sectional dependence was explored using four tests: Pesaran (2021), Pesaran et al. (2008), Breusch and Pagan (1980), and Baltagi et al. (2012). The results, presented in Table 4a, indicate that all tests reject the null hypothesis of cross-sectional independence among the economies. This suggests that policies related to globalisation and informality are formulated independently across African economies. Additionally, the presence of slope heterogeneity is assessed using Pesaran and Yamagata's (2008) robust test in the context of cross-sections with heterogeneity. The empirical findings in Table 4b confirm the presence of heterogeneity in slopes. Taken together, these results affirm the presence of cross-sectional independence, heterogeneity in slopes, and unit root stationarity, thus justifying the use of the system GMM, quantile method of moments, and the Dumitrescu and Hurlin (2012) causality tests for the estimation of the nexus.

Table 4. (**a**) Cross-sectional dependence test: Unit Root Test. (**b**) Slope homogeneity test results.

(a)				
Variables	**Breusch–Pagan LM**	**Pesaran Scaled LM**	**Bias-Correlated Scaled LM**	**Pesaran CD**
Overall globalisation	5624.49 ***	175.94 ***	175.44 ***	63.87 ***
Economic global	2722.76 ***	77.56 ***	77.06 ***	6.43 ***
Trade globalisation	2034.76 ***	54.24 ***	53.74 ***	6.94 ***
Informality	5541.37 ***	173.12 ***	172.62 ***	40.96 ***

(b)		
Models	**Test 1**	**Test 2**
$informality = f(Consump, Inflat, Urban, growth, Overall\ gobalisation)$	17.79 ***	20.84 ***
$informality = f(Consump, Inflat, Urban, growth, economic\ gobalisation)$	20.06 ***	23.51 ***
$informality = f(Consump, Inflat, Urban, growth, trade\ gobalisation)$	20.87 ***	24.45 ***
$Globalisation = f(informality)$	34.86 ***	36.68 ***
$informality = f(globalisation)$	18.80 ***	19.78 ***

Note: *** represent 1% significant levels.

3.2. Discussions on Causality Findings

3.2.1. Evidence from Symmetric Causality Framework

To investigate the causal relationship within the nexus, this study employed both linear/symmetric and nonlinear/asymmetric causality approaches from a homogeneous perspective. This choice is based on the recommendation of the dependency and slope

homogeneity test, which enables the identification of country-specific findings for appropriate policy implications. The outcomes of the linear and symmetric causality analyses are presented in Tables 5–7. In these analyses, three different measures of globalisation (i.e., overall, economic, and trade globalisation) are individually applied. Table 5 reveals evidence of a causal relationship from the informal sector to overall globalisation in Cote d'Ivoire, Ghana, Guinea Bissau, Liberia, Mozambique, Malawi, Namibia, Tunisia, and Zambia. This finding suggests that the current size of the informal sector in these economies is influenced by past absorption of globalisation policies (Bolarinwa and Simatele 2024; Pham 2017). The collective engagement of these countries with the global economy significantly impacts their informal economies. Changes in globalisation patterns directly affect the dynamics of informal businesses, self-employment, and non-formal economic activities (Bellakhal et al. 2024). Policymakers should be cognizant of the tangible effects that global economic shifts can have on local informal economies.

Table 5. Granger causality results for overall globalisation–informality nexus.

Overall Globalisation Does Not Granger Informality				Informality Does Not Granger Cause Overall Globalisation			
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	0.0666	0.328	Accept	−0.0753	0.579	Accept
Burkina Faso	−0.0576 **	0.050	Reject	−0.7089	0.121	Accept
Cote d'Ivoire	−0.1002	0.141	Accept	−1.112 **	0.036	Reject
Cameroon	−0.0465 **	0.049	Reject	−0.9404	0.228	Accept
Congo, Rep	0.0206	0.639	Accept	−0.4015	0.188	Accept
Ethiopia	−0.0419 ***	0.005	Reject	−0.0553	0.902	Accept
Gabon	0.0189	0.691	Accept	0.1182	0.667	Accept
Ghana	−0.0643 *	0.062	Reject	−0.5993 *	0.065	Reject
Guinea	−0.0186	0.479	Accept	−0.6463	0.177	Accept
Gambia, The	0.0097	0.825	Accept	−0.0812	0.775	Accept
Guinea-Bissau	−0.0473	0.281	Accept	−1.329 **	0.034	Reject
Kenya	−0.0693 *	0.100	Reject	−0.112	0.570	Accept
Liberia	0.0234	0.804	Accept	0.3430 *	0.069	Reject
Madagascar	0.0647 *	0.077	Reject	0.3871	0.197	Accept
Mali	−0.0484	0.143	Accept	−0.3372	0.385	Accept
Mozambique	−0.0255	0.182	Accept	−1.2522 **	0.045	Reject
Malawi	−0.1373 ***	0.005	Reject	−1.0328 **	0.018	Reject
Namibia	−0.0231	0.333	Accept	−1.7787 ***	0.009	Reject
Niger	−0.0759 ***	0.010	Reject	0.0179	0.969	Accept
Nigeria	−0.0604 **	0.050	Reject	−0.0097	0.984	Accept
Senegal	0.0371	0.260	Accept	0.0651	0.788	Accept
Sierra Leone	−0.1074 **	0.016	Reject	−0.6329	0.287	Accept
Togo	−0.0648 **	0.014	Reject	0.1940	0.708	Accept
Tunisia	0.0133	0.763	Accept	−0.7695 *	0.078	Reject
Tanzania	−0.0859 *	0.077	Reject	−0.1451	0.534	Accept
Uganda	−0.0561 **	0.024	Reject	−0.3415	0.603	Accept
South Africa	−0.0053	0.571	Accept	−0.4253	0.536	Accept
Congo, D Rep	−0.0457 **	0.042	Reject	0.2405	0.305	Accept
Zambia	0.0496	0.491	Accept	−0.3629 **	0.013	Reject
Zimbabwe	0.0379	0.539	Accept	0.0249	0.871	Accept
Panel Result	7.7121 **	0.037	Reject	4.0084 ***	0.0001	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Consequently, when formulating economic policies, authorities should carefully consider how globalisation influences the informal sector. Strategies must be implemented to address the challenges and opportunities posed by global economic trends on local informal enterprises. Achieving a balance between participation in the global economy and support for the growth and stability of the informal sector is essential for promoting sustainable economic development. Ultimately, these findings suggest that the informal economies of these countries are not isolated from the broader global economic landscape. By managing

the impact of globalisation on informal activities, more effective economic policies and development strategies can be formulated. Using economic globalisation as the primary indicator, this study confirms that Angola, Ethiopia, Gabon, Guinea, Guinea-Bissau, Liberia, Sierra Leone, Tunisia, and Tanzania provide evidence of Granger causality, indicating a causal relationship from globalisation to informality.

Table 6. Granger causality results for overall globalisation–informality nexus.

	Trade Globalisation Does Not Granger Informality			Informality Does Not Granger Cause Trade Globalisation		
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0101	0.660	Accept	0.6868 **	0.033	Reject
Burkina Faso	−0.0216	0.135	Accept	−0.4139	0.407	Accept
Cote d'Ivoire	−0.0626	0.133	Accept	−0.0434	0.880	Accept
Cameroon	−0.0198	0.257	Accept	−0.1137	0.865	Accept
Congo, Rep	−0.0014	0.966	Accept	0.3088	0.399	Accept
Ethiopia	−0.0243 **	0.038	Reject	0.5713 *	0.080	Reject
Gabon	−0.0624	0.159	Accept	−0.7996 **	0.015	Reject
Ghana	−0.0151	0.281	Accept	−0.6415	0.302	Accept
Guinea	0.0082	0.584	Accept	−2.0179 **	0.021	Reject
Gambia, The	0.0113	0.796	Accept	−0.0789	0.890	Accept
Guinea-Bissau	−0.0674 *	0.085	Reject	−2.2329 ***	0.009	Reject
Kenya	0.0113	0.409	Accept	0.7651	0.178	Accept
Liberia	0.0021	0.923	Accept	0.9186 **	0.022	Reject
Madagascar	0.0800 **	0.028	Reject	0.0955	0.865	Accept
Mali	−0.0071	0.806	Accept	0.2819	0.634	Accept
Mozambique	−0.0083	0.428	Accept	−0.8382	0.131	Accept
Malawi	−0.0005	0.990	Accept	0.3035	0.693	Accept
Namibia	0.0021	0.885	Accept	−0.4926	0.341	Accept
Niger	−0.0617 **	0.046	Reject	0.0081	0.991	Accept
Nigeria	0.0002	0.994	Accept	2.8194	0.013	Accept
Senegal	−0.0505 *	0.087	Reject	−0.0479	0.938	Accept
Sierra Leone	−0.0378	0.165	Accept	−1.8249 **	0.038	Reject
Togo	−0.0241	0.241	Accept	0.7685	0.292	Accept
Tunisia	−0.0099	0.808	Accept	−1.043 *	0.085	Reject
Tanzania	−0.0207	0.384	Accept	0.4916 **	0.050	Reject
Uganda	−0.0177	0.227	Accept	−0.6858	0.245	Accept
South Africa	−0.0024	0.818	Accept	−0.3745	0.653	Accept
Congo, D Rep	−0.0205	0.309	Accept	0.3827	0.367	Accept
Zambia	0.0410 *	0.067	Reject	0.3424	0.494	Accept
Zimbabwe	0.0238	0.413	Accept	−0.5760	0.215	Accept
Panel Result	1.7615 *	0.0782	Reject	4.8908	0.0000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Furthermore, the measure of trade globalisation supports these findings in Angola, Ethiopia, Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Mozambique, Nigeria, Togo, and Tanzania. These results suggest that the size of the informal sector is largely influenced by the absorption of globalisation, which significantly disrupts both formal and informal sectors within these African economies. These findings challenge the assumption of homogeneity in the existing literature on globalisation (Olaniyi and Odhiambo 2024), thereby justifying the use of the DH causality method and highlighting the need for country-specific policy measures to address the implications of overall, economic, and trade globalisation.

Conversely, the first three columns of Table 5 present evidence of causality from globalisation to informality. These results are reported for the overall globalisation measure and include Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Niger, Nigeria, Sierra Leone, Togo, Tanzania, Uganda, and Congo. The evidence suggests that the past economic activities and size of the informal sectors in these African economies explain the current levels of globalisation absorption. Therefore, changes in the informal sector have

a consequential impact on subsequent changes in overall globalisation levels. Policymakers should acknowledge that the vibrancy or challenges within the informal economy of these countries can significantly affect their integration into the global economy. Consequently, economic policies must consider the role of the informal sector in shaping a country's global engagement, with strategies addressing the impact of the informal economy on international economic relationships, trade patterns, and global integration. Moreover, evidence for economic globalisation causality is also validated in Ethiopia, Guinea-Bissau, Madagascar, Niger, Senegal, and Zambia.

Table 7. Granger causality results for trade globalisation–informality nexus.

	Trade Globalisation Does Not Granger Informality			Informality Does Not Granger Cause Trade Globalisation		
Countries	**Wald Stat**	**Prob.**	**Decision**	**Wald Stat**	**Prob.**	**Decision**
Angola	−0.0107	0.564	Accept	0.9197 **	0.029	Reject
Burkina Faso	−0.0381 *	0.102	Reject	−0.2658	0.615	Accept
Cote d'Ivoire	−0.0114	0.619	Accept	0.2901	0.459	Accept
Cameroon	0.0012	0.927	Accept	−1.2349	0.2790	Accept
Congo, Rep	0.0019	0.934	Accept	0.4840	0.370	Accept
Ethiopia	−0.013 *	0.091	Reject	1.0145 **	0.032	Reject
Gabon	−0.0388	0.248	Accept	−0.4334	0.304	Accept
Ghana	0.0005	0.964	Accept	−0.6585	0.358	Accept
Guinea	−0.0137	0.122	Accept	−2.874 **	0.036	Reject
Gambia, The	−0.0025	0.958	Accept	1.1756 *	0.099	Reject
Guinea-Bissau	−0.0625 **	0.042	Reject	−2.6678 **	0.025	Reject
Kenya	0.0097	0.340	Accept	2.0828 **	0.031	Reject
Liberia	0.0083	0.630	Accept	0.2761	0.811	Accept
Madagascar	0.0273	0.319	Accept	2.3554 ***	0.002	Reject
Mali	−0.0025	0.894	Accept	−0.1629	0.876	Accept
Mozambique	−0.0004	0.947	Accept	−1.7519 **	0.049	Reject
Malawi	0.0538 **	0.023	Reject	0.2517	0.769	Accept
Namibia	0.0142	0.200	Accept	−0.6867	0.354	Accept
Niger	−0.0366	0.139	Accept	−0.0926	0.861	Accept
Nigeria	−0.0094	0.627	Accept	3.2302 ***	0.006	Reject
Senegal	−0.0401 *	0.064	Reject	−0.8108	0.138	Accept
Sierra Leone	−0.0203	0.359	Accept	−0.8214	0.352	Accept
Togo	−0.0231 *	0.077	Reject	0.8125 **	0.024	Reject
Tunisia	−0.0282	0.206	Accept	−0.8574	0.247	Accept
Tanzania	−0.0014	0.919	Accept	1.0089 ***	0.042	Reject
Uganda	−0.0177	0.222	Accept	−0.8680	0.226	Accept
South Africa	−0.0194	0.225	Accept	−0.8011	0.534	Accept
Congo, D Rep	−0.0184	0.468	Accept	0.4899	0.341	Accept
Zambia	0.0206	0.243	Accept	−0.1610	0.774	Accept
Zimbabwe	−0.0001	0.995	Accept	−0.5187	0.516	Accept
Panel Result	1.5718	0.6110	Accept	5.9058 **	0.036	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

3.2.2. Evidence from Asymmetric Causality Framework

One significant limitation of the symmetric causality analysis is its failure to incorporate shocks. To rectify this, the asymmetric analysis includes these shocks within the nexus. This section presents the findings of the asymmetric analysis. Following the established literature, such as the works of Hatemi-J (2020a, 2020b), Olaniyi (2020), Olaniyi and Olayeni (2020), Olaniyi and Ologundudu (2022), and Olaniyi and Odhiambo (2024), the asymmetric models employ 1000 bootstrapped iterations to adequately address shocks and policy responses. The results are shown in Tables 8–15.

Table 8. Granger causality results for overall globalisation–informality nexus.

Overall Globalisation (+) Does Not Granger Informality (+)				Informality (+) Does Not Granger Cause Overall Globa (+)			
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision	
Angola	0.1028 **	0.038	Reject	0.2430	0.302	Accept	
Burkina Faso	0.0123	0.363	Accept	1.1866 *	0.064	Reject	
Cote d'Ivoire	0.0157	0.400	Accept	0.7566	0.128	Accept	
Cameroon	0.0302	0.145	Accept	2.7177 ***	0.002	Reject	
Congo, Rep	0.0403 **	0.051	Reject	0.3321	0.397	Accept	
Ethiopia	−0.0011	0.900	Accept	0.8123	0.221	Accept	
Gabon	0.0329	0.407	Accept	0.6466	0.115	Accept	
Ghana	0.0333	0.128	Accept	1.8909 **	0.046	Reject	
Guinea	0.0273 **	0.014	Reject	2.8637 **	0.047	Reject	
Gambia, The	0.1117 **	0.042	Reject	0.0197	0.883	Accept	
Guinea-Bissau	0.0218	0.372	Accept	0.2305	0.346	Accept	
Kenya	0.0182	0.352	Accept	1.4359 **	0.016	Reject	
Liberia	0.0173	0.646	Accept	0.2158	0.197	Accept	
Madagascar	0.1152	0.155	Accept	0.6309 ***	0.005	Reject	
Mali	0.0361	0.206	Accept	0.7563 *	0.083	Reject	
Mozambique	0.0112 *	0.074	Reject	1.3579	0.272	Accept	
Malawi	0.0353	0.203	Accept	−0.2038	0.746	Accept	
Namibia	0.0059	0.455	Accept	1.2869	0.228	Accept	
Niger	0.0376	0.225	Accept	0.8164 *	0.092	Reject	
Nigeria	0.0228	0.381	Accept	1.5476 ***	0.002	Reject	
Senegal	0.0474	0.115	Accept	0.4283	0.184	Accept	
Sierra Leone	0.0332 *	0.100	Reject	0.1533	0.717	Accept	
Togo	0.0114	0.495	Accept	1.2942 **	0.043	Reject	
Tunisia	0.0411 **	0.030	Reject	−0.1308	0.507	Accept	
Tanzania	0.0391 *	0.077	Reject	1.0225	0.259	Accept	
Uganda	0.1165 *	0.102	Reject	2.1715 **	0.058	Reject	
South Africa	0.0098	0.215	Accept	2.1564 **	0.034	Reject	
Congo, D Rep	0.0042	0.751	Accept	0.3381	0.163	Accept	
Zambia	0.0448 *	0.067	Reject	0.1921	0.713	Accept	
Zimbabwe	0.1943 **	0.015	Reject	0.5012 ***	0.001	Reject	
Panel Result	6.1066 ***	0.000	Reject	9.3682 ***	0.000	Reject	

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

The findings derived from the asymmetric causality framework contribute significantly to our comprehension of the relationship between globalisation and informality within the African countries under study. To ensure robustness, this study further investigated this relationship within an asymmetric/nonlinear framework, which helped address shocks within the causal framework for policy formation. The paper follows the established literature (Hatemi-J 2020a, 2020b; Olaniyi 2020; Olaniyi and Olayeni 2020; Olaniyi and Ologundudu 2022; Olaniyi and Odhiambo 2024) to analyse the asymmetric models and employs 1000 bootstrapped iterations. It is important to note that asymmetric causality effectively captures shocks and policy responses, making it more applicable for policy recommendations than the ordinary causality framework.

Accordingly, this paper presents the outcomes of the causal responses between positive shocks in globalisation (globalisation +, indicating an increase in globalisation absorption) and positive shocks in informality (informality +, suggesting an increase in the size of the informal sector), as shown in Table 8. These results indicate that a notable positive change or shock in the levels of globalisation in the studied countries, attributable to increased international trade, foreign direct investment, or other factors indicating greater integration into the global economy, is accompanied by a subsequent positive shock in the size of the informal sector. In simpler terms, as globalisation increases, the informal sector in these nations also experiences growth, and conversely, when globalisation decreases, the size of the informal sector tends to decrease as well. In Uganda for instance, the persistent globalization absorption expands the informal sector. Thus, Uganda's strategic initiatives

to boost tourism and agriculture have facilitated informal employment in these sectors. Increased global demand for agricultural products can lead to a more robust informal sector, as small-scale farmers and traders benefit indirectly from enhanced export opportunities.

Table 9. Granger causality results for total globalisation–informality nexus.

Overall Globalisation (−) Does Not Granger Informality (−)				Informality (−) Does Not Granger Cause Overall Global (−)		
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0175	0.835	Accept	0.1819	0.116	Accept
Burkina Faso	0.1425	0.518	Accept	0.1862	0.135	Accept
Cote d'Ivoire	0.1013	0.373	Accept	0.1386	0.230	Accept
Cameroon	0.0312	0.152	Accept	0.3020 *	0.100	Reject
Congo, Rep	−0.0160	0.745	Accept	1.0816 ***	0.006	Reject
Ethiopia	0.0116	0.581	Accept	0.3224	0.157	Accept
Gabon	0.0136	0.576	Accept	0.5315	0.179	Accept
Ghana	0.0161	0.879	Accept	0.7383 **	0.050	Reject
Guinea	0.0249	0.335	Accept	0.1015	0.645	Accept
Gambia, the	0.0519	0.718	Accept	2.3623 ***	0.003	Reject
Guinea-Bissau	0.0195	0.326	Accept	2.108 **	0.018	Reject
Kenya	0.0290	0.213	Accept	0.0924	0.376	Accept
Liberia	−0.0241	0.776	Accept	0.4134 ***	0.001	Reject
Madagascar	0.3474 **	0.026	Reject	0.0613	0.494	Accept
Mali	0.0571	0.554	Accept	0.2332 *	0.100	Reject
Mozambique	0.0123	0.635	Accept	0.1857	0.409	Accept
Malawi	−0.0030	0.940	Accept	0.9264 ***	0.008	Reject
Namibia	0.0178	0.294	Accept	0.5723	0.172	Accept
Niger	0.0664	0.244	Accept	0.1144	0.289	Accept
Nigeria	0.0222	0.293	Accept	0.2866	0.110	Accept
Senegal	0.0128	0.893	Accept	0.1081 *	0.075	Reject
Sierra Leone	0.0596 *	0.065	Reject	0.0813	0.399	Accept
Togo	−0.0081	0.786	Accept	0.3498 *	0.080	Reject
Tunisia	0.0243	0.554	Accept	0.0791	0.717	Accept
Tanzania	−0.0332	0.710	Accept	0.3349 ***	0.006	Reject
Uganda	0.0476	0.581	Accept	0.5541 **	0.012	Reject
South Africa	−0.0229	0.681	Accept	0.1897 **	0.050	Reject
Congo, D Rep	0.0407	0.254	Accept	0.1196	0.343	Accept
Zambia	0.1662 **	0.011	Reject	−0.0695	0.676	Accept
Zimbabwe	0.0623	0.506	Accept	0.5045 **	0.017	Reject
Panel Result	0.2636	0.7921	Accept	10.628 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Furthermore, the study examined the causality flows from globalisation to informality using an overall measure of globalisation. The results of the asymmetric causality test reveal that the persistent and continuous absorption of globalisation has led to an expansion of the informal sector in Angola, Congo, Guinea, Gambia, Mozambique, Sierra Leone, Tunisia, Tanzania, Uganda, Zambia, and Zimbabwe. Therefore, these findings suggest a positive correlation between higher levels of globalisation and the growth of the informal sector. This trend could be attributed to the increased economic opportunities, changes in market dynamics, or shifts in labour patterns influenced by globalisation. It is important to note that positive shocks in globalisation can generate new economic prospects but can also contribute to the growth of the informal sector as individuals and businesses adapt to changing conditions.

In conclusion, the informal sector in the studied African countries is responsive to changes in globalisation levels, potentially playing a prominent role in labour absorption, providing employment opportunities, and adapting to market demands influenced by global economic trends. The validity of the results is supported by robustness checks using economic globalisation. This study investigated the reverse causal relationship between

positive shocks in informality and positive shocks in globalisation. This relationship was examined and confirmed in twelve countries: Burkina Faso, Cameroon, Ghana, Guinea, Kenya, Madagascar, Mali, Niger, Nigeria, Togo, Uganda, South Africa, and Zimbabwe. The findings indicate that a positive shock in informality leads to a significant expansion in the size and dynamics of the informal sector. This expansion can be attributed to various factors, such as the growth of informal businesses, self-employment, and changes in labour patterns. Furthermore, the study concludes that positive shocks in informality also contribute positively to globalisation in the specified countries. This suggests that, as the informal sector grows, there is a corresponding positive effect on the level of global economic integration.

Table 10. Granger causality results for total globalisation–informality nexus.

	Overall Globalisation (−) Does Not Granger Informality (+)			Informality (−) Does Not Granger Cause Overall Global. (+)		
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0765	0.185	Accept	−0.3096 ***	0.024	Reject
Burkina Faso	−0.2921 **	0.012	Reject	−0.6473 **	0.047	Reject
Cote d'Ivoire	−0.0560	0.334	Accept	−1.0282 **	0.031	Reject
Cameroon	−0.0443 *	0.100	Reject	−1.5957 ***	0.002	Reject
Congo, Rep	−0.0267	0.348	Accept	−0.7761 **	0.044	Reject
Ethiopia	−0.0383 *	0.077	Reject	−0.4402	0.393	Accept
Gabon	−0.0062	0.912	Accept	−0.8848 *	0.096	Reject
Ghana	−0.0414	0.165	Accept	−0.7283 **	0.038	Reject
Guinea	−0.0192 *	0.100	Reject	−0.7021	0.143	Accept
Gambia, The	−0.4056 **	0.017	Reject	−0.1221	0.669	Accept
Guinea-Bissau	−0.0423	0.250	Accept	−0.9051	0.127	Accept
Kenya	−0.0431 **	0.016	Reject	−0.3289 *	0.091	Reject
Liberia	−0.0887 **	0.050	Reject	−0.1167	0.190	Accept
Madagascar	−0.3663	0.230	Accept	−1.9143 ***	0.000	Reject
Mali	−0.1261	0.132	Accept	−0.3262	0.198	Accept
Mozambique	−0.0308 **	0.032	Reject	−0.5205	0.181	Accept
Malawi	−0.0569 *	0.091-	Reject	−1.0747 **	0.021	Reject
Namibia	0.0909	0.301	Accept	−0.8742 *	0.099	Reject
Niger	−0.0812 *	0.064	Reject	−0.2746	0.413	Accept
Nigeria	−0.0323	0.176	Accept	−0.6281 *	0.072	Reject
Senegal	0.0207	0.784	Accept	−0.0616	0.808	Accept
Sierra Leone	−0.0770	0.154	Accept	−0.0664	0.863	Accept
Togo	−0.0593 **	0.044	Reject	0.3202	0.371	Accept
Tunisia	−0.0831	0.135	Accept	−0.0769	0.791	Accept
Tanzania	−0.0353	0.303	Accept	−0.2885	0.307	Accept
Uganda	−0.0259	0.371	Accept	−0.9314	0.245	Accept
South Africa	−0.0390	0.598	Accept	−0.9561	0.224	Accept
Congo, D Rep	0.0189	0.702	Accept	0.1727	0.536	Accept
Zambia	−0.019	0.612	Accept	−0.3718	0.152	Accept
Zimbabwe	−0.0581	0.461	Accept	−0.4821 ***	0.005	Reject
Panel Result	5.3786 ***	0.000	Reject	10.085 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Conversely, the study also examined the causal relationship between negative shocks in globalisation and negative shocks in informality. The results of the asymmetric causality test, presented in Table 9, support this relationship in three countries: Madagascar, Sierra Leone, and Zimbabwe. These findings suggest that the informal sector in these countries is vulnerable to changes in globalisation levels (Canh and Thanh 2020; Canh et al. 2021). For instance, in Sierra Leone, reductions in global economic activities can lead to significant impacts on informal sectors, notably in urban areas, where informal trade is a major livelihood. Economic downturns in the global economy can lead to a decreased demand for raw materials like minerals, affecting local informal mining operations. Therefore, policymakers

should take into consideration the potential effects of globalisation shocks on the informal sector when devising economic policies. It may be crucial to implement strategies that support the resilience of informal businesses during periods of reduced globalisation. The study also emphasizes the responsiveness of the informal sector to changes in the global economic environment. As a result, policies that enhance the adaptability and resilience of the informal economy during economic contractions should be seriously considered.

Table 11. Granger causality results for total globalisation–informality nexus.

	Overall Globalisation (+) Does Not Granger Informality (−)			Informality (+) Does Not Granger Cause Overall Global (−)		
Countries	**Wald Stat**	**Prob.**	**Decision**	**Wald Stat**	**Prob.**	**Decision**
Angola	−0.0543	0.410	Accept	−0.3076 *	0.071	Reject
Burkina Faso	−0.0266	0.327	Accept	−0.2204	0.427	Accept
Cote d'Ivoire	−0.0264	0.703	Accept	−0.4404 **	0.041	Reject
Cameroon	−0.0259	0.161	Accept	−0.4506	0.210	Accept
Congo, Rep	0.0037	0.905	Accept	−0.8362 **	0.011	Reject
Ethiopia	−0.0273 **	0.027	Reject	−0.3729	0.449	Accept
Gabon	−0.8848 *	0.096	Reject	−0.0062	0.912	Accept
Ghana	−0.0650 *	0.100	Reject	−1.6503 ***	0.0001	Reject
Guinea	−0.0183	0.366	Accept	0.1455	0.790	Accept
Gambia, The	−0.1943 ***	0.005	Reject	−0.2090 **	0.049	Reject
Guinea-Bissau	−0.0292 **	0.050	Reject	−0.9652 **	0.029	Reject
Kenya	−0.0686 **	0.014	Reject	−0.1120	0.777	Accept
Liberia	0.0118	0.839	Accept	−0.1939	0.397	Accept
Madagascar	0.0291	0.706	Accept	−0.0561	0.385	Accept
Mali	−0.0178	0.542	Accept	−0.6506 ***	0.002	Reject
Mozambique	−0.0139	0.264	Accept	−1.1997	0.124	Accept
Malawi	−0.0710 **	0.023	Reject	−1.1781 ***	0.009	Reject
Namibia	−0.0143	0.291	Accept	−1.2983 *	0.097	Reject
Niger	−0.0964 ***	0.006	Reject	−0.1047	0.488	Accept
Nigeria	−0.0537 **	0.011	Reject	−0.3212	0.237	Accept
Senegal	−0.0270	0.522	Accept	−0.0920	0.289	Accept
Sierra Leone	−0.0486 **	0.032	Reject	−0.2619	0.178	Accept
Togo	−0.0409 **	0.051	Reject	−0.6057	0.233	Accept
Tunisia	−0.0587	0.263	Accept	−0.0769	0.791	Accept
Tanzania	−0.0710	0.136	Accept	−0.6536 **	0.049	Reject
Uganda	−0.0707 **	0.044	Reject	−0.7268 **	0.038	Reject
South Africa	−0.0101	0.561	Accept	−0.3006	0.181	Accept
Congo, D Rep	−0.0359 *	0.068	Reject	−0.5183 **	0.022	Reject
Zambia	−0.0855	0.147	Accept	−0.2481	0.344	Accept
Zimbabwe	−0.1239 *	0.074	Reject	−0.2316 *	0.092	Reject
Panel Result	7.4014 ***	0.000	Reject	9.4336 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Additional robustness checks using economic globalisation are presented in Table 10. This paper conducts an analysis of alternate causality, specifically exploring the transmission of negative shocks from the informal sector to negative shocks in globalisation. Empirical evidence supports this relationship in several African countries, including Cameroon, Congo, Ghana, Gambia, Guinea-Bissau, Liberia, Mali, Malawi, Senegal, Togo, Tanzania, Uganda, South Africa, and Zimbabwe. These findings indicate that significant negative changes or shocks have occurred in the informal sector in these countries, such as reduced informal economic activities, increased formalization, or changes in local economic conditions. Moreover, the causality results suggest that, following a negative shock in informality, there is a subsequent negative shock in globalisation in these nations. This implies that, as the prevalence of informality decreases, the level of globalisation in these countries also experiences a decline. For instance, Zimbabwe's economic policies, including land reform and sanctions, have led to a volatile economic environment where globalization shocks have a pronounced impact. For example, reduced trade or investment (negative

globalization shocks) correlate with a contraction in the informal sector, possibly due to the decreased availability of goods to trade or reduced informal cross-border activities.

Table 12. Granger causality results for economic globalisation–informality nexus.

Countries	Economic Globalisation (+) Does Not Granger Informality (+)			Informality (+) Does Not Granger Cause Economic Glo (+)		
	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	0.0382 *	0.060	Reject	0.9388	0.144	Accept
Burkina Faso	−0.0008	0.893	Accept	1.0541	0.134	Accept
Cote d'Ivoire	0.0170	0.425	Accept	0.8194	0.137	Accept
Cameroon	0.0350 **	0.044	Reject	2.0499	0.207	Accept
Congo, Rep	0.0889 ***	0.001	Reject	0.0674	0.909	Accept
Ethiopia	−0.0004	0.950	Accept	0.7918	0.231	Accept
Gabon	−0.0228	0.535	Accept	0.2754	0.166	Accept
Ghana	0.0129	0.133	Accept	4.511 **	0.031	Reject
Guinea	0.01238 **	0.028	Reject	8.613 **	0.011	Reject
Gambia, The	0.1153 **	0.023	Reject	0.2465	0.519	Accept
Guinea-Bissau	0.0261	0.238	Accept	0.0205	0.945	Accept
Kenya	0.0099	0.247	Accept	3.1988 **	0.012	Reject
Liberia	0.1570 **	0.050	Reject	1.010 ***	0.005	Reject
Madagascar	0.1187 **	0.051	Reject	0.6340 *	0.083	Reject
Mali	0.0219	0.156	Accept	1.8790 **	0.028	Reject
Mozambique	0.0088 **	0.036	Reject	−0.4986	0.716	Accept
Malawi	0.0176	0.253	Accept	−0.1617	0.826	Accept
Namibia	0.0119	0.295	Accept	0.3557	0.816	Accept
Niger	0.0108	0.560	Accept	1.0105 **	0.044	Reject
Nigeria	0.0086	0.402	Accept	2.8069 ***	0.003	Reject
Senegal	0.0122	0.444	Accept	1.4564 **	0.018	Reject
Sierra Leone	0.0203 *	0.063	Reject	0.3866	0.670	Accept
Togo	0.0056	0.561	Accept	2.2098 **	0.023	Reject
Tunisia	0.1067	0.725	Accept	0.0295 **	0.040	Reject
Tanzania	0.0231 *	0.065	Reject	−0.2927	0.828	Accept
Uganda	0.0215 **	0.045	Reject	2.4335	0.216	Accept
South Africa	0.0139	0.113	Accept	0.2481	0.695	Accept
Congo, D Rep	0.0057	0.563	Accept	0.5558	0.244	Accept
Zambia	0.0140 *	0.097	Reject	0.7692	0.597	Accept
Zimbabwe	0.0990 ***	0.001	Reject	1.2387 ***	0.001	Reject
Panel Result	8.2219 ***	0.000	Reject	8.5932 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

To provide further validation, we present robustness checks in Table 10, employing economic globalisation as a control variable. Additionally, we investigate the causality within the framework of the policy mix. Specifically, we examine the effect of a surge in the size of the informal sector on globalisation, and vice versa. Firstly, we present the results of the nonlinear causal relationship between negative shocks in globalisation (i.e., decrease in globalisation absorption) and positive shocks in informality (i.e., increase in size of the informal sector) in Table 11. These results are verified for Burkina Faso, Cameroon, Ethiopia, Guinea, Gambia, Kenya, Liberia, Mozambique, Malawi, Niger, and Togo. From a practical perspective, the observed causal relationship suggests that a negative shock in globalisation leads to a significant decrease in the level or intensity of global economic integration, which may encompass factors such as reduced international trade, investment, or economic interconnectedness.

Conversely, positive shocks in informality indicate an increase in the size or activities of the informal sector. This could be attributed to a surge in informal businesses and self-employment or changes in labour patterns within these African economies. The findings of this study reveal that there is a relationship between negative shocks in globalisation and positive shocks in the informal sector. These shocks refer to a decrease in globalisation absorption and an increase in the size of the informal sector, respectively. Several factors

can account for this phenomenon, including economic downturns that lead individuals to seek informal activities for their livelihoods after experiencing job losses in the formal sector. From an economic perspective, this nonlinear and asymmetric causal relationship suggests that the response of the informal sector to positive and negative shocks in globalisation may differ. During periods of economic downturns, the informal sector may serve as a safety net, absorbing individuals who have been displaced from the formal sector. However, the reverse may not be true during periods of positive economic growth, as the informal sector may not shrink to the same extent.

Table 13. Granger causality results for economic globalisation–informality nexus.

Economic Globalisation (−) Does Not Granger Informality (−)				Informality (−) Does Not Granger Cause Economic Glob. (−)			
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0089	0.647	Accept	0.5228 *	0.078	Reject
Burkina Faso	0.0254	0.696	Accept	0.6168 *	0.094	Reject
Cote d'Ivoire	0.0238	0.525	Accept	0.3171	0.272	Accept
Cameroon	0.0106	0.497	Accept	1.6821 **	0.023	Reject
Congo, Rep	−0.0275	0.260	Accept	0.7236 **	0.049	Reject
Ethiopia	−0.0206	0.322	Accept	1.5510 ***	0.004	Reject
Gabon	0.7024	0.162	Accept	0.0316	0.257	Accept
Ghana	0.0162	0.616	Accept	1.8768 *	0.100	Reject
Guinea	0.0290 **	0.015	Reject	0.2543	0.705	Accept
Gambia, the	0.0230	0.527	Accept	1.0722 **	0.013	Reject
Guinea-Bissau	0.0192	0.218	Accept	1.8485 **	0.038	Reject
Kenya	0.0156 *	0.062	Reject	0.2839	0.466	Accept
Liberia	−0.0112	0.617	Accept	0.6698 **	0.012	Reject
Madagascar	0.1169 **	0.020	Reject	0.4352	0.255	Accept
Mali	−0.0010	0.957	Accept	0.9965 ***	0.006	Reject
Mozambique	−0.0426	0.483	Accept	0.9688 ***	0.001	Reject
Malawi	0.01873	0.306	Accept	0.8615	0.326	Accept
Namibia	0.0301 *	0.060	Reject	0.7153	0.347	Accept
Niger	0.1636 ***	0.003	Reject	0.9804 **	0.017	Reject
Nigeria	0.0132 *	0.080	Reject	0.9107 *	0.094	Reject
Senegal	0.0216	0.626	Accept	0.5002 **	0.022	Reject
Sierra Leone	0.0244 **	0.048	Reject	0.3328	0.306	Accept
Togo	0.0269	0.295	Accept	0.6003	0.256	Accept
Tunisia	0.0068	0.765	Accept	0.6472	0.193	Accept
Tanzania	0.0026	0.933	Accept	2.0187 ***	0.0000	Reject
Uganda	0.0321	0.208	Accept	2.3253 ***	0.006	Reject
South Africa	0.0150	0.486	Accept	0.7258 **	0.047	Reject
Congo, D Rep	0.0285 *	0.100	Reject	0.6508	0.142	Accept
Zambia	0.0397 **	0.020	Reject	−0.4295	0.517	Accept
Zimbabwe	0.0311	0.376	Accept	1.2141 **	0.028	Reject
Panel Result	4.1237 ***	0.000	Reject	13.9635 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

Furthermore, this study found evidence of asymmetric shocks between negative shocks in informality (indicating a reduction in the size of the informal sector) and positive shocks in globalisation (representing an increase in globalisation adoption) in several African countries, namely Angola, Burkina Faso, Cote d'Ivoire, Congo, Cameroon, Ghana, Gabon, Kenya, Madagascar, Malawi, Namibia, Nigeria, and Zimbabwe. These findings have important implications for the economic context, suggesting that when there are negative shocks in informality resulting in a decrease in the size of the informal sector, there tends to be a positive response in the adoption of globalisation. One possible explanation for this relationship is that a decrease in informality may be associated with a more formalized and globalized economic environment. Additionally, the results indicate that a decrease in informality is associated with an increased embrace of globalisation, likely driven by factors

such as improved regulatory frameworks, greater access to formal markets, or efforts to align with global standards.

Table 14. Granger causality results for economic globalisation–informality nexus.

Economic Globalisation (−) Does Not Granger Informality (+)				Informality (−) Does Not Granger Cause Economic Glob (+)		
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0125	0.354	Accept	−0.06298 **	0.051	Reject
Burkina Faso	−0.0750 **	0.015	Reject	−0.3694	0.263	Accept
Cote d'Ivoire	−0.0605 **	0.030	Reject	−0.2171	0.585	Accept
Cameroon	−0.0325 **	0.047	Reject	−0.8370	0.169	Accept
Congo, Rep	−0.0155	0.392	Accept	−1.1436 ***	0.004	Reject
Ethiopia	0.0002	0.979	Accept	−0.4259	0.410	Accept
Gabon	−0.0071	0.830	Accept	−1.2534 **	0.037	Reject
Ghana	−0.0182 *	0.064	Reject	−2.0196 ***	0.010	Reject
Guinea	−0.0097	0.130	Accept	−1.5057	0.268	Accept
Gambia, The	−0.1028 **	0.050	Reject	−0.6408	0.195	Accept
Guinea-Bissau	−0.0768 **	0.026	Reject	−1.1069	0.110	Accept
Kenya	−0.0161 **	0.021	Reject	−0.8095 *	0.063	Reject
Liberia	−0.0125	0.347	Accept	−0.1377	0.305	Accept
Madagascar	−0.0991	0.278	Accept	−1.1444 *	0.080	Reject
Mali	−0.0152	0.365	Accept	−0.5295	0.284	Accept
Mozambique	−0.0170	0.336	Accept	−0.3214	0.458	Accept
Malawi	−0.0209 *	0.099	Reject	−1.2859 **	0.041	Reject
Namibia	−0.0062	0.384	Accept	−1.4953 **	0.028	Reject
Niger	−0.0099	0.770	Accept	0.0870	0.883	Accept
Nigeria	−0.0145 *	0.076	Reject	−1.4322 **	0.020	Reject
Senegal	−0.0173	0.604	Accept	−0.7238	0.237	Accept
Sierra Leone	−0.0327 *	0.068	Reject	−0.2412	0.756	Accept
Togo	−0.0178	0.193	Accept	0.2179	0.808	Accept
Tunisia	−0.0562 **	0.031	Reject	−1.2493 *	0.073	Reject
Tanzania	−0.0115	0.215	Accept	−0.4628	0.186	Accept
Uganda	−0.0057	0.497	Accept	−1.0302	0.176	Accept
South Africa	−0.0294	0.226	Accept	−1.3447 **	0.024	Reject
Congo, D Rep	0.0024	0.860	Accept	0.2144	0.608	Accept
Zambia	−0.0023	0.670	Accept	−1.3716	0.157	Accept
Zimbabwe	−0.0050	0.861	Accept	−1.2398 ***	0.002	Reject
Panel Result	4.6218 ***	0.000	Reject	7.8953 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5%, and 10% significant levels, respectively.

This study examined the causal relationship between positive shocks in globalisation, signifying an increase in the absorption of globalisation, and negative shocks in informality, indicating a decrease in the size of the informal sector. These findings are validated in a sample of African countries consisting of Ethiopia, Gambia, Guinea-Bissau, Kenya, Malawi, Niger, Nigeria, Sierra Leone, Togo, Uganda, Congo, and Zimbabwe, as indicated in Table 10. From an economic perspective, this implies that when positive shocks in globalisation occur, such as an increase in globalisation absorption, there tends to be a negative response in informality within these economies, resulting in a reduction in the size of the informal sector. This suggests that a more globally integrated economy is associated with a decline in informal economic activities in these countries. The presence of a nonlinear and asymmetric causal relationship suggests that an increase in globalisation absorption may be accompanied by policies, economic conditions, or regulatory changes that contribute to a reduction in the size of the informal sector.

Alternatively, the study explores the causal relationship between positive shocks in informality, indicating an increase in the size of the informal sector, and negative shocks in globalisation, suggesting a decrease in the adoption of globalisation, in a selected group of African countries, including Angola, Congo, Cote d'Ivoire, Ghana, Gambia, Guinea-Bissau, Mali, Malawi, Namibia, Tanzania, Uganda, Congo DR, and Zimbabwe. The results indicate

that when positive shocks in globalisation occur, such as an increase in globalisation absorption, in these African economies, there is a negative response in informality, indicating a decrease in the size of the informal sector. This suggests a potential association between a more globally integrated economy and a decrease in informal economic activities. It also suggests that an increase in globalisation absorption could be linked to policies, economic conditions, or regulatory changes that result in a reduction in the size of the informal sector. The robustness of these findings is further supported by additional analyses using economic globalisation, presented in Tables 12–15.

Table 15. Granger causality results for economic globalisation–informality nexus.

Economic Globalisation (+) Does Not Granger Informality (−)				Informality (+) Does Not Granger Cause Economic Glob (−)		
Countries	Wald Stat	Prob.	Decision	Wald Stat	Prob.	Decision
Angola	−0.0168	0.467	Accept	−0.8531 **	0.049	Reject
Burkina Faso	−0.0079	0.473	Accept	−1.0178	0.166	Accept
Cote d'Ivoire	−0.1477 ***	0.005	Reject	−1.4788 *	0.073	Reject
Cameroon	−0.0164	0.110	Accept	−1.9799	0.121	Accept
Congo, Rep	−0.0355	0.268	Accept	−0.9230 **	0.016	Reject
Ethiopia	−0.0250 **	0.016	Reject	−0.4650	0.153	Accept
Gabon	−0.1629 ***	0.000	Reject	−0.4679 **	0.050	Reject
Ghana	−0.0195	0.230	Accept	−5.1923 ***	0.002	Reject
Guinea	−0.0184	0.120	Accept	−1.2633	0.498	Accept
Gambia, The	−0.0776 *	0.057	Reject	−0.9861 **	0.013	Reject
Guinea-Bissau	−0.0176	0.208	Accept	−0.5554	0.323	Accept
Kenya	−0.0293 **	0.024	Reject	−1.9754	0.201	Accept
Liberia	−0.0918	0.275	Accept	−0.6401	0.816	Accept
Madagascar	−0.0714 *	0.090	Reject	−0.5027 **	0.043	Reject
Mali	−0.0044	0.778	Accept	−1/2478 **	0.038	Reject
Mozambique	−0.0094	0.269	Accept	−1.1811 **	0.031	Reject
Malawi	−0.0391 **	0.050	Reject	−1.5419 *	0.091	Reject
Namibia	−0.0282	0.115	Accept	−1.8229 *	0.098	Reject
Niger	−0.0810 **	0.023	Reject	−0.9191 **	0.029	Reject
Nigeria	−0.0139 *	0.096	Reject	−1.1500	0.139	Accept
Senegal	−0.0248	0.359	Accept	−0.3448	0.258	Accept
Sierra Leone	−0.0314 ***	0.004	Reject	−0.7127	0.215	Accept
Togo	−0.0321	0.133	Accept	0.7845	0.253	Accept
Tunisia	−0.0392	0.244	Accept	−0.2310	0.694	Accept
Tanzania	−0.0412 *	0.068	Reject	−2.6393 **	0.036	Reject
Uganda	−0.0486 ***	0.010	Reject	−2.8487 **	0.031	Reject
South Africa	−0.0063	0.671	Accept	−0.5225	0.468	Accept
Congo, D Rep	−0.0129	0.264	Accept	−0.5180	0.272	Accept
Zambia	−0.0466 *	0.080	Reject	−0.3041	0.750	Accept
Zimbabwe	−0.0347	0.201	Accept	−0.5999 *	0.080	Reject
Panel result	9.10.7819 ***	0.000	Reject	8.7306 ***	0.000	Reject

Note: ***, **, and * represent 1%, 5% and 10% significant levels, respectively.

4. Conclusions and Policy Recommendations

The present study examined the causal relationship between informality and globalisation across 30 African countries. Departing from previous research that assumes a linear causality and examines the impact of globalisation on informality from a unidirectional standpoint, this study adopted a bi-directional framework to address reverse causation. To achieve this objective, the study employed the DH causality method within a linear and nonlinear framework. The findings indicate that the causal relationship is not linear, but rather explained adequately within a nonlinear asymmetric causal structure. Based on these findings, the following policy recommendations are put forth:

For the countries where causality is observed to run from globalisation to informality, namely Angola, Congo, Guinea, Gambia, Mozambique, Sierra Leone, Tunisia, Tanzania, Uganda, Zambia, and Zimbabwe, the following recommendations are suggested: Firstly,

these countries should formulate policies aimed at integrating the informal sector into the formal economy. Recognizing the role of the informal sector in absorbing labour and providing employment opportunities, these policies should concentrate on facilitating the transition of informal businesses into the formal economy, ensuring that they can benefit from legal protections and access formal financial systems.

Secondly, these countries should implement skills development and training programs tailored to the requirements of the informal sector. By improving the adaptability of informal businesses through relevant skills and training, individuals and businesses can seize the economic opportunities generated by globalisation and effectively navigate changing market dynamics. Thirdly, it is recommended that these economies establish support mechanisms specifically designed for entrepreneurship and small businesses. This would create an environment that fosters entrepreneurship and facilitates the growth of small businesses. Such mechanisms can include providing access to financing, offering mentorship programs, and simplifying regulatory procedures to aid in the formalisation of informal businesses.

Additionally, it is proposed to develop social safety nets to assist individuals in the informal sector during times of economic transition. Enhancing market access and infrastructure for informal businesses and implementing effective monitoring and regulation systems for this sector are also crucial steps to take. Furthermore, efforts should be made to promote education and awareness regarding the benefits and challenges of globalisation. Encouraging international cooperation and partnerships can enable informal businesses to participate in global value chains. Lastly, investing in data collection and conducting research on the informal sector will contribute to a better understanding of its dynamics. This article presents a set of recommendations aimed at harnessing the positive aspects of the informal sector's response to globalisation, while also addressing potential challenges. Adherence to these recommendations is crucial for policymakers who seek to promote sustainable and inclusive economic development, as it calls for tailoring them to the unique economic, social, and cultural contexts of each country.

Moreover, the article proposes investing in initiatives aimed at enhancing market access for informal businesses as a key policy. This strategy involves improving infrastructure, connectivity, and digital platforms to facilitate the connection between informal businesses and larger markets. By expanding the reach and opportunities available to informal businesses, this approach amplifies the positive impact of the informal sector on globalisation.

Additionally, it stresses the importance of implementing skills development programs specifically designed to cater to the needs of the informal sector. Such programs would enhance the adaptability of individuals engaged in informal businesses by equipping them with relevant skills and training. This, in turn, enables them to effectively respond to changing market dynamics and contributes to increased global competitiveness. Policymakers are encouraged to customize these policy recommendations based on the specific economic, social, and cultural contexts of their respective countries to ensure comprehensive and sustainable economic development.

To mitigate the negative effects of shocks in globalisation and convert them into positive outcomes for informality, the article suggests policy measures aimed at building resilience within the informal sector. These policies recognize the role of the informal sector as a safety net during economic downturns and propose support mechanisms for individuals transitioning from the formal to the informal sector. This support includes initiatives such as skill development opportunities, access to resources, and financial assistance during challenging economic periods.

Furthermore, the article advocates for the establishment of social safety nets to aid during the transition from the formal to the informal sector in times of negative shocks caused by globalisation. This policy acknowledges that economic downturns resulting from the negative effects of globalisation can result in job losses in the formal sector. To aid individuals seeking employment in the informal sector, safety-net programs should be

developed to provide temporary support, including unemployment benefits, retraining programs, and healthcare. Furthermore, it is imperative for these economies to enact flexible labour policies and training initiatives that facilitate transitions between formal and informal employment. Recognizing the dynamic nature of employment patterns during economic shocks, policies that allow for flexibility in employment arrangements and provide relevant training can empower individuals to adapt to changing economic conditions. These measures aim to address the uneven response of the informal sector to positive and negative shocks caused by globalisation. Through the implementation of targeted policies, governments can enhance the resilience of the informal sector and support individuals in navigating economic challenges, thereby contributing to overall economic stability and inclusive growth.

Lastly, in relation to the causal relationship between positive shocks in globalisation and negative shocks in informality, which suggests that an increase in globalisation is associated with a reduction in the size of the informal sector, three policy recommendations are proposed. Firstly, it is advised that these economies implement incentives and support programs to encourage the formalization of informal businesses. Such policies acknowledge the potential benefits of a more globally integrated economy with a formalized economic structure. Incentives such as tax breaks, simplified regulatory processes, and improved access to financial services should be provided to encourage informal businesses to transition to the formal sector. Secondly, these economies should invest in skills development programs that align with the demands of formal employment sectors. The reduction in the size of the informal sector may indicate a shift towards formal employment opportunities.

Therefore, it is crucial to enhance the employability of individuals by offering training programs that match the skill requirements of formal sectors, thus facilitating a smoother transition from informal to formal employment. Lastly, it is recommended that these economies develop and implement economic diversification strategies to create formal job opportunities. This is because an increase in globalisation is often associated with the growth of formal sectors. The implementation of strategies that diversify the economy, with a focus on industries capable of absorbing labour from the informal sector, such as technology, manufacturing, and service sectors that are in line with global economic trends, can pave the way for the creation of formal jobs. These policy recommendations seek to harness the potential advantages of heightened globalisation by advocating for formalization, harmonizing skills training with the requirements of formal employment, and fostering economic diversification. Policymakers should consider the distinct economic, social, and cultural circumstances of each nation to effectively tailor these recommendations and foster inclusivity. This study was limited to the selected African countries and depended on data availability. It is advisable to include evidence from other African countries as more data become available. Similarly, incorporating evidence from other continents, such as Asia and Europe, is recommended for future studies. Also, another measure of informality is advised for further evidence.

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Is There a Link between Tax Administration Performance and Tax Evasion?

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Abstract: The performance of tax administrations (TAs) is usually described as their capacity to complete activities with the minimum of resources engaged. Accordingly, tax administration performance is a multifaceted phenomenon, and measuring and benchmarking its performance against other countries or regions remains a puzzle for researchers and practitioners. This paper introduces a new approach for measuring tax administration performance using the Composite I-Distance Indicator (CIDI) based on 11 individual performance measures from 35 European tax administrations over two consecutive years (2018–2019). For the given scores of tax administrations, we conducted a correlation analysis with (a) tax evasion loss and (b) the fiscal deficit of countries in which these tax administrations operate, aiming to assess the strength of the statistical relationship between these variables. The study highlights Denmark and the Netherlands as exemplary models for tax administration, with "Revenue Collection" being identified as a crucial driver of excellence and "Operational Performance" (such as "e-filing" and "on-time filing") forming critical aspects of TA efficiency. Also, the study finds a negative correlation between tax avoidance and tax administration performance.

Keywords: tax administration; performance measurement; composite indicators; Europe

1. Introduction

The performance of tax administrations (TAs) is usually described as their capacity to complete activities with the minimum of resources engaged (Savić et al. 2015). As inferred by OECD (2011), tax administration performance depends on its internal organizational structures, allocated budgeted funds to meet new or changed priorities, utilization of novel ICT initiatives to reduce costs, and the capacity of its staff.

Accordingly, tax administration performance is a multifaceted phenomenon, and measuring and benchmarking its performance against other countries or regions remains a puzzle for researchers and practitioners (Arltová and Kot 2023; Belmonte-Martin et al. 2021). Many attempts have been made to measure the performance of tax administrations (Cordero et al. 2021; Crandall 2010; Aktaş 2023; Nguyen et al. 2020). Moreover, in the last few decades, an enormous amount of research has been carried out to explain, examine, and measure the performance of TAs (Gerritsen 2023). However, scant attention has been paid to creating any comprehensive, multiple performance measures of tax administration that could be used to measure the relative performance of tax administrations between and among countries.

Previous attempts to measure the performance of tax administrations have been either idiosyncratic or overly biased in subjective judgments, making them highly judicious and speculative. We aim to fill the lacuna in the present body of knowledge by creating a comprehensive and unbiased score for tax administration performance. The framework we proposed is rooted in the concept algorithmic governance. Algorithmic governance allows for human-free decision making, or, in our case, human-free country rankings. Our approach is based on a neutral, data-driven aggregation of individual measures into

a comprehensive performance index based on a Composite I-Distance Indicator (CIDI) methodology. Concurrent literature offers a myriad of different neutral, data-driven aggregation techniques based either on statistical or machine learning approaches (Milosavljević et al. 2023a). However, these approaches are complex with hard-to-understand black boxes. The main rationale behind the selection of the CIDI as a methodology is its simplicity. Alongside the main aim, we explored the relationship between TA performance and tax avoidance.

The specific goals of our study are as follows:

1. Compare the performance of TAs across the dataset of selected European tax jurisdictions and isolate the one that can serve as a role model;
2. Examine the most critical driver of tax administration and where the most energy, planning, and resources should be invested;
3. Examine the correlation between TA performance and tax evasion, building upon the prior works showing that, even if tax administrations improve their operations, there are exogenous factors inflating different irregularities, including tax avoidance;
4. Examine the relationship between TA performance and fiscal deficit, building upon the work of Cowx et al. (2022), which shows that, when governments incur large fiscal deficits, firms avoid more taxes because they perceive that the enforcement capability of the tax authority is undermined.

To our knowledge, a study of this kind has never been conducted before. The same class of problem has already been approached in a recent survey by Milosavljević et al. (Milosavljević et al. 2023a). However, the rankings obtained from this study are based on the machine learning algorithm as described in Milosavljevic et al. (2021). It is noteworthy to mention that the CIDI methodology has been vastly used in recent studies related to the efficiency of public administration (Maricic et al. 2019; Milosavljević et al. 2019). However, it has never been applied to the analysis of tax administration performance.

Our study is motivated by the practical need to create a universal approach to measuring the performance of a very important societal structure—tax administration. Following the ideals of the New Public Management (Kostic et al. 2013), measuring the performance of public administration in an effective manner is vital for policymaking purposes (Brignall and Modell 2000).

Our paper contributes to the extant body of knowledge in several ways. First, we isolated 'the polar star', a tax administration that can serve as a benchmark in further studies on the efficiency, effectiveness, or different method of performance of tax administrations, a goal that has been highly valued by policymakers and scholars (Vázquez-Caro and Bird 2011). Our results show that the role model tax administration is Denmark (with SKAT as the central tax authority of Denmark). The 'first runner-up' in our analysis was the tax administration of the Netherlands. The results are the same for both observed years. Accordingly, the main contribution of our study is a data-driven neutral ranking. Second, we show that Value Revenue Collected is the most important group of performance drivers for efficient tax administration. Additionally, the results show that, over the two observed years, e-taxation has become more important. In contrast, human resources have become a less important determinant of the overall performance of tax administrations. Third, this study provides a novel approach to measuring the performance of tax administrations and accordingly allows for ex post analyses of public policies related to taxation. Finally, we find that our rankings have a statistically significant positive relationship with the fiscal deficits of the observed countries.

The remainder of this paper is organized as follows. The next section presents a brief literature review of tax administration and the concept of algorithmic governance. Section 3 explains the methodology of this study, outlining the analytical framework used to rank the TAs and the data sources. Section 4 shows the study results based on the CIDI methodology. Section 5 contextualizes the study findings, elaborating on key findings, contributions, and implications. Section 6 is reserved for the concluding remarks—the novelties of the approach, limitations, and further recommendations.

2. Literature Review

In this section, we first provide a literature review on the concept and importance of tax administration performance. Afterwards, we provide an explanation of the background concept for the analytical framework—algorithmic governance.

2.1. Tax Administration Performance

Efficient tax administration is crucial for economic growth and development, as it ensures that taxes are collected effectively, funds are appropriately allocated, and public services are adequately provided (Evans 2001). Even when the tax rates are high and tax perception leans towards viewing taxation as a burden, efficient tax administrations can lead towards the optimal collection of public funds (Mohammed and Tangl 2023).

The definition of efficient tax administration is still vague, and no unanimous and standardized definition of such efficiency exists. Efficiency in tax administration can be understood as the ability to collect taxes effectively, allocate funds efficiently, and provide public services adequately. This critical role of tax administration in economic and societal development has prompted the focus on measuring and improving its efficiency. However, a universally accepted definition of efficiency in tax administration is yet to be established.

Despite the lack of a standardized definition, the significance of efficient tax administration cannot be overstated. Studies have highlighted its role in stabilizing revenue generation, minimizing tax gaps, and optimizing public revenues. These approaches, while important, may not fully address the potential for enhancing taxation efficiency through improvements in tax administration performance (Taufik 2018).

In the European context, there has been a vivid debate on which tax administration has been the best-performing one. Factors such as the use of technology, organizational capacity, administrative efficiency, and the ability to reduce tax evasion have been identified as key drivers for the performance of European tax administrations (Okunogbe and Santoro 2022). Some countries have been marked as highly efficient in tax administration, such as Estonia, which has a fully digitalized tax system and efficient online services for taxpayers. Also, Nordic countries were categorized as efficient due to their effective use of technology, high administrative capacity levels, and low tax evasion rates (Hanna and Olken 2019). Conversely, some European countries, particularly new EU member states, have been criticized for their inefficient tax administration, characterized by bureaucratic processes, limited use of technology, and high levels of tax evasion. This is mainly attributed to the lack of political will, inadequate resources, perceived corruption, and ineffective governance structures (Ponomariov et al. 2017).

2.2. The Background Concept of Algorithmic Governance

The idea and the concept of algorithmic governance are only a decade old, although the roots and the idea have been present for much longer (D'Agostino and Durante 2018). The concept refers to the use of algorithms, computational models, and automated decision-making processes in the management and regulation of various aspects of society. At this point, it should be noted that we do not advise absolute automation in decision-making processes, as they can lead to a number of pitfalls (Sanchez-Graells 2024).

This concept is particularly relevant in the context of modern digital technologies and the increasing reliance on algorithms to inform or automate decision making in areas such as government, business, and social institutions. Algorithmic governance involves the use of algorithms to make decisions that were traditionally made by humans. These decisions can range from simple tasks, such as sorting and filtering data, to more complex decisions like resource allocation, policy enforcement, and risk assessment (Janssen and Kuk 2016). The system critically depends on data analysis to drive decision making. Extensive datasets are systematically analyzed to identify underlying patterns, trends, and correlations, which can subsequently inform predictive modeling or process optimization.

For the purpose of our study, the value-neutral weighting of policy choices is a particularly relevant feature of algorithmic governance. From a philosophical point of view,

value-neutral strategy is restricted to data and decision outcomes, thereby omitting internal value-laden design choice points (Katzenbach and Ulbricht 2019). Traditional systems (such as the World Bank Ease of Doing Index, for instance) rely heavily on the subjective weighting of idiosyncratic performance measures. The algorithmic approach, however, allows for very efficient and expert-free, neutral decision making.

When such a concept is applied to tax administration performance measurement, it allows for the expert-neutral ranking of countries in terms of the efficiency of their tax administrations. The use of algorithms in governance has several potential benefits, including increased efficiency, objectivity, and consistency in decision-making processes (Gritsenko and Wood 2020).

3. Materials and Methods

This section explains the data sources used for the analysis, the analytical framework based on the CIDI methodology, and data preparation, emphasizing normalization.

3.1. Data Sources

The main source of data comes from the OECD "The International Survey on Revenue Administration" (ISORA) database (OECD 2019), a specialized database that covers many indicators related to tax administration outcomes. Crandall et al. (2021) infer that this database's main purpose is to provide reliable and comparable indicators for tax administration efficiency. The OECD's statistical products, in general, are thought to be of excellent quality and reliability, and the ISORA data are no different. The survey uses defined procedures and stringent quality controls to ensure accuracy and consistency. One of the strengths of the ISORA is its comprehensive coverage of tax administration practices across tax jurisdictions, including both OECD member countries and non-member countries. This allows for comparisons and the benchmarking of tax administration performance across various jurisdictions.

We retrieved the data from the ISORA database and filtered them for the missing values. Accordingly, we used only data for two consecutive years (2018–2019), since most of the tax administrations had complete data included for these two years. The other important reason for using only these two years in the analysis are the changes in the structure of indicators in the ISORA database. Using a different set of indicators might jeopardize any intertemporal comparability in the rankings. Following the recommendations given in Milosavljević et al. (Milosavljević et al. 2023a), some data were retrieved as original (when the indicators were presented as relative measures), while some were transformed into ratios to provide a sound basis for cross-tax-administration comparison. A detailed explanation for the retrieved and computed (calculated) indicators is given in Table 1.

To further explain the logic of the use of these indicators, we provide detailed explanations for (1) retrieving original or recalculating some indicators and (2) for the use of this set of indicators.

The logic of retrieving the first three indicators is grounded in their relative value, thus being comparative among the observed tax administrations no matter if the tax administration is large or small. The remainder of the indicators has been recalculated to the relative rather than absolute numbers so not to allow for large differences among the observed tax administrations. Another option could be the use of natural logarithms. However, even then, the difference between tax administrations (for instance, Germany and Albania) would have been large.

As for the use of this specific dataset, our logic was straightforward. ISORA is by far the most frequently used dataset to benchmark tax administration performance across the globe. This dataset has been agreed upon by the following five large international organizations: the International Monetary Fund (IMF), the Asian Development Bank (ADB), the Inter-American Center of Tax Administration (CIAT), the Intra-European Organization of Tax Administrations (IOTA), and the Organization for Economic Co-operation and

Development (OECD). Furthermore, it has been empirically confirmed that these measures of operational excellence positively affect the tax efficiency of a country (Chang et al. 2020).

Table 1. Tax administration performance indicators.

Group	Indicators	Abbrev.	Type	Explanation
Value of revenue collected	Revenue collected to total government revenue	REV1	Original	(Total net revenue collected—VAT gross import)/Total government revenue
	Revenue collected to GDP	REV2	Original	(Total net revenue collected—VAT gross import) × 100/GDP
	Tax collected excluding SSC to GDP	REV3	Original	(Total net revenue collected—VAT gross import—Nontax revenue—Social security) × 100/GDP
	FTE per 10,000 citizens	RES1	Calculated	Total staff measured as Full-Time Equivalent over 10.000 citizens within the tax jurisdiction
Resources and staff indicators	ICT Intensity Index	RES2	Calculated	ICT operating costs divided by Staff cost of tax administration
	Hiring to Attrition Index	STAFF1	Calculated	Hiring rate [recruitments]/Attrition rate [departures] by FY
	Staff Experience Index	STAFF2	Calculated	Experience of staff measured by weighted number of years spent at tax administration
	Staff Education Index	STAFF3	Calculated	Previous education of staff working for tax administration
Operating performance, arrears, and auditing	Average on-time filling rate	OE1	Original	Average percentage of on-time filling for CIT, PIT, PAYE, and VAT
	Average e-filling	OE2	Calculated	Average percentage of e-fillings for CIT, PIT, PAYE, and VAT
	Average on-time payment rate	AA1	Calculated	Average percentage of the on-time payment for CIT, PIT, PAYE, and VAT

Note: VAT: value-added tax, CIT: corporate income tax, PIT: personal income tax, SSC: social security collection, PAYE: pay as you earn, FTE: full-time equivalent.

As for the indication of tax avoidance, we selected the data provided by the Tax Justice Network. Specifically, we used the State of Tax justice (SOTJ) dataset, from which we retrieved the Tax Avoidance Loss indicator. Since this indicator is given as an absolute number, we used natural logarithm (ln) to normalize its value. Finally, for the indication of fiscal deficit, we used IMF statistics (Fiscal Monitor datasets).

3.2. Analyzed Countries (Units of Observations)

We selected 35 tax administrations from the list of European countries which participated in the ISORA survey: Denmark, the Netherlands, Slovenia, Finland, Norway, Latvia, the United Kingdom, Portugal, Belgium, Russia, Ireland, Austria, Estonia, Sweden, Poland, Israel, Czechia, Georgia, Lithuania, Greece, Bulgaria, Croatia, Serbia, Albania, Slovakia, France, Iceland, Montenegro, Armenia, Spain, Moldova, Italy, Cyprus, Turkey, and Switzerland. These tax administrations were filtered from the full list of European countries when missing values were taken into consideration.

These countries show some elements of similarity and convergence. However, they differ in terms of the historical roots (Menjot et al. 2022), as well as efficiency and outputs (Pîrvu et al. 2021). More importantly for the purpose of this paper, these administrations differ in the selection of preferred performance measures related to tax administration (van Stolk and Wegrich 2008).

3.3. Analytical Framework for the Composite I-Distance Indicator (CIDI)

To create a single indicator adequate to rank the economies for which we measure the tax administration performance, we propose the Composite I-Distance Indicator (CIDI) methodology. The CIDI methodology is based on the I-distance methodology developed by Ivanovic in the 1970s (Ivanovic 1973; Ivanovic 1977; Ivanovic and Fanchette 1973). Both methodologies, the I-distance and CIDI, are characterized by the fact that they are unbiased. The majority of composite indicators are created from the subset of individual indicators, which are weighted according to the specific methodology. In most cases, they require opinions from experts, making them biased. The CIDI methodology forms a composite indicator created from the subset of individual indicators that are given data-driven rather than expert-driven weights. This objectiveness of the method is the main precedence of the procedure, which is why we propose the CIDI methodology for measuring tax administration performance.

To further elaborate on the methodology, we will first describe the I-distance methodology in detail. The I-distance methodology calculates the distances between the observed entities in the research concerning the single one chosen as the reference entity (Išljamović et al. 2015; Jeremic et al. 2011). According to Ivanovic, it is more suitable to use the squared I-distance if the number of selected variables is large, so we do not lose the influence of lower-ranked variables, or if all of the variables are not of the same direction, so negative correlation coefficients and negative partial correlation coefficients may occur.

The squared I-distance, also known as squared Ivanovic distance (Ivanovic 1973; Ivanovic 1977), is presented with the following formula (Ivanovic and Fanchette 1973):

$$D^2_{s,w} = \sum_{i=1}^{k} \frac{d_i^2(s,w)}{\sigma_i^2} \left(1 - r_{i.12...j-1}^2\right) \tag{1}$$

In the formula, D^2 represents the squared I-distance measure between two observed entities, e_s and e_w, while s and w are the indices of these two observed entities, e_s and e_w. The measure $d_i(s,w) = x_{is} - x_{iw}$ represents the distance between the values of the individual indicator X_i, one of the k indicators, $i = 1 \ldots k$, and for entities $e_s = (x_{1s}, x_{2s}, \ldots x_{ks})$ and $e_w = (x_{1w}, x_{2w}, \ldots x_{kw})$. The variance σ_i^2 is the variance of the individual indicator X_i. Further, $r_{i.12 \ldots j-1}$ is a partial correlation coefficient between the individual indicators X_i and X_j, where $j < i$ (Dobrota et al. 2012).

The squared I-distance measure can also be used to rank the observed entities unbiasedly. However, it may suffer from weaknesses, since it is not transparent and its values are harder to explain and comprehend, especially compared to other composite indices. This is why we propose a Composite I-distance Indicator (CIDI) based on I-distance. The CIDI approach is a methodology that creates a synthesized indicator from a list of separate indicators (in this case, the list of indicators given in Table 1), which is transparent and easier to comprehend.

To obtain the CIDI, after the squared I-distance is calculated, we can calculate the correlation coefficients between the I-distance values and each individual sub-indicator in the methodology (Milosavljević et al. 2019). These correlation coefficients are mainly positive analogously to the squared I-distance methodology. If, in rare cases, the correlation coefficient fabricates as negative, they are then scaled from 0 to their maximum value.

The CIDI weights of any given composite indicator are constructed by weighing the above empirical correlations. Specifically, the values of the correlations are divided by the sum of the correlations, thus creating a CIDI weighting system. These are the data-driven aspects that are responsible for building large or small weights for the sub-indicators. The idea behind the principle comes from the particular feature of the I-distance

method, which is that it can determine the relevance of individual indicators (Jeremic and Jovanovic-Milenkovic 2014). As a result, the CIDI weights are obtained as follows:

$$w_i = \frac{r_i}{\sum\limits_{j=1}^{k} r_j} \tag{2}$$

Here, r_i, $i = 1 \ldots k$ represents the Pearson correlation between the individual indicator X_i and the squared I-distance value. In the described methodology, instead of predefining the values of weights in a biased manner, the CIDI is based on a methodological and statistical concept defined by the squared I-distance method (Milosavljević et al. 2019).

The specific feature of the CIDI is its independence from any expert opinions and viewpoints. It rather relies on the given data. Many global composite indicators are criticized, particularly for using the sub-indicator weights created by experts in the field. Those weights may suffer from shortcomings such as the bias or prejudice of the artists behind the methodologies. Moreover, the indicators are often not even examined by experts, but instead simply given equal weights.

As noted, the CIDI creates an aggregated index using weights that are data-driven rather than expert-driven (Dobrota et al. 2016). It extracts the weights from the derived data (Dobrota et al. 2015b). The CIDI is accordingly widely applicable to any ranking methodology where one wants to overpower the impact of bias.

In the final step, we conducted a correlation analysis (2-tailed Spearman correlation test) to measure the existence and the strength of the relationship between the TA performance and tax avoidance.

The summary and the graphical display of the analytical framework used in this study are given in Figure 1.
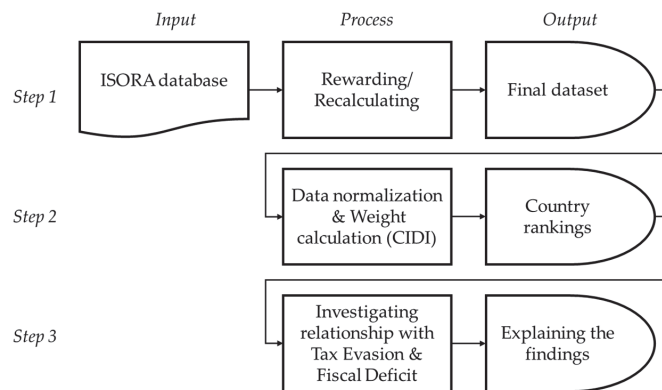
Figure 1. Graphical diplay of the analytical framework.

3.4. Data Preparation

To calculate the total score of the observed economies for which we measured the tax administration performance, we needed to prepare the data in terms of normalization. To do so, we used min–max normalization, where we rescaled the range of all individual indicators, given in Table 1, to scale the range in [0, 100]. In addition, the CIDI methodology proposes the additive data aggregation model, which was applied to normalized individual indicators.

4. Results

This section first explains the pre-analysis—how we obtained weights for the individual performance measures using the CIDI methodology—and, later, the main analysis—the ranking of the tax jurisdictions.

4.1. Pre-Analysis

We first created a set of data-driven weights for the distinctive set of sub-indicators based on the CIDI methodology. The novel weighting scheme, calculated according to formula 2 (Section 3.3), is given in Table 2. The weights are given as decimals, but, in essence, they present the percentages of importance for the sub-indicators. Since the method is cross-sectional, the weights were obtained for two consecutive years, 2018 and 2019. The largest weight for FY2018 was obtained for the three indicators related to the Value of Revenue Collected (REV1 = 11.5%, REV2 = 14.1%, and REV3 = 14.7) and for one indicator from the group of Resources and Staff Indicators (RES1 = 13.8%). They maintained the same level of relevance in 2019, but their importance shrunk over the observed period. When we observe the change, the results show that Operational Efficiency (particularly OE2, with a positive change of 70.97%) has risen in importance.

Table 2. CIDI indicators' weights.

VarCode	Variable	Weight 2018	Weight 2019	Year-on-Year Difference		% Change	
REV1	Revenue collected to total government revenue	0.115	0.101	↓	−0.014	↓	−12.17%
REV2	Revenue collected to GDP	0.141	0.134	↓	−0.007	↓	−4.96%
REV3	Tax collected excluding SSC to GDP	0.147	0.144		−0.003	↓	−2.04%
RES1	FTE per 10,000 citizens	0.138	0.137		−0.001		−0.72%
RES2	ICT Intensity Index	0.094	0.102		+0.008		+8.51%
STAFF1	Hiring to Attrition Index	0.110	0.078	↓	−0.032	↓	−29.09%
STAFF2	Staff Experience Index	0.002	0.003		+0.001	↑	+50%
STAFF3	Staff Education Index	0.027	0.017	↓	−0.01	↓	−37.04%
OE1	On-time filling rate	0.068	0.087	↑	+0.019	↑	+27.94%
OE2	Average e-filling	0.062	0.106	↑	+0.044	↑	+70.97%
AA1	Average on-time payment rate	0.095	0.091		−0.004	↓	−4.21%

Legend: ↑ increase higher than 1%; ↓ decrease gigher than 1%.

4.2. Main Analysis

After obtaining the weights, we analyzed the performance of 35 tax administrations for two consecutive years. The results are given in Table 3. The results in the table display the obtained value for each tax administration, the rank for a specific year, and the relative change in the difference in ranks. The obtained values range from 0 to 100, while the tax administrations are ranked from the largest to the smallest value.

Table 3 shows that the Danish tax authority held the first place in both observations. The Netherlands held second place. The difference to the second place is relatively high (the Relative Efficiency Score calculated as a relation between the first and the second place was 1.254 and 1.169, respectively). This finding implies that Denmark's tax authority was 25.4 and 16.9% more efficient than its counterpart, holding the second position. The 'second runner-up' was changed—Norway replaced Slovenia in this position. The most significant decline in rank was attributed to Russia (from the 10th to the 22nd position), whilst the tax administration of Greece made the largest incline on the scale (from the 20th to the 11th position). The last place was reserved for Switzerland in both years.

Table 3. CIDI scores and CIDI ranks of the tax administration performance of selected European countries.

Tax Jurisdiction	2018		2019		Difference in Rank	
	Total	Rank	Total	Rank		
Denmark	80.693	1	80.587	1		0
Netherlands	64.346	2	68.943	2		0
Slovenia	61.424	3	62.588	4		−1
Finland	60.268	4	62.485	5		−1
Norway	58.977	5	63.591	3		+2
Latvia	53.741	6	56.290	10		−4
United Kingdom	53.675	7	57.121	6		+1
Portugal	53.601	8	56.861	7		+1
Belgium	53.462	9	56.383	8		+1
Russia	53.156	10	49.965	22	↓	−12
Ireland	53.041	11	56.306	9		+2
Austria	53.029	12	55.062	13		−1
Estonia	52.212	13	54.378	14		−1
Sweden	51.860	14	50.069	21	↓	−7
Poland	51.807	15	51.579	18		−3
Israel	51.659	16	53.367	16		0
Czechia	49.829	17	51.073	19		−2
Georgia	49.715	18	48.597	24	↓	−6
Lithuania	49.584	19	55.140	12	↑	+7
Greece	49.457	20	55.695	11	↑	+9
Bulgaria	49.341	21	53.555	15	↑	+6
Croatia	47.420	22	50.658	20		+2
Serbia	46.690	23	49.763	23		0
Albania	46.096	24	52.438	17	↑	+7
Slovakia	43.871	25	45.036	26		−1
France	41.725	26	44.315	27		−1
Iceland	40.889	27	48.355	25		+2
Montenegro	38.455	28	32.073	33		−5
Armenia	37.068	29	39.106	28		+1
Spain	35.313	30	37.634	30		0
Moldova	33.244	31	21.874	34		−3
Italy	32.888	32	35.654	32		0
Cyprus	32.881	33	38.489	29	↑	+4
Turkey	32.684	34	35.915	31	↑	+3
Switzerland	21.848	35	19.466	35		0

It should, however, be noted that the comparison between the two observed years has some limitations. First, this methodology is a cross-sectional rather than time-series analysis. Comparison between the two or many more years is, therefore, a discretionary, rather than continuous analysis. Second, sharp changes in the total ranking might be viewed as an imperfection of the CIDI methodology. Contrary to that, this is an upside of the methodology, as it augments the differences in the country rankings with smaller changes in the difference in individual indicators. Finally, comparison between the years is a demonstration of a 'clay pigeon' effect created with a ranking provided with this methodology. Improving only one performance indicator might not reflect on the overall score. Accordingly, tax administrations must improve the overall score.

When grouped into the quantiles (groups of five), we see that the 'Old Continent' was divided into the efficient north and the inefficient south (see Figure 2). As for Tier 1, six tax jurisdictions remained in this stratum in both years: Denmark, the Netherlands, Slovenia, Finland, Norway, and the United Kingdom, whereas Latvia was replaced by Portugal in 2019.
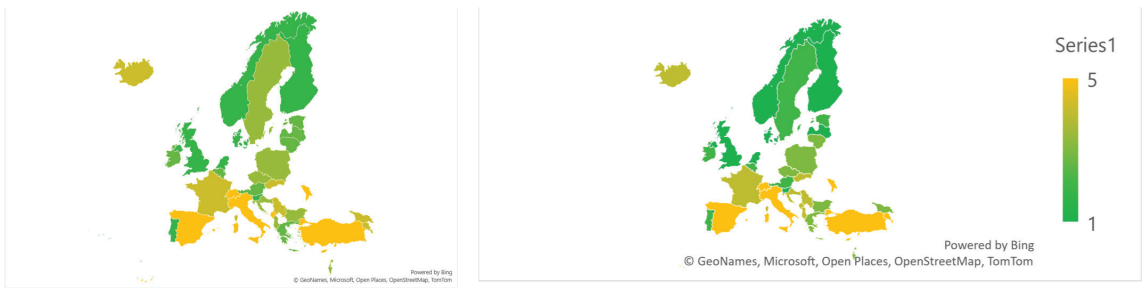
Figure 2. Heatmap for tax administration performance in 2018 (**left**) and 2019 (**right**). Notes: Russian Federation was excluded from the map for the clarity of presentation. This country was in Tier 2 and Tier 4 respectively.

Finally, we conducted a correlation analysis between the TA performance (CIDI-based scores) and tax avoidance for a single year. The results are presented in the following Table 4.

Table 4. Correlation matrix for the CIDI score and tax avoidance.

	Mean	**STD**	**1**	**2**	**3**
CIDI Score (2018)	48.170	19.084	1		
Ln SOTJ Tax Avoidance	10.877	2.789	0.175 **	1	
Fiscal Deficit	−0.452	2.268	0.130	0.414 *	1

Legend: * *p*-value < 0.01; ** *p*-value < 0.05.

As shown in Table 4, the relationship between our ranking and tax avoidance had the *p*-value (0.00) was below the traditional threshold of 0.05 (Milosavljević et al. 2023b), and we confirmed that there is a positive correlation between the two observed variables. It should be noted, though, that the strength of this relationship is rather small (b = 0.175). As for the relationship between our ranking and fiscal deficit, the *p*-value (0.013) was also below the standard threshold, but the strength of the relationship was modest (b = 0.414).

5. Discussion

This section contextualizes our findings by explaining the key findings, delineating the main contributions, and providing implications for scholars and practitioners.

5.1. Key Findings

This study offers a fresh approach to the objective ranking of the effectiveness of selected European tax administrations. This study assesses the overall performance of tax administrations over two years, 2018 and 2019. In both years, Denmark served as a "role model" for the tax administrations. Several explanations can be found for this finding. First, The Danish tax authority (SKAT) has invested significantly in cutting-edge technologies, such as data analytics, to enable effective and efficient tax collection and compliance procedures. The digitalization process is ongoing, with some aspects (i.e., legality and transparency) still being questioned (Fjord and Schmidt 2023). Considering the total tax burden of the Danish taxpayers, we were surprised by this finding. Other studies indicate that 'Danish taxpayers generally appear to be content with the situation', particularly when knowing that these funds are used to finance the Danish welfare system.

The 'first runner-up' in our analysis is the Dutch tax administration. Contrary to the central system in Denmark, the Dutch tax administration (Belastingdienst) is decentralized and complex. The system is highly digitalized, with even some reports on mismanaging algorithms for fraud detection in processing and storing personal information in a "blacklist" used to detect fraud (EDPB 2022).

The first tier is reserved for North and West European countries. Surprisingly, one tax jurisdiction from the 'New EU', Slovenia, has been ranked in the first tier. Although some studies point out that Slovenian tax administration requires a myriad of IT and procedurally related measures for further improvements (Ravšelj et al. 2019), the tax administration of Slovenia can be a 'small role model' for the countries that are behind the 'iron curtain'.

In both observed years, Switzerland served as the worst-ranked tax jurisdiction. The explanation for this phenomenon is that the Swiss tax system is highly complex, with 26 cantons having their own tax laws. Swiss fiscality offers profound diversity but comes with the price of complexity (Soguel 2019). It should be noted, however, that some tax jurisdictions were out of the scope of our analysis. Some studies find that the Swiss tax compliance burden (at least for businesses) is far lower than those of Germany or the USA (Braunerhjelm et al. 2021). These observations and discussions should be taken into account with a lot of precaution. This means that the specificity of national tax systems, the quality of law, rates, structure, computerization, and other factors should be more profoundly related to the purely quantitative findings of this study.

Finally, we confirmed that there is a positive relationship between the performance of TAs and tax avoidance. This finding might be puzzling, since it would be expected that the more efficient the tax administration, the lower the tax avoidance would be. However, this conundrum is similar to the strength of police forces and the crime in a country. The higher the first one, the higher the later one.

5.2. Contributions

This study adds to the developing body of knowledge on tax administration performance measurement in several ways.

First, different European tax jurisdictions have been pointed out as 'good examples' of tax administration performance. Our study finds that Denmark can be viewed as a role model for policymakers and researchers interested in tax administration performance analyses. Denmark was even anecdotally known for having a highly efficient tax administration prioritizing taxpayer service and compliance. This finding is aligned with the findings of Milosavljević et al. (Milosavljević et al. 2023a), who found that the Nordic countries generally outperform other European regions regarding tax authority efficiency. Contrary to this, some analyses, such as the one conducted by Athanasios et al. (2022), find that the 'tax administrations of Germany, Ireland, the Netherlands, Spain and the United Kingdom are the most decisive efficient units, forming the efficiency frontier.' In our analysis, Spain can serve as a 'bad example' rather than an efficient frontier. An explanation for the difference in results is the weight given to the indicators reflecting the efficiency of human resources in tax administration. By comparing Denmark to Spain, we can see that the SKAT (Danish tax authority) has a smaller workforce than the AEAT (Agencia Tributaria—Spanish tax authority) but has a decentralized organizational structure. However, this explanation is only judicious speculation requiring further in-depth examination.

Second, our findings prioritize Value Revenue Collected as the main group of drivers for the overall performance of TAs. Usual 'suspects' investigated in other studies are digitalization and the use of novel technologies (Faúndez-Ugalde et al. 2020; Martínez et al. 2022), and human resources and the culture of taxation (Chuenjit 2014; Radonić and Milosavljević 2019). Contrary to the findings of previous studies, we identified the variables in the operational excellence group (on-time filling and e-filling) as indicators that will drive excellence in the years to come. Consequently, investments in a modern and reliable IT infrastructure will be crucial for efficient tax administration. Simply put, automated systems will speed up processing times and reduce the risk of errors.

Third, our approach allows for changes in the weighting and overall ranking. Thus, it mitigates the potential risk of policy implementers' fast adherence to a previously defined output, as with stable-weight indices (such as the Ease of Doing Business Index).

Fourth, we also emphasize that the CIDI methodology used in this research is data-driven rather than biased. Although some authors would prefer that a weighting scheme

of composite indicators should reflect the intuitive and biased importance of the individual sub-indicators, our research is predominantly guided by the methods that advocate data-driven results, such as Data Envelopment Analysis (DEA) (Charnes et al. 1978; Milanović et al. 2022) or Distance-Based Analysis (DBA) (Dobrota et al. 2015a). Additionally, through the CIDI methodology, we provide a transparent composite indicator that is easily interpretable and comprehensive.

Fifth, this study contributes to a growing body of research that examines tax administration performance and tax avoidance. Contrary to other studies suggesting that simplifying tax systems and fortifying institutions (such as tax administration) inevitably leads to the decrease in tax avoidance, our study finds that (at least in the short term) institutional quality only pushes taxpayers (both corporate and individual) to be more prone to tax avoidance. Simply put, strong tax administrations will only create "stronger" tax optimization strategies.

This study directly contributes to the proliferation of machine learning and artificial intelligence in taxation studies in an indirect manner. Artificial intelligence can certainly have an even more direct effect on tax administrations than indicated in this study (Brynjolfsson and Unger 2023). Artificial intelligence may reduce the demand for labor, in which case, tax collection via income taxes may become an obsolete policy. Moreover, AI may increase the efficiency of the tax authority and reduce both tax evasion and tax avoidance. These two premises provide tension as to what is the direction of the overall effect. If labor income is irrelevant, then artificial intelligence is undermining tax collection. Conversely, if capital (especially artificial intelligence capital investments) is taxed, then artificial intelligence is ultimately increasing tax collection. Along these lines, tax administration performance plays a central role, insofar as an efficient tax authority is needed to adjust to different forms of taxation.

5.3. Implications

This study provides several valuable implications for both practitioners and scholars. As for the practitioners, the findings are significant for policymakers and implementors, regulators, and public administration analysts. The analytical framework described in this study allows for the ex ante analysis of tax administration-related policy. The most important implication is that this approach enables changes in the weights for individual factors without any expert-based bias. The more the policymakers work on individual performance measures, the less it becomes vital for the overall score. Accordingly, a tax system will never become atrophied in any sphere of performance. Policymakers in the tax administration realm should always consider clear tax policies and regulations, adequate staffing and training, efficient and streamlined processes, adequate IT support, and effective electronic services for taxpayers.

This study also sheds a new light on the relationship between taxation efficiency and countries' debt-to-GDP trends. In fact, even highly developed countries that have the benefit of capital markets regarding its sovereign debt as a "safe asset" (He et al. 2016), the consequences of a sovereign default are simply catastrophic (Govindarajan et al. 2023). Efficient tax collection policies can be a financing substitute for raising sovereign debt. Because of population aging and growing social inequality, it is unlikely that governments would be able to cut down on spending. Hence, to finance government spending, governments either need to raise sovereign debt or collect taxes more efficiently (or the classic Ricardian equivalence argument that suggests that larger spending increases expectations of future tax increases).

This study might be useful for scholars, as well. The field of tax administration performance measurement is a developing field with several approaches used so far (Dabla-Norris et al. 2020; Doiar et al. 2022; Pîrvu et al. 2021). Our approach, however, utilizes neutral aggregation based on empirical data to obtain a single performance measure. Thus, this approach can evaluate many other multi-criteria problems in public economics.

6. Conclusions, Limitations, and Further Recommendations

In this study, we analyzed the performance of 35 European tax administrations and created a unique and comprehensive performance measurement score for each tax administration. Rooting our analytical framework in the broad area of algorithmic governance, the score for each tax administration was obtained in a data-driven manner. By applying the CIDI methodology to rank the 'Old Continent tax administrations', we demonstrated that Denmark and the Netherlands are exemplary models for tax administration, with revenue collection being identified as a crucial driver of excellence and operational performances, such as e-filing and on-time filing forming critical aspects of future efficiency. Such methodology can benefit policymakers, public administration analysts, and other stakeholders interested in the efficiency of tax administrations.

The study has several restrictions that can jeopardize the generalizability of the findings. These are elaborated as follows.

First, it only employs a limited number of performance indicators for tax administration. A more comprehensive range of indicators should be considered in follow-up studies, particularly those pertaining to the effectiveness of internal processes, taxpayer expectations, segmentations, corruption, and other factors.

Then, this study uses information from 35 tax administrations in two consecutive years. Accordingly, this study is cross-sectional by nature and as such has some downsides typical for cross-sectional examinations (Radonić et al. 2021). Even though we provided results for two years in a row, this does not imply that the study is robust to time-varying factors. The analysis of time series and the use of larger samples might be advantageous for future investigations.

Next, due to the incomplete datasets utilized as input data, only a few performance metrics and observation units (tax administrations) are used. Additional studies could also include other performance measures. To name a few, follow-up studies could incorporate indicators depicting the service quality of tax administrations as public bodies (Milanović et al. 2019), or taxpayer convenience and the reduction in taxation costs (Saragih et al. 2022). Additionally. The inclusion of tax administrations outside 'the Old Continent' would additionally improve the benchmarking capacity of the ranking provided in this study.

Finally, the nature of this research is quantitative. From a broader perspective, every quantitative study fails to capture the in-depth characteristics of observed units (Milosavljevic et al. 2016). Accordingly, any profound discussion on the performance of tax administrations would require an in-depth analysis of every tax jurisdiction and its tax system. Some studies even find that different tax systems in Europe react in the same manner to any efficiency changes (Ottone et al. 2018), which could imply that our study extensively emphasizes slight differences between and among European tax administrations (somewhat similar to the Freud's explanation of the narcissism of minor differences). Following this, an avenue for further research is digging deep into the drivers and consequences of tax administration performance, which could be acquired through qualitative research.

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"Optimal Honesty" in the Context of Fiscal Crimes

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Abstract: This paper begins by contrasting the caricatures '*homo and femina economicus*' with '*homo and femina realitus*'. Against this backdrop, the paper considers three 'apparently falsified' empirical predictions of the standard expected utility model of individual decision-making concerning participation in fiscal crimes: that tax evasion and benefit fraud can be treated identically; fiscal crimes should be endemic; and that all individuals, depending on parameter values, should be either honest or dishonest. A utility function relating to decisions with a moral dimension is used to offer insight into the rationalization of the predictions and involves defining an individual's 'optimal honesty' in the context of fiscal crimes. The policy implications of the approach are briefly explored.

1. Introduction

Economists apply their 'cultural' perspective (Rubinstein 2008, p. 11) to almost all individual choices and actions. Such choices and actions could be influenced by a myriad of social, psychological and biological factors. Economists cut the Gordian knot of multiple potential competing analyses by adopting the Paretian value judgments and ascribing particular attributes to the unit of analysis—individuals. The preferences and capabilities of *homo and femina economicus* are the focus. This 'representative' individual is described as: (i) 'rational'; (ii) egoistic; (iii) with egoism predicated on self-interest narrowly defined in terms of income or wealth (Brennan and Lomasky 1993). Armed with this caricature, the world is the economists' oyster. The world of fiscal crimes is captured in the 'workhorse model' developed by Allingham and Sandmo (1972) in particular. Doubtlessly, it offers great insights by modeling tax evasion as amoral expected utility maximizing decisions. In this context, policy prescriptions also become clear—manipulate the detection probabilities and the penalties contingent on detection.

What is wrong with this? For some economists absolutely nothing—job done! For others, there are a number of misgivings about the theory. The question as to "what do you want economic theory to do?" highlights aspects of the misgivings. As a bold generalization, you might want theory to be pre-(post-) dictive, prescriptive, descriptive, and elegant in the sense of being sparse (conforming to Occam's razor). Famously, Friedman (1953) has claimed the only relevant criterion for a 'good' economic model is its pre-(post-) dictive accuracy—the 'gold standard' test. In the 'workhorse model', as taxpayers, individuals consider the net expected utility gain of under-reporting income. As benefit claimants (of cash and in-kind benefits), individuals consider the net expected utility gain of under-reporting income. This 'economic' analysis of the decision to commit criminal activity focuses on expected outcomes alone (Becker 1968). However, for all the merits of this approach, it seems to present three puzzles. More specifically, three predictions of this theoretical approach seem falsified.

First, Halla and Schneider (2014, p. 412) note, "... tax evasion and benefit fraud are almost identical in the standard neoclassical model of compliance". If individuals experience the same financial loss from benefit fraud as from tax evasion, there is no reason in the neoclassical world to assume that individuals' perceptions and attitudes toward these fiscal crimes will differ. But they do. Empirical studies indicate that citizens are far more condemnatory of benefit fraud than of tax evasion, even though the estimated financial loss from tax evasion is greater than the estimated financial loss from benefit fraud (e.g., see Cullis et al. 2015). By comparison, the 'economic' approach (based on amoral, instrumental motivations) predicts that citizens will be more condemnatory of the activity (tax evasion) that produces the greatest financial loss (*ceteris paribus*).

Second, Alm et al. (1992) are early authors who complain that the 'economic' analysis of an 'evasion gamble' predicts that most individuals will evade, when, in practice, most declare income honestly. In Andreoni et al.'s (1998) seminal literature review, the authors note that, in 1995, the audit rate in the USA for individual tax returns was 1.7 percent, and the civil penalty for underpayment of taxes was 20 percent of the underpayment. They emphasize the implicit prediction that many more individuals were likely to evade tax than the number estimated for 1995.

Third, the model cannot predict a separating equilibrium in which some individuals tax evade alongside others who do not. It generates pooled equilibria in which, depending on parameter values, all individuals will evade or all individuals will comply with the law (this result is independent of different degrees of risk aversion individuals might display). Unfortunately, for the theory, it is the former separating equilibrium that is widely observed. The 'workhorse' theory seems to fail the 'gold standard' test of the 'non-falsified predictions' purpose of theory. As regards the other criteria noted above, the theory would not seek descriptive accuracy but, as long as you accept '*homo and femina economicus*', would meet the prescriptive purpose for that caricature. It can also claim elegance. Given this judgment, what is to be done? The old joke goes: Q: "What do you do if the empirical data does not support your theory?" A: "Amend the data". Sadly, this is not as far-fetched as it may seem, as empirical work is not that often replicated in economics, and Duvendack et al. (2017) note that one reason why replication is important is to avoid data error and 'outright fraud'.

But what of the current context? In the face of these apparently empirically falsified predictions, it is not surprising that many have sought to amend the theory in various ways. In particular, this paper explores the relevance and possible determinants of moral costs in the decision to commit or not to commit the fiscal crimes of tax evasion and benefit fraud. When is 'honesty the best policy' and what 'policy is best for honesty'?

The paper is organized as follows: Section 2 provides a brief literature review on various factors influencing '*homo and femina realitus*' in their decision to engage in fiscal crimes, which helps extend Levitt and List's utility function model (Levitt and List 2007) by incorporating the moral hinterland variables discussed in Section 3. A discussion of the policy implications of this revised model, followed by concluding remarks, is presented in Sections 4 and 5, respectively.

2. Responding to Evidence

Gordon (1989) has individuals with an honesty characteristic who suffer a private stigma cost when they tax evade. Further, they incur public reputation costs depending on the strength of the evolving evasion norms that surround them. Privately they feel shame, and publicly they are shamed. These themes are explored elsewhere. Spicer (1986) and Kirchler (2007) argued that individuals experience a 'psychic cost' when they engage in tax evasion. Cullis et al. (2012) have citizens experiencing discomfort when they feel they are not complying with a social norm. Another strand in the literature draws attention to the intrinsic value that individuals derive when acting honestly. Deci (1971, p. 105) argues that an individual is "...intrinsically motivated to perform an activity when... (the individual) ... receives no apparent reward except the activity" (see also Deci and Ryan 1980).

If this broader analysis is to shed insight (and be more than a tautology), it is important to focus on the determinants of perceptions of the intrinsic value of action. It has been argued that moral beliefs are a determinant of individuals' perceptions of the intrinsic value of action. Brekke et al. (2003, p. 1969) argue: "People want to think of themselves as socially responsible ('What kind of person am I?')". They argue that "... individuals first determine their morally ideal effort by asking themselves the following question: 'What would the consequences for social welfare be if everybody acted like me'". Essentially a Kantian perspective. Individuals choose to trade-off their wish to be socially responsible against the cost they will incur (in terms of consumption and leisure).

Frey (1997) emphasizes that individuals' perceptions of the intrinsic value of action also depend on recognition—i.e., on an awareness that others acknowledge their action. To date, analysis has focused largely on the impact of acknowledgement of individuals' action. When paying tax, individuals are far more likely to act honestly the more they see that others act honestly (Kirchler 2007). By comparison, less attention has been paid to the relevance of morality and to the way in which moral beliefs are likely to influence the decision to evade tax and the decision to commit benefit fraud. An important contribution here is Rabin (1995), who follows the logic of viewing acting morally as an 'internal constraint' on what otherwise would be narrowly self-interested behavior.

This paper questions the relevance of moral cost and the different ways in which moral costs are likely to influence the decision to act honestly. To facilitate this task, a different caricature to that of '*homo and femina economicus*' is invoked.

Recent decades have witnessed the development of a different caricature for theory to work with, which has been dubbed in 'cod' Latin '*homo and femina realitus*' (see Barile et al. 2018). This caricature draws on the type of arguments made above and numerous empirical findings from social and cognitive psychology and experimental economics. Relevant economics Nobel Laureates who made fundamental contributions in this field are 1978 winner Herbert Simon (see, for example, Simon 1955), 2002 winner Daniel Kahneman (see, for example, Kahneman 2011), and 2017 winner Richard Thaler (see, for example, Thaler 1994). This newer actor has a number of characteristics, exhibiting:

1. Bounded abilities. Individuals are not all powerful, and the sources of their limitations can be subdivided into (a) bounded rationality in choices and (b) bounded self-will over actions.

2. Bounded self-interest being concerned with more than pure self-interest narrowly defined—a 'bigger and richer person' than '*homo and femina economicus*'. Again, a subdivision may be helpful: (a) individuals have an internal moral or ethical dimension that shows up in concepts like intrinsic motivation—a desire to do 'the right thing' for its own sake and (b) an external dimension where they are wary that if they follow their narrow self-interest, they will unjustifiably impose costs on others and/or disappoint by failing to act in line with an accepted social norm. The flipside is where others act in a narrowly self-interested way, imposing cost on them and/or offending by showing disregard for an accepted social norm. Such norms are likely to be culturally specific. The estimated varying sizes of 'black' or shadow economies in different countries seems to bear witness to this (see, for example, Schneider and Williams 2013). The Corruption Perceptions Index is published annually by the non-governmental organization Transparency International on a scale of 0 ("highly corrupt") to 100 ("very clean"). Denmark has topped the index for the last six years and had a score of 90 for 2023. Somalia was the most corrupt country in the same year with a score of 11. An implication of this is that in any policy discussions it is very unlikely that "one size will fit all".

3. A preference map that is endogenous and malleable (as opposed to the traditionally assumed exogenous and fixed preferences that facilitate much of Neo-classical economic analysis). Here a distinction can be made by (a) looking at what might be termed transient endogeneity (e.g., by emotion priming in experiments to influence results or 'micro' framing effects); (b) focusing on more permanent endogeneity where the actor is responsive to public policy and other signals that affect preferences ('macro' framing effects). This raises much

debated issues as to the appropriate role of government in a market economy, especially related to the use of "nudges".

In what follows, insights relating to characteristic (2) above are employed in Section 3, whereas characteristics (1) and (3) are germane to Section 4.

3. 'Optimal' Honesty: The Relevance of Moral Costs

In this section, a utility function canvassed by Levitt and List (2007) is adopted to illustrate the impact of both instrumental and intrinsic motivation in determining optimal honesty. The objective is to apply and adapt the Levitt and List formulation to 'solve' the three falsified predictions noted above. What part (if any) are moral convictions likely to play in individuals' assessment of the 'wrongness' of action: (i) to evade tax and (ii) to engage in benefit fraud? To what extent (if at all) are perceptions of the 'wrongness' of action relevant in individuals' decisions: (i) to evade tax and (ii) to engage in benefit fraud?

Following Levitt and List (2007), an individual, *i*, has a choice over action *a* (here to be tax evader or benefit fraudster) that generates two sources of utility. First, there is the utility derived from income (*Y*). Second, there is a non-pecuniary source of (dis)utility derived from the moral costs (intrinsic value) of acting dishonestly or honestly. If an individual chooses to act dishonestly, the disutility (*M*) is the 'psychic cost' incurred as the intrinsic value of seeing yourself as honest atrophies—the moral cost of acting dishonesty. To begin, both *Y* and *M* depend on the value of the financial sum (*v*) that might be achieved if the individual were to act dishonestly.

Levitt and List (2007) also draw attention to other considerations that are likely to affect the costs of acting dishonestly. The first of these are the costs of non-compliance with social norms, *n*. These costs increase, the more that your action offends against a norm (or a legal rule) in society. Such norms vary from society to society. In a series of articles, Wenzel (2004, 2005a, 2005b) theoretically and empirically, using Australian data, finds a complex relationship between personal and social norms in relation to tax compliance. For example, social norms "behavior and shared ethics attributed to others" (Wenzel 2004, p. 214) become relevant when attributed to a group with which an individual identifies.

The second is the extent of scrutiny (*s*). Scrutiny increases the likelihood that individuals will experience stigma or shame costs the more that others become aware of an individual's immoral action[1]. The individual's additively separable utility function is described in Equation (1):

$$U_i = Y_i\,(a, v) + M_i\,(a, v, n, s) \tag{1}$$

In the absence of a 'moral dimension' the utility function collapses to an 'income' (or 'wealth') maximizing utility function. When moral considerations are relevant, individual choices are likely to deviate from a pure income-maximizing choice. The moral costs increase with the size of the deception *v*, the strength of the (honesty) norm *n* and the extent of scrutiny/stigma costs *s*. Pecuniary gains naturally increase as *v* increases.

Apart from considering *n* and *s* (are they different for tax evasion and benefit fraud?) and holding *v* constant, what other variables might impact whether tax evasion and benefit fraud are viewed differently? Given this question, it is reasonable to extend the list of variables affecting moral costs with an eye to a possible empirical investigation of decisions discussed here that involve, for most, moral costs. In particular, political affiliation, *p*, religion, *r* and moral rectitude (*mr*) suggest themselves as relevant factors. Questions on religion and political affiliation are common in social surveys on fiscal crime. Moral rectitude is a variable that is likely to require 'proxying'. *A priori*, what might be the impact of these variables on the willingness to tax evade or indulge in benefit fraud.

p refers to political affiliation. Your political leaning provides a lens through which you view tax evasion and benefit fraud. A right-wing leaning is associated with a "low tax, small spending government", "standing on your own two feet", "carrying your own pack", etc., predicting a weaker disapproval of tax evasion compared with benefit fraud. The equivalent caricature on the left-leaning perspective is a "high tax, big spending government", "we are our brother's keeper", "take from the rich to give to the poor", etc.,

predicting a weaker disapproval of benefit fraud compared to tax evasion. In short, other things equal, left-leaning individuals will be less inclined to view fraud benefits as 'wrong' and more likely to perceive tax evasion as 'wrong' than right-leaning individuals.

Further, *r* is for religion. Where moral costs arise, religion ought to matter. After all, the eighth commandment says, "thou shalt not steal". It is the case that most religions see stealing as morally wrong. Given this, it can generally be predicted that religious individuals are less likely to be tax evaders or benefits fraudsters and be more disapproving of the activities. *A priori*, it is not clear whether tax evasion and benefit fraud would be seen as equally wrong or one more wrong than the other.

Finally, there is the moral stance an individual adopts. Much of economics has a largely amoral actor that seems at odds with the notion of people as moral beings. Individuals differ. The saying "being more Catholic than the pope" captures the notion that individuals display different degrees of moral rectitude (*mr*) in making choices. Zamir (2012) discussed below provides an argument that the moral costs of benefit fraud will exceed the moral costs of tax evasion. Adopting these amendments, Equation (1) can be modified to:

$$U_i = Y_i\,(a, v) + M_i\,(a, v, n, s, p, r, mr) \tag{2}$$

The variables *n*, *s*, *p*, *r*, and *mr* are seen here as defining an individual's 'moral hinterland'[2] which feeds into the moral cost of acting dishonestly.

Focusing (in the first instance) on the decision to evade tax (ignoring for the moment the curves MCb in panel (a) and TCb in panel (b) of Figure 1), it is possible to illustrate the relevance of moral/intrinsic and instrumental/money motivations in Figure 1. In this skeletal analysis, the utility costs are illustrated on the *y*-axis, and the extent of dishonesty is illustrated on the *x*-axis (running from 'total honesty', at the origin, to 'total dishonesty'). If the individual is 'totally honest', ('psychic') moral costs (MCt) are zero. The more that the individual is dishonest, the greater the moral costs, with 'total dishonesty' generating very high costs. Income costs (YC) are essentially tY, where t is the tax rate and Y represents income (for the benefit fraud case, YC would be the value of potential benefits not fraudulently claimed). When the individual becomes more dishonest, YC = tY falls. This cost is zero when the individual is 'totally dishonest'[3].

For any individual, 'optimal honesty' occurs where total costs (YC + MCt), captured as TCt in Figure 1b, are minimized. This will occur where the absolute values of the slopes of MCt (the moral costs) and YC (the income costs) are equalized. As drawn, optimal honesty is at Ht* in Figure 1b, which represents a high degree of honesty. Empirical evidence, using different research methods, accords with this depiction. In an 'indirect' applied econometrics approach, Engström and Hagen (2017) analyze the consumption patterns of the 'tax evader tarred' self-employed. They try to establish whether their consumption is consistent with their reported income. Employing the permanent income concept, they find, for their Swedish data, that correcting for transitory income fluctuations in current income, leads to an overestimate of income underreporting by as much as 40%. Clearly, this is a substantial correction in the 'honesty' direction.

In a 'direct' behavioral approach, Cohn et al. (2019) had researchers drop 17,000 apparently "lost wallets" in 355 cities in 40 countries. Surprisingly, the majority of wallets containing money were reported, with reporting rising with the size of the 'find'. Some 72% of wallets containing a 100 USD were reported, compared to 61% of wallets with just over 13 USD. Interestingly, only 46% of wallets containing no money were brought forward. It appeared that individual honesty was not dependent on economic gain (the instrumental-pecuniary motivation) but rather how bad the act of dishonesty made them feel (the intrinsic-psychic motivation). One explanation was altruism, so that individuals show empathy for the (other) person who lost the wallet. More consistent with the framework outlined here, and favored by the authors themselves, is that individuals want to maintain a positive image of themselves as honest moral beings, so that not reporting wallets containing more money engenders greater shame or moral costs to themselves.

The economics of tipping raises similar issues of contrasting pecuniary and non-pecuniary motivations. Azar (2020) reports the results of a survey he conducted in the USA and Israel on the main reasons for tipping. 'Tipping being a social norm' and 'Show gratitude' attracted strong support ('Avoiding feeling guilty' was also prominent in the USA responses). Psychological and social motivations for choices seem commonplace for the majority of individuals. However, what about the minority. Not all individuals are the same, and some individuals are much more extreme than others in their choices. The 'least cost' optimal honesty approach allows 'corner' solutions.
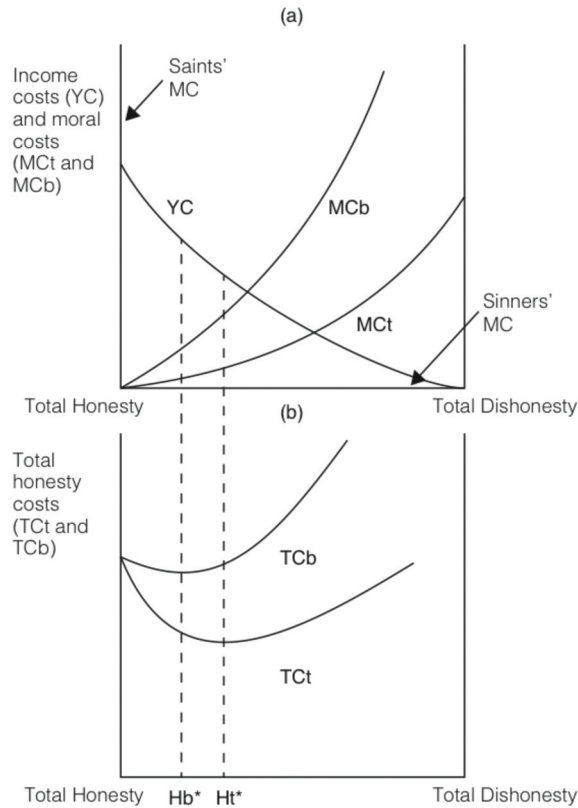
Figure 1. 'Optimal' Honesty. Note: Panel (**a**) depicts the monetary and moral costs of acting dishonestly, whereas Panel (**b**) illustrates the optimal level of honesty given the costs of acting dishonestly.

For individuals displaying 'real honesty' there is an infinitely steep MCt curve. These 'saints', whose moral rectitude is beyond reproach, always incur YC and enjoy MCt = 0. Real 'sinners', the morally bankrupt, are at the other end of the scale; MCt is the *x*-axis, so that cost minimization always predicts complete dishonesty. In practice, it is likely that an individual's 'optimal honesty' will lie somewhere in the interior. Corner solutions can also be obtained if the MCt (YC) curve is everywhere steeper in absolute value than the YC (MCt) curve producing 'apparent' saints and sinners. 'Apparent' because these individuals give credence to illegal pecuniary gains and moral costs, respectively, thereby keeping the door to future dishonesty and honesty ajar as slopes might change.

The picture is of a minority of saints and sinners alongside a majority of individuals who dabble with a socially acceptable level of tax evasion. Or as psychologist Abigail Marsh put it, commenting on the lost wallets study noted above: "...what I like about this study is that it supports so much of the data out there... that most people are trying to *do the*

right thing most of the time." (Quoted in Fieseler 2019, emphasis our). The optimal honesty approach, so far, sheds light on the second and third implications above—fiscal crimes will not be endemic and not all will act in the same way. But what about the first implication? How is an asymmetrical attitude to tax evasion and benefit fraud to be explained?

Cullis et al. (2015) provide a hedonic coding explanation of this implication. Tax evasion is about illegally not putting into the community pot, whereas benefit fraud is about illegally taking out of the community pot. With the former coded as a foregone gain and the latter as a loss, the particular shape of the Kahneman and Tversky (1979) value function does the rest. Illegal monetary gains of equal size are labeled by their different source/mental account. However, can this coding be given a more fundamental moral foundation? Zamir (2012) has considered why tort law is more developed than unjust enrichment law and why there is more constitutional protection of civil and political rights compared to social and economic rights. He argues that the explanation is premised on moral intuition. He draws attention to the concept (in moral philosophy) of 'common sense morality'. If morality is relevant, there is every likelihood that individuals will be more condemnatory of benefit fraud than of tax evasion *ceteris paribus*.

By definition, 'common sense morality' is deontological. It focuses on action rather than outcome. Zamir (2012, pp. 876–77) explains that: "Deontology does not primarily judge the morality of an action (or anything else) according to its outcomes but rather focuses on the morality of the action itself". With 'common sense morality', individuals weight the possibility of "...intentionally or actively harming other people..." far more heavily than the benefits that might be achieved. Zamir (2012) provides many examples. The first of these is the "...instinctive immorality of killing one person to harvest organs that will save the lives of three others". He notes that such acts are "...*inherently wrong*, they are impermissible even as a means to furthering the overall good." (our emphasis). Common sense morality "...distinguishes between harming a person and not benefiting her".

When focusing on individuals' preferences, the "... law conforms to prevailing moral intuitions... (that)...are closely linked to notions of reference points and loss aversions..." (ibid, p. 876). The implication is that individuals are likely to perceive tax evasion as a foregone or unrealized gain to the community (via 'not benefiting' the public purse), while benefit fraud is likely to be perceived as a loss to the community (via 'harming' the public purse). The moral costs of taking from the public purse are instinctively greater than the moral costs of not contributing to the community. As the intrinsic value of honesty, when claiming government benefits, is likely to be greater than the intrinsic value of paying tax honestly, the moral costs of dishonesty when fraudulently claiming government benefits are likely to be greater than the moral costs of dishonesty when making false income declarations.

The implications are that, in Figure 1, MCb (the costs of acting dishonestly) when committing benefit fraud are: (i) greater than MCt (the costs of acting dishonestly) when evading tax, and (ii) that MCb will increase at a faster rate when committing benefit fraud than MCt when committing equivalent tax evasion (see Figure 1a). As a consequence, in Figure 1b in the cost-minimizing model, the 'optimal' level of honesty will be greater when individuals consider benefit fraud than when they consider tax evasion (referring to TCb, the 'optimal level of honesty' will be higher at Hb* compared to TCt and Ht* in Figure 1b).

The impact of perceptions of the 'wrongness' of benefit fraud as a brake on criminal activity is likely to be greater than the impact of perceptions of the 'wrongness' of tax evasion as a brake on tax evasion. Is there evidence consistent with this? United Kingdom government statistics for the financial year ending in 2024 estimate the 'tax gap' between what is collected and what should be collected at 4.8% of total theoretical tax liabilities, or £39.8 billion in absolute terms (see HM Revenue 2024). For the financial year ending 2024, the level of fraud and error in the Great Britain benefit system amounted to £9.7 billion in absolute terms and was 3.7% of total benefit expenditure (see Department of Work and Pensions 2024). If the direct translation of these data to the theoretical depiction in Figure 1

were permissible and total honesty is 100%, then Ht* = 95.2% and Hb* = 96.3%. While this is casual empiricism, it is clearly not inconsistent with the depiction.

4. Policy Implications and Discussion

The policy relevance of this paper can be captured by reference to Figure 1. In the standard Allingham and Sandmo (1972) model, the *YC* income costs line would, in effect, become the expected utility (*EU*) maximizing income declaration (*D*) out of actual income (*Y*) determined by:

$$EU = (1 - p)\, U(Y - tD) + pU(Y - tD - F[Y - D]) \tag{3}$$

where *t* is a proportional tax rate, *p* is the probability of detection, and *F* is the fine rate that exceeds *t*. This narrowly instrumental approach naturally directs policy towards setting *t*, *p*, and *F* to influence *D*. It might be noted that raising *p* will have a limit in terms of its real resource implications, and raising *F* will have a limit in terms of making the punishment commensurate with the crime. That said, ideal policy would result in *D* = *Y*, no false declarations. It relies on one blade of a scissors. This formulation ignores the MC curves in Figure 1, highlighting the limitation of ignoring intrinsic/moral costs.

The difference between the set of variables that influence the behavior of '*homo and femina economicus*' and the set of variables that influence '*homo and femina realitus*' is evident when comparing Equations (2) and (3). If policies are to be made actionable, information is required about the impact of each variable. Different empirical methodologies have been employed. Questionnaire surveys and interview surveys report individuals' attitudes toward changes. Experiments and field trials indicate individuals' actual responses. This literature has identified the importance of the way a decision is framed. Tax authorities now frame the decision to comply by informing taxpayers of the prevalence of honest compliance by their peer group. The literature has also identified behavioral anomalies (when '*homo and femina realitus*' responses are deemed 'irrational' by comparison with '*homo and femina economicus*' responses). With evidence that individuals might regret 'irrational' decisions, there is a case for government intervention (by way of a 'nudge') that encourages individuals to avoid mistakes. Such intervention is premised on 'liberal paternalism' (Thaler and Sunstein 2009). Of course, policy might also be designed simply to minimize criminal activity.

Once '*homo and femina realitus*' supplants '*homo and femina economicus*' as the relevant caricature actor, the tax evasion/benefit fraud policy palette is transformed from monochrome to Van Gogh vibrant. Alm et al. (2023) illustrate the many interventions that are possible when government relies on a behavioral approach to improve tax compliance.

The discussion above focused particularly on the second characteristic of '*homo and femina realitus*'—bounded self-interest. A subdivision was made between an internal and external stimulus to the individual stimulus to 'honesty'. Most studies identify two important determinants of the perceptions of the intrinsic value of action (e.g., Frey 1997; Luttmer and Singhal 2014). The first is the value individuals attach to the moral (or social) norm itself-i.e., to acting honestly. The second is the importance individuals attach to evidence that others acknowledge honest behavior (and reciprocate). Government policies might trade on one (or both) of these two determinants of citizens' perceptions of the moral costs of dishonesty. As noted, it may not just be about how others view you but also about how you view others' actions. 'Hot lines' that invite you to report suspected tax evaders and benefit fraudsters allow you to take some responsibility for the fiscal environment. In this vein, the UK His Majesty's Revenue and Customs (HMRC) publishes a 'shame list' of the names of individuals who have incurred a penalty for deliberately providing inaccurate documents or failing to comply with the tax rules where there is more than £25,000 of tax at risk. Characteristic 1—bounded abilities were subdivided into: (a) bounded rationality in choices and (b) bounded self-will over actions. Bounded rationality recognizes the cognitive limitations of individuals and their information stock. With respect to tax/benefit systems, the level of confusion and misunderstandings among the vast majority of individuals seems

legion. Less complicated tax codes and benefit regulations recommend themselves. Policies providing information and illumination could be intensified and the 'fiscal connection' between taxes and public sector benefits highlighted. Information has to come from 'trusted' sources if it is to be acted on. Who are the community leaders that are listened to rather than using the organs of government who may be mistrusted. Policy in Practice estimated in 2024 that some £23 billion in benefits go unclaimed each year due to stigma (how others perceive you) and the complexities of the welfare system (Ghelani and Walker 2024; emphasis ours). Bounded self-will is consistent with individuals deliberately overpaying tax in a withholding system using the tax system effectively as a compulsory savings scheme—a self-control mechanism. Individuals who succumb to the temptation of tax evasion and/or benefit fraud may regret their actions and feel guilt. In this respect, tax and fraud amnesties would have appeal. Characteristic 3—preferences that are endogenous and malleable suggests any communications with individuals should take advantage of what is known about 'framing' effects to encourage honesty—the micro perspective. As regards the macro perspective, Jones et al. (1998) use a shifting (endogenous to government policy signals) preference map to indicate how government redistribution (that acknowledges the involvement and competence of private voluntary redistribution) will mitigate the 'one for one crowding out' predicted by neoclassical theory. Proxying the efficiency and effectiveness of government spending programs is often part of econometric work in this area. While the optimal allocation of resources between different fiscal enforcement policies on tax evasion and benefit fraud remains to be determined, it is evident from this brief discussion that there are many diverse fiscal enforcement policies that can be explored if '*homo and femina realitus*' are front and center. The use of policy prescriptions based on findings in behavioral economics is not without controversy. Many of the policies are seen as paternalistic and have been criticized on the grounds "they arbitrarily privilege one set of preferences over another" (Le Grand 2018, p. 281). Here the objection seems to have less force because the behavior under discussion is illegal. Fiscal laws and regulations are about imposing a 'state' set of preferences. The issue may then become whether the tax code and benefit system rules are set by a legitimate authority/government. In this respect, it might be expected that legitimacy might be attributed to more democratic regimes than to autocratic ones.

As regards methodological considerations, compared to the standard model, the analysis presented here lacks elegance and prescriptive precision. However, at the core of behavioral economics "...is the belief that increasing the realism with which individual behavior is seen will improve the ability to predict behavior and to devise policies" (Alm and Sheffrin 2017, p. 4). If the approach appears 'messier' (because it does not always assume that individuals are "...rational, outcome-oriented, self-controlled, selfish, and egoistic..."), it is now "... an essential part of the public sector economics dialogue" (Alm and Sheffrin 2017, pp. 4–9). In this context, Olsen et al. (2018, p. 408) argue that: "a model should be evaluated in terms of the reasonableness of its assumptions, its predictive power, and its potential usefulness to policymakers".

5. Conclusions

Decisions with a moral dimension raise the question of the moral costs associated with the choices that individuals make. Here individuals display optimal honesty if they weigh illegal pecuniary gain alongside non-pecuniary intrinsic/moral costs associated with crimes in a cost-minimizing way. More specifically, this paper explores the role of moral costs in defining 'optimal' honesty in the context of tax evasion and benefit fraud. The framework is consistent with shedding light on three, at minimum, uncomfortable implications of the 'standard' expected utility approach to fiscal crimes by suggesting: a high level of individual honesty, allowing for honest, mostly honest, and dishonest individuals to be observed alongside one another, and rationalizing benefit fraud as being viewed as more morally wrong than pecuniary equivalent tax evasion. Extant research is used to support the theoretical depiction in Figure 1. In addition, variables relevant to

defining an individual's 'moral hinterland' as a precursor to possible econometric work were explored.

Considering the question posed at the end of Section 1, "honesty is the best policy" when the moral costs of dishonesty are high relative to the pecuniary payoff from dishonesty. While this may be somewhat of a tautology, what is not a tautology is the answer to the second part of the question, which asks what is "the best policy for honesty". Here the answer is an eclectic set of policies that include detection rates and penalties but also a carefully chosen and culturally tailored selection of policies, often associated with behavioral economics and the 'nudge' agenda, that serve to raise the moral costs of dishonesty.

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Notes

[1]   The size of v in the *M* part of the function indicates that moral costs are greater the bigger your crime and the more a decision imposes a financial externality on others.

[2]   This paper is based on the work of Barile et al. (2022), where econometric evidence using this approach can also be found.

[3]   As noted in Section 4, Equation (3), below, *YC* can be equated to the standard Allingham and Sandmo (1972) model of optimal tax declaration in a more sophisticated presentation.

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Article

Earmarking Taxation and Compliance: Some Evidence from Car Ownership in Italy

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Abstract: This study focuses on tax evasion within the framework of earmarking taxation, specifically focusing on the evasion of car ownership taxes. We utilize a unique and extensive micro-database that combines information on regular payments of the tax due, late payments following friendly warnings, and non-payment of vehicle ownership taxes, integrated with fiscal data, individual data, and municipal-level data. The empirical analysis examines individual, socio-economic, and institutional factors related to this issue. Drawing a rich dataset from the 2014 Tuscany car tax, we employ a multilevel logistic model for our empirical investigation. Our findings reveal that tax evasion poses an equity problem, as the inclination to evade vehicle ownership taxes is concentrated among specific demographic categories and types of vehicles. We also suggest that regional-level policies, such as friendly warnings, could be more effective if implemented with greater rigour. Lastly, our results indicate that reinforcing civic responsibility and enhancing institutional and political quality could prove particularly beneficial in enhancing tax compliance.

Keywords: vehicle ownership tax; earmarking taxation; compliance; evasion; friendly warnings; institutional quality; behaviour; regional taxation

JEL Classification: H26; H71; C2

1. Introduction

Vehicle ownership tax is a widespread form of taxation in many European countries. This form of taxation is commonly used as an environmental and earmarked tax aimed at internalizing externalities derived from transportation. In many countries, earmarked taxes are collected to contribute to local governments' revenues due to the increased accountability in resource utilization, and a higher level of compliance for this type of taxation.

The literature has shown increasing attention to earmarked taxation and its effect on consumer behaviour and emission reduction. A growing number of studies are looking at the effect of carbon taxation on passenger vehicle sales and usage, for example (see, e.g., Alberini et al. 2018; Alberini and Bareit 2019; Alberini and Horvath 2021; Cerruti et al. 2019). Most of these studies show that modifying the vehicle registration tax and linking it directly to carbon emissions has proven to be effective in switching individuals' preferences toward less polluting vehicles (e.g., Alberini and Bareit 2019; Cerruti et al. 2019). Furthermore, in the context of durable goods, "new car registrations react to tax cuts and fee-bates significantly more than to tax increases" (see Soldani and Ciccone 2019, p. 1).

Other authors have also focused on the effect of earmarking taxation on tax compliance, claiming that direct democracy, decentralization and earmarked taxation can foster tax compliance (Schaltegger and Torgler 2008; Torgler et al. 2010). In a controlled lab experiment, Brockmann et al. (2016) show that governments can increase tax compliance by rewarding honest taxpayers, though the effect seems to affect only females, thus suggesting there is no "one-size fits all" approach to boost tax compliance. Recent development in the literature seems to suggest that earmarking taxation can increase taxpayers' compliance by enhancing the 'procedural utility' (see Frey and Stutzer 2005 for a discussion) of paying taxes. According to Brockmann et al. (2016), this can be achieved via two different mechanisms: (1) earmarking taxation raises taxpayers' awareness of the potential usefulness of their tax payment; and (2) this opportunity allows taxpayers to actively participate in policy decisions by making them *policy-makers* rather than *policy-takers*[1].

This paper gives a contribution to that part of the literature that analyses why people choose to engage in tax evasion in the context of earmarking taxation that is regionally administered. In this case, citizens' involvement in policy choices is greater, and non-payments can be promptly identified by the tax administration[2]. Our paper focuses on car tax compliance in the Italian region of Tuscany, though vehicle ownership taxation in Italy applies to all vehicles and motorcycles registered within the country's borders. We use a unique dataset collected in Tuscany over the fiscal year 2014 to identify factors affecting tax dodgers' behaviour. The dataset gathers car tax information, car characteristics and car owners' socio-demographics.

In Italy, vehicle taxation represents an important source of tax revenue. Indeed, the tax applies to 52 million vehicles, of which more than 40 million are cars in 2022. The tax has been introduced in 1953 to finance road construction and maintenance costs and it is currently a pillar of local taxation. Italian regions administer the tax and are responsible for enforcing compliance. The tax is levied annually based on the vehicles' engine power (measured in kW), age and pollution emissions.

Car ownership taxation in Italy is extremely unpopular among taxpayers. Although it is easy to assess thanks to a national vehicle register, the level of tax evasion is significant (13% at the national level in 2014)[3]. However, this figure is difficult to quantify with certainty, given the high proportion of late payers and the ineffectiveness of enforcement procedures, which varies from region to region. For example, in the region of Tuscany, with 3.7 million inhabitants, 3.8 million vehicles and 2.5 million cars, almost 20% of the tax due was not paid on time in 2014, and this has not changed significantly to date (Baldaccini 2023). In Emilia-Romagna, a region close to Tuscany in geographical and socio-economic terms, tax evasion was estimated at 9% for 2015–2016, with late payers and evaders accounting for more than 40% (Corte dei Conti 2022).

Whilst a vast amount of literature explores the impact of tax morale on individuals' behaviour (Torgler 2007; Luttmer and Singhal 2014), and estimates the size of the shadow economy (Ahumada et al. 2007; Schneider 2000; Schneider and Buehn 2013), to the best of the authors' knowledge, this is the first empirical study on taxpayers' behaviour in the context of vehicle ownership taxation, based on a large dataset on individuals' characteristics and extensive information at municipal level.

The 'economic' analysis of the decision to evade taxes was pioneered in Allingham and Sandmo's (1972) paper on optimal tax declaration, where individuals consider the net benefits of evading taxes to maximize their expected utility. However, for all the merits of this approach, there are important limitations to the model. First, the model considers the taxpayer as a rational individual, who makes decisions only to maximize their own utility. However, according to Spicer and Lundstedt (1976), the decision to evade taxes does not depend merely on the associated utility, but also on moral aspects and taxpayers' attitudes towards illegal crimes. Erard and Feinstein (1994b), for example, suggest that moral sentiments drive tax compliance. This indicates that the reasons for taxpayers' compliance must be sought not only in the economic sphere, but also in the psychological and moral spheres (Bott et al. 2020). Recent developments in neuroscience also provide

a foundation of the relevance of moral sentiments for tax compliance (Dulleck et al. 2016). Alongside individual attitude, the social environment and moreover the governance and institutional quality also have importance (Torgler and Schneider 2007). Trust in institutions and transparency regarding the direct use of taxation may encourage compliance, thereby enhancing the provision of public services (Marien and Hooghe 2011).

Our paper contributes to the literature studying the drivers of tax compliance and the relationship between taxpayers and institutions. In this work, we base our analysis on a comprehensive micro-database, which allows us to clearly identify several characteristics of tax evaders. We integrate this individual dataset with an extensive set of information at the municipal level. Another advantage of our setting is that the micro-database collects individual information on regular/late payments after friendly warning/non-payment of vehicle ownership tax in Tuscany. This is particularly valuable when results in the literature are mixed, as is the case for interventions appealing to friendly warning messages (Bott et al. 2020; De Neve et al. 2021). Moreover, there is growing interest on the use of "nudges" to prevent tax evasion, being this seen as a more effective intervention than punishment. This paper proceeds as follows. Section 2 presents some preliminary data analysis on individual car ownership tax in Tuscany. Section 3 discusses some implications of the Allingham and Sandmo (1972) model and compares expected and experienced car ownership tax evasion in Tuscany. Section 4 presents empirical results. Section 5 briefly discusses the results and concludes.

2. Car Ownership Tax in Italy: Trends and Perspective

Amongst the EU Member States with the highest motorization rates in 2022, Italy ranks first, followed by Luxembourg, with 682 cars per thousand inhabitants (vs. 673 cars per thousand inhabitants in Luxembourg). The Italian motorization rate shows a certain variability between geographical areas, but Tuscany stands out with a very high motorization rate.

All EU countries levy taxes on vehicle ownership, which have increasingly been used to influence driver behaviour and encourage the purchase of low-polluting or more fuel-efficient vehicles. Although the tax base characteristics are quite homogeneous across countries (and based on engine power and emissions), the tax rates vary widely. In Italy, the tax is paid annually by anyone who owns a vehicle registered in the Vehicle Public Registry (Pra). The tax due on cars is based on engine power, expressed in kW/m^3, and on environmental classes, so it is higher for cars with high environmental impact and indirectly operates as an environmental levy[4]. The Italian vehicle ownership tax is administered at a regional level, but with a limited degree of discretional power, which means that the Italian regions can make only minor changes to the basic tax rate and introduce specific exemptions. Tax collection is a regional task, so regional governments are also responsible for strategies to encourage tax compliance. The vehicle ownership tax in Italy was equivalent to more than EUR 7 billion in 2022, representing on average about 13% of total regional revenues.

Despite perfect information on vehicle ownership, there is a significant prevalence of tax evasion for this earmarked taxation in Tuscany, similar to what can be found in other Italian regions.

Car Ownership Tax in Tuscany: Descriptive Statistics and Context

Table 1 presents the vehicle distribution, based on tax due, regular and late payments, and evaded tax for 2014, our year of analysis. We work with this specific year as it is the only period in which we have availability of complete information about car tax and taxpayers. The due revenue in 2014 was EUR 502 million, of which only 340 million was collected in due time and 63 million as late payments. More than 98 million (19.6%) can be classified as tax evasion. It is interesting to note that cars—72% of the vehicles in the region—account for 86% of total tax evasion.

Table 1. Evasion and compliance for vehicle type in Tuscany (2014), in EUR (millions).

	Vehicle Number	%	Regular Payment (a)	Late Payment (b)	Tax Evasion (c)	Tax Evasion/Tax Due % c/(a + b + c)	Late Payment/Tax Due % b/(a + b + c)
Cars	2,202,730	72%	305.276	54.320	84.985	19.12%	17.79%
Motor vehicles	446,501	15%	14.483	4.673	5.508	22.13%	32.26%
Bus	5102	0.2%	1.298	0.075	0.085	5.85%	5.81%
Lorries	402,374	13%	19.683	4.339	8.031	25.06%	22.04%
Total	3,056,707	100%	340.740	63.408	98.611	19.61%	12.61%

We can categorize the taxpayers as follows:

- Regular: those who paid in due time.
- Late payers: those who have paid after a request for payment (friendly warning).
- Evaders: those who have not paid tax (starting from 6 months after the due date, considered an unwanted delay).

In the same way, we can categorize the amounts of payments, with the sum of regular payments, late payments and evaded amounts representing the total tax due.

Given the high level of tax evasion characterizing a specific subset of homogenous taxpayers, i.e., car owners, we focus our analysis on taxpayers owning at least one car and residing in Tuscany[5]. After excluding incomplete observations, our final dataset consists of 1,485,283 individuals owning 1,693,083 cars. The dataset comprises information on car features, individuals' socio-economic and demographic characteristics (at individual and aggregate levels), and economic and institutional aspects of the local municipality[6].

The unpaid amount represents 18% of the tax due, for a total of 13% of tax evaders (see Table 2). This shows how widespread the phenomenon is, despite available information on car ownership taxation and specific nudges (such as friendly warning letters)[7] put in place by the local authorities. We also observe that this phenomenon is primarily concentrated among individuals with the highest tax liabilities, many of whom own high-performance vehicles.

Table 2. Breakdown of taxpayers and tax revenue (cars only, excluding incomplete observations).

Taxpayers			Overall Car Tax Revenue			Per Capita Car Tax Due
	Frequencies	%		EUR (Millions)	%	EUR
Regular	1,137,467	76%	Regular	248.485	71%	218
Late	156,671	11%	Late	40.761	11%	259
Evaders	191,145	13%	Evaders	62.330	18%	322
Total	1,485,283	100%	Total	351.577	100%	236

We therefore consider the relationship between tax evasion and income (see Figure 1) and note that higher tax evasion is concentrated both in the first and in the last car tax quintiles (24%). This seems to suggest a U-shaped relationship between the value of the car and the car tax evaded.

Observing the car owners' distribution of regular and late payers in relation to income quintiles (see Figure 2), the data show that the share of car owners paying in due time increases with income, while the percentage of evaders and late payers decreases with income. However, it is worth noting that for most tax evaders, income data are not available[8]. We hypothesize that this lack of information could stem from either a correlation between undeclared income and evasion of car taxes or the possibility that many of these taxpayers had no taxable income, being among the poorest segment of the population. This being said, the share of car tax evaders in the group of 'not-available' income is much higher than in the overall sample (28% vs. 13%; see Table 2).
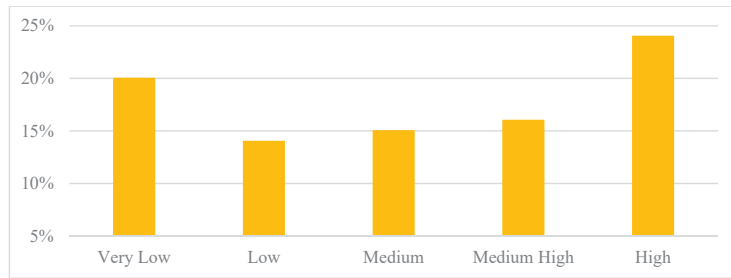
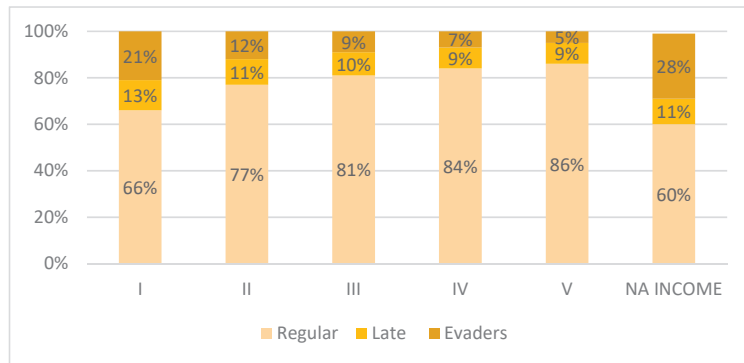**Figure 1.** Incidence of car tax evasion by car tax quintile.

Figure 2. Taxpayer composition for income quintile. Note: I–V represent different income quintiles (in Roman numbers), and NA stands for 'not available' income information.

Considering the sample of 'no-available-income' taxpayers (i.e., those who are liable for the car tax but are not reporting annual income), as expected, there seems to be a direct link between the car tax due and tax evasion. That is, taxpayers who are due to pay the highest car tax are also those who evade it the most. Presumably, some of these taxpayers are also dodging their income tax and own the most expensive and high-performance vehicles. Figure 3 shows that in the highest car tax decile, corresponding to an average tax of EUR 498, tax evasion reaches a peak of 67%, which is the highest level across all car tax deciles.
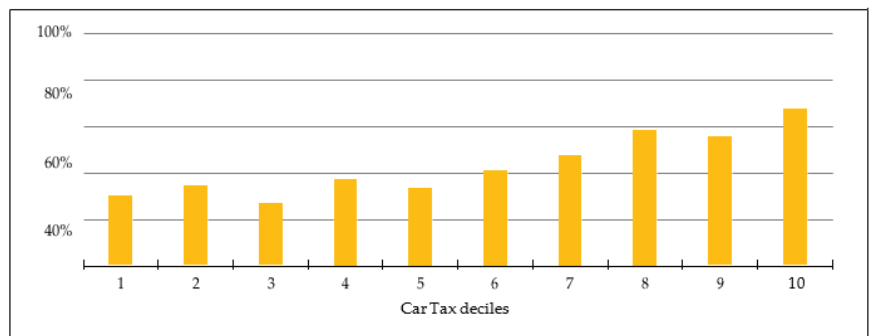
Figure 3. Share of tax evasion for car tax deciles (no-available-income subset).

This evidence highlights that further investigation is needed to better understand the decision to participate in tax evasion in the context of earmarking taxation.

3. Expected and Experienced Tax Evasion

The seminal Allingham and Sandmo (1972) model of tax evasion (hereafter ASY model)[9] describes the trade-offs a taxpayer faces when making the decision to evade taxes. This approach requires for the taxpayer to know with certainty the probability of being audited, *p*.

Based on our classification of compliance behaviour,[10] we can consider different expected loss functions, L(T), per type of taxpayer:

- Regular taxpayer: L(T) = T;
- Taxpayer with late payments: L(1 + DT);
- Evader: L(T + 0.3T) or L(1.3T) if caught; L(T) = 0 if not caught,

where T is the due tax and D the fine for late payments equal to 1% or 3,75% depending on the delay (D = 0.01 or 0.0375); for tax evaders, there is a fine equal to 30% applicable to the undeclared car tax, which in this context equals the tax due.[11] For simplicity, we assume a linear (or quasi-linear) relationship between L and T. This suggests that if the taxpayer is not caught by the tax authority, L(T) = 0, i.e., the expected loss is equivalent to zero. By contrast, if caught, the loss function will be given by L(1.3T), i.e., the loss is a function of the tax that the individual has to pay, plus a fine (=30%*T). The expected loss E(L) of the taxpayer will therefore depend on a probability *p* of being caught by the tax authority:

$$E(L) \; = \; p * L(1.3T) + (1 - p) * L(T) \; = \; p * L(1.3T) \tag{1}$$

If we compare Equation (1) with the expected loss of the honest taxpayer, E(L) = L(T) = T, and under the standard assumption that an individual will pay taxes honestly if the expected loss from paying taxes honestly is smaller than that expected loss by acting dishonestly, we can then rewrite (1) as follows:

$$L(T) \leq p * L(1.3T) \tag{2}$$

Rearranging (2) and solving for p, in our study, we find that for $p \geq 76.92\%$, it is convenient to pay the fine on time, while for lower probabilities, it is convenient to evade. This is in line with predictions of the ASY model, though it seems to suggest very high levels of tax evasion than those found in the real world (for a discussion, see, e.g., Weber et al. 2014).

Second, the result discussed above reveals interesting insights on how people form expectations on audit probability. For the car tax discussed here, on the one hand, the probability of detection is almost 100%; thus, the conventional ASY tax evasion model would suggest zero tax evasion. On the other hand, given that after receiving the friendly warning letter, the fine increases up to 300 times, one would expect the vast majority of taxpayers to comply within six months to one year from the missed deadline. Nevertheless, only 38% of those who failed to meet the initial deadline paid after the friendly warning (mostly just late payers), with the remaining 62% being tax evaders. Two important aspects are worth noting here. First, even though the tax administration in Italy can promptly identify the car owner, tax evaders appear perceiving the probability of detection and actual prosecution as being very low (or equal to zero). Perhaps, taxpayers act under the rooted assumption that they will not be prosecuted by law and think that they will obtain greater benefit by evading taxes. Second, the use of a friendly warning message in this context seems to be only partially effective. The letter, in fact, has the potential to signal high probabilities of coercive procedures as it revealed that taxpayers' liability can be identified and monitored. In the case of further non-payment, additional punishments are also applicable.[12] However, our data seem to suggest that individuals who pay the car tax after receiving an early warning are predominantly late payers (and might have paid the tax regardless), raising questions about the efficacy of this intervention on tax evaders.

This result is in line with Galmarini et al. (2014), who find that receiving a notice from the tax authority is not effective in reducing tax evasion, thus suggesting that more efficient ways to enhance tax compliance would include reinforcing the strength of the warning,

e.g., by making the names of those who refuse to pay publicly available[13] (exploiting reputational costs) or making it more difficult for those who evade taxes to access bank loans (reporting tax evaders to banks).

Recent developments in behavioural public policy also suggest that a nudge (such as a friendly warning letter) could become more effective and legitimate if incorporating an element of reflection (the *plus*), potentially leading to long-term, consistent, and sustainable behaviour change (Banerjee and John 2024). To give an example, in the context of earmarking taxation, a nudge *plus* could be implemented by adding to the friendly warning message an explanation of how taxpayers' individual contributions will help finance specific projects.

Going back to our study, an increase in the penalty rate above the current 30% (which seems not to be a deterrent for tax evaders) may also be desirable. Cranor et al. (2020), for example, using data from Colorado on the tax year 2015, show that sending reminders with information about 'progressive' (and increasing with delays) financial penalties[14] to tax delinquents may have a stronger impact on tax compliance than sending messages highlighting the relevance of social norms. The authors conclude that 'attention to seemingly minor decisions about the wording of notices' might have important consequences on taxpayers' compliance behaviour (Cranor et al. 2020, p. 331). Furthermore, a related recent study suggests that communication that manipulates the taxpayers' perception about the likelihood of an audit can also help in improving tax compliance (see, e.g., Mazzolini et al. 2022; Carfora et al. 2018; Gangl et al. 2014; Castro and Scartascini 2015; and, more recently, Bott et al. 2020). Under the ASY model, the decision to evade taxes is modelled considering taxpayers' payoffs, pondered with the adverse event of a tax audit. This approach requires taxpayers to know their probability of being audited. This is a very strong assumption considering that in real life, it is widely expected that this probability is unknown to the taxpayer. Schmeidler (1989) states that the formation of individual probabilities leads to an incorrect estimate of the probability itself, which, instead of reflecting the frequency of the event, reflects the subject's confidence level, thus providing probability estimates that do not add up to one. Similarly, Snow and Warren (2005a, 2005b) and Dhami and Al-Nowaihi (2007) suggest that, under uncertainty, risk aversion leads individuals to severely overestimate the probability of a tax audit, thus becoming more compliant. However, the opposite is true for risk lovers (i.e., they become less compliant). Therefore, according to (Snow and Warren 2005a, 2005b), given that governments cannot screen taxpayers based on their risk aversion, it might be not advisable to foster uncertainty as a policy tool to boost compliance.

Our findings imply that taxpayers' confidence in evading taxes without facing legal repercussions appears to be significant and likely reinforced over time. Indeed, tax evasion tends to be recurrent (Angeli et al. 2023), suggesting that a more proactive policy in this regard could prove effective in the Tuscany context.

4. Data and Empirical Strategy

Having established some interesting aspects of earmarking taxation and individuals' tax compliance, this study seeks to understand the impact of some socio-economic and environmental factors that affect the decision to evade earmarking taxation.

4.1. The Dataset

For the analysis, we consider a comprehensive dataset on car tax in 2014. The base unit for the analysis is a single taxpayer who owns one or more vehicles. In total, our dataset consists of 1,485,283 individuals for 2014. Motorbikes have been excluded from the sample. We focus our analysis on cars as they represent a large proportion of the vehicles included in the database. In addition, people may have different tax attitudes/behaviours when considering different vehicles. We also excluded taxpayers who did exhibit ambiguous behaviour toward vehicle taxation from the sample, e.g., paying the tax for one vehicle but not for another. The dataset is built using a combination of different sources, including

the Public Register of vehicles (PRA), which reports data on vehicles for which the car tax is due; the Italian Automobile Club (ACI), which is the institution in charge of collecting car tax; and the National Statistical Office and Regional data on taxpayers. Aside from the binary variable describing taxpayer behaviour, we can distinguish four core macro areas, covering the most common determinants of tax evasion that we collect at the individual, fiscal and municipal levels. These include the following:

1. *Socio-economic and demographic variables.* An extended literature studies the effects of individual characteristics on individual propensity to evade (see, e.g., Alm and Torgler 2006; Halla and Schneider 2008, 2014; Torgler and Valev 2010). Results are mixed, but in general, variables such as age, gender, marital status and income can be crucial in predicting taxpayers' compliance and risk attitudes, under the standard assumption that risk-loving individuals are also more inclined to commit fraudulent acts.

2. *Variables associated with car characteristics* (e.g., present car value, number of cars owned by a taxpayer, car tax and age). These are used to investigate the relationship between the car value and the tax due, and to test whether the car depreciation has a negative impact on tax compliance. A proxy of the present value of the car is calculated considering the linear link between the car tax, the value of the car, and the effective tax rate (ratio between the car tax and the actual value of the car): the effective tax rate increases as the car value depreciates. Therefore, we consider this effective tax rate as the ratio between the nominal car tax and the depreciation factor for the car. This is provided as follows:

$$ECT = \frac{CT}{(1-i)^n} \tag{3}$$

    where CT is the car tax, ECT the effective car tax rate, *i* represents the car depreciation rate, and *n* is the car age. This variable captures the individual's lower propensity to pay the tax due to the car depreciation. The car tax here is used as a proxy for the present car value.

3. *Economic environment variables.* Collected at the municipal level, these variables proxy the local economic situation faced by different taxpayers. The objective here is to investigate whether wealthier areas of Tuscany are less likely to engage in tax evasion. The literature shows that subjects with high tax compliance are also those who receive benefits from the welfare system, e.g., elderly and most educated people (Rodriguez-Justicia and Theilen 2018). Experimental and survey evidence support the conclusion that citizens are more willing to pay taxes if they receive public goods and services in return (see, e.g., Torgler 2002). More deprived areas may also offer fewer public goods and services, which may lead individuals to evade more taxes. To test whether tax evasion is concentrated in deprived areas of Tuscany, we consider a set of variables as indicators of the local economy. These are the car owners' income source (taken from the car owner and fiscal datasets and captured by the percentage of individuals with different occupational statuses on total residents), the number of firms per capita and the percentage of firms in the tertiary sector. We finally include the average taxpayer income (municipal statistics).

4. *Institutional variables.* These are included to capture the relationship between the taxpayer and public (regional) administration and proxy the quality of the local institution. Both aspects play an important role in increasing tax compliance (see, e.g., Nicolaides 2014; Hallsworth et al. 2017; Alstadsæter et al. 2018). Considering quality, Torgler and Schneider (2007) show that lower levels of tax evasion are obtained when citizens trust both central and local governments, and even more so when the latter approves the choices in the field of public finance (Buehn et al. 2013). The institutional approach suggests that high institutional quality and open government initiatives enhance tax revenue and compliance by legitimizing tax burdens and expenditures and encouraging open participation in policy and law-making processes (Khaltar 2024). Earmarking taxation can strengthen the legitimacy of the tax burden by providing transparency, ensuring accountability and demonstrating that tax

revenues are being used effectively for specific purposes. This process can build and maintain trust in governments, leading to greater tax compliance and a more positive relationship between taxpayers and institutions (see, e.g., Torgler and Schneider 2007). However, the literature also suggests that the greater the (physical and political) distance from the centre of power, the greater the level of tax evasion, as taxpayers may feel they are not engaged with the decision-making process (Pukeliene and Kažemekaityte 2016; Buehn et al. 2013). Moreover, complex tax systems may lead to higher levels of tax evasion (Pukeliene and Kažemekaityte 2016; Daude et al. 2013). This suggests that the tax collection agency must work in a transparent and cooperative manner with the taxpayer to boost taxpayers' confidence in the government (Lisi 2014). Taxation transparency has proven to be particularly important to enhance tax compliance (see, e.g., Johannesen and Larsen 2016), and might be particularly relevant for earmarking taxation given that people may be more willing to pay taxes if they know how their money is being used (Seely 2011; Perez-Truglia 2020). We proxy the complexity of the regional administration with the regional political fragmentation represented here by the number of parties in the municipalities. In addition, we include variables such as the local municipal tax burden (proxied by the per capita average tax burden per municipality), and specific municipal budget items such as investments in transport and fixed public expenditures to capture the flexibility/rigidity of local public expenditures, which justifies earmarking taxation as a designated budget to finance specific public services. We also use the geographical distance from Florence, the chief town of Tuscany, to capture the perceived distance from the central decisional government.

5. Moving to the relationship between citizens and the public authority, we include variables related to civic participation, such as the presence of volunteers (i.e., the percentage of individuals engaged in charity activities per municipality) and individuals' participation in elections (municipal dataset) to capture citizens' identification and participation with the local governments. The literature suggests a positive relationship between civic duty and moral attitudes to tax evasion (see, e.g., Orviska and Hudson 2003). Therefore, we expect that higher levels of participation in local government activities are also associated with lower tax evasion, mediated by moral factors.[15]

All variables used in the empirical analysis are reported in Table A1 in Appendix A.

4.2. The Empirical Strategy

Our data involve different levels of aggregation (i.e., individual and municipal levels). Therefore, we consider a simple random intercept logistic regression as our empirical strategy. A multilevel model will allow us to simultaneously quantify the impact of individual characteristics on tax compliance and better understand how groups' heterogeneity in different municipalities affects the decision to evade taxes. The model is described below:

$$\begin{cases} Y_{ij} = \beta_{0j} + \beta_1 X_{ij} + \beta_2 Z_j + R_{ij} \\ \beta_{0j} = \gamma_{00} + U_{0j} \end{cases}, \tag{4}$$

where Y_{ij} is the dependent variable, i represents the *i*-th individual of group *j*, β_{0j} is the intercept, X_{ij} is a matrix of individual explanatory variables also called independent first-level variables with the coefficient vector given by β_1, Z_j is a group or second-level variable matrix with coefficient β_2, and R_{ij} are first-level residues or individual residues. The randomly intercepting multilevel structure is given by the second system equation. The intercept β_{0j} is given by a γ_{00} constant, and a random U_{0j} component that varies from group to group and that is called the second-level or group residue.

The dependent variable is a dichotomous variable that takes on a value of 1 if the individual has not paid the tax, and 0 otherwise. Table 3 below reports regression results.[16] Calculations were performed in STATA14 using the milogit routine.

Table 3. Results for logistic multilevel regression.

	Variable	Coef	Std.	P > z		95% Conf. Interval	
	Constant	−1.186	0.441	0.007	***	−2.05	−0.32
Vehicle variables	Car tax	0.244	0.003	0	***	0.24	0.25
	Average car tax per municipality	−0.006	0.02	0.77		−0.05	0.03
	Number of cars	−0.052	0.003	0	***	−0.06	−0.05
	Number of cars (per capita)	−0.015	0.016	0.352		−0.05	0.02
	Present car value	−0.074	0.005	0	***	−0.08	−0.06
	Average present car value per municipality	0.032	0.036	0.37		−0.04	0.1
	Car age	0.56	0.004	0	***	0.55	0.57
	Average car age per municipality	−0.064	0.039	0.102		−0.14	0.01
Socio-economic and demographic variables	Taxpayer age	−0.276	0.004	0	***	−0.28	−0.27
	Average taxpayer age per municipality	0.003	0.031	0.932		−0.06	0.06
	Taxpayer income	−0.468	0.003	0	***	−0.47	−0.46
	Foreigners	1.21	0.008	0	***	1.19	1.23
	% foreigners	0.627	0.959	0.513		−1.25	2.51
	Chinese	2.371	0.026	0	***	2.32	2.42
	% Chinese	−2.887	1.967	0.142		−6.74	0.97
	Marital status	0.065	0.006	0	***	0.05	0.08
	Female	−0.142	0.006	0	***	−0.15	−0.13
	% female in municipality	−0.92	0.582	0.114		−2.06	0.22
	Self-employed	0.31	0.008	0	***	0.29	0.33
	Retired	−0.653	0.011	0	***	−0.67	−0.63
	Other source of income	−0.403	0.012	0	***	−0.43	−0.38
	"Not available" income	0.199	0.012	0	***	0.18	0.22
Economic environment variables	Number of firms per capita	−2.655	0.826	0.001	***	−4.27	−1.04
	% of firms in tertiary sector	−0.038	0.013	0.003	***	−0.06	−0.01
	Average taxpayer income per municipality	−0.02	0.024	0.404		−0.07	0.03
	% employed	−0.021	0.012	0.093	*	−0.05	0
	% unemployed	0.022	0.012	0.061	*	0	0.05
	% retired	0.016	0.841	0.985		−1.63	1.66
	% self-employed	0.177	0.727	0.807		−1.25	1.6
	% other source of income	1.883	0.828	0.023	**	0.26	3.51
Institutional variables	% volunteers	−1.123	0.208	0	***	−1.53	−0.71
	Number of parties	0.037	0.019	0.049	**	0	0.07
	% voters	−0.826	0.318	0.009	***	−1.45	−0.2
	Distance from Florence	0.069	0.017	0	***	0.04	0.1
	Tax burden per municipality	0.013	0.011	0.211		−0.01	0.03
	Investment in transports	−0.031	0.008	0	***	−0.05	−0.02
	% fixed public expenditure	−0.017	0.01	0.093	*	−0.04	0
	Municipality	1.465	0.689	0.033	**	0.11	2.81
	McKelvey–Zavonia R^2			R^2 count (adjusted)			
	0.2833			0.3131			

Note: *, **, and *** indicate respectively 10%, 5%, and 1% significant levels.

The results provide us with a clear picture of tax compliance and evasion relating to car ownership taxes in Tuscany. As expected, there are four key drivers of car tax evasion grouped in the macro-areas listed below:

1. Car characteristics (at the individual and aggregate levels).
2. Economic environment variables (averaged at the municipal level).
3. Socio-economic and demographic variables (at the individual and aggregate levels).
4. Institutional variables (averaged at the municipal level).

As discussed in Section 2, the car tax has a negative effect on tax compliance with higher levels of taxation corresponding to increased willingness to evade. Similarly, the effective car taxation plays an important role on the decision to evade the tax: when the car depreciates and/or becomes older, tax compliance decreases. It is interesting to note that as taxpayers with several cars tend to be more compliant, probably because of a higher ability to pay.

Civic duty is a significant element in explaining taxpayers' compliance since municipalities with a higher level of volunteers and participation in elections are less likely to evade. The political fragmentation of the city council, proxied by the number of parties, is also significant: scarce identification with political parties and local government leads to a greater aversion to paying car tax. This is particularly relevant when considering the nature of earmarking taxation. Tax earmarking can mitigate agency problems in public provision, fostering accountability and creating a more direct linkage between private monitoring choices and taxes paid (Dhillon and Perroni 2001). Losing this direct link due to lack of identification with the local government may lead to higher resistance to earmarking taxation.

The effect of individual characteristic emerges clearly from the results, with the elderly, women, and families not surprisingly complying more often than others with their obligations (see, e.g., Barile et al. 2022; Halla and Schneider 2008, 2014).

Among the socio-economic and demographics variables, households' income and occupational status play a significant role on the willingness to evade taxes (at the individual level). According to the literature, as per other types of income taxation (see, e.g., Torgler and Valev 2010), higher levels of car tax evasion are present among the self-employed, while, as expected, retired people and employees have higher levels of tax compliance. Moreover, in line with what was discussed in Section 2, higher income levels correspond to lower evasion (see Figure 2), while ceteris paribus, no-available-income taxpayers are significantly more likely to engage in tax evasion (by approximately 20%).

A greater propensity to evade taxes is found among foreigners, possibly attributed to their lower incomes, or less familiarity with the tax system.

Looking at the aggregate economic environment variables, industrial areas seem to be less likely to engage in tax evasion. However, different occupational statuses and average household incomes have limited influence on tax compliance, with the percentage of employed and unemployed individuals per municipality only being significant at the 10% level (with income and all other occupational variables remaining insignificant).

The results also suggest that public infrastructures play a role in determining taxpayers' behaviour, with higher investments in public transport being positively correlated with higher levels of tax compliance. This confirms previous findings in the literature (see, e.g., Buehn et al. 2013): when taxpayers see a return on the amount of taxes paid, they are also more likely to contribute to the public budget. Interestingly, local taxes do not seem to have a significant effect on the willingness to evade the car tax. Note that this result may also be due to the high level of correlation between higher tax burden and public transport investments, with the former being the strongest predictor for tax compliance. In fact, the higher the public revenue (collected via taxation), the greater the investments in infrastructure.

In addition, the distance from the regional capital, Florence, significantly and positively affects the willingness to evade. Further investigation of the data shows that the areas that appear to be distant from Florence, and, in particular, those in the coastal area

have a higher level of evasion (see also Section 2). This is in line with the work by Pukeliene and Kažemekaityte (2016), who assert that those living at a greater (geographical or psychological) distance from central governments tend to be reflected less often in government choices, and thus tend to evade more.

In general, many of these factors can be traced back to the concept of institutional quality, understood as civic virtue, and the ability of the administration to respond to citizens and politics' linkage with citizens. This is an interesting result of our work, which suggests that besides socio-economic and demographic variables collected at the individual level, in the context of earmarking taxation and regional administration—the focus of this analysis—proximity to the political and administrative centre and civic participation are important factors for individuals' willingness to evade tax. Finally, institutional quality of local administration is found to be a boost towards a collective awareness and civic participation.

4.3. Predicted Probabilities and Car Tax Evasion

We consider predicted probabilities to evaluate the effect of different factors on the decision to evade car tax. For comparison, we consider 12.9% as the average probability of evading car tax (see Section 2).

To account for differences in risk attitudes, we compare four different groups of taxpayers, who, according to the literature and the results described in Section 4.2, may exhibit different attitudes towards tax evasion.

These taxpayers differ by gender and age. In particular, we compare women and men aged 35 or 65 years old. The literature indicates (for example, Borghans et al. 2009) that women exhibit greater levels of risk aversion compared to men, while older individuals tend to opt for less risky decisions when contrasting their life cycle choices with those of younger generations (Tymula et al. 2013). We compare the expected probability to evade the car tax for all four groups. The results are reported below.

Young Woman	Young Man	Av. Probability	Aged Woman	Aged Man
19.38%	23.50%	12.89%	5.47%	5.01%

As expected, the results show that a risk-loving person (i.e., a taxpayer in their younger years) is more likely to engage in tax evasion (differences vary between 14 and 18 percentage points for women and men, respectively)[17]. This pattern is exacerbated with age. Women are more risk averse than men, but only when in their younger years. In fact, among the elderly, we find a higher level of tax compliance for males. As per Tymula et al. (2013), this phenomenon could stem from either increased risk aversion among older individuals or a heightened sense of civic duty, which may grow with age as individuals gain wisdom.

As discussed in Section 4.2, civic duty, captured by individuals' engagement with the local administration, plays an important role in our analysis. Communities actively engaged in public life tend to align more closely with political decisions and consequently adhere to taxation principles, actively contributing to public goods. Spatial clustering further supports the perspective of Erard and Feinstein (1994a, 1994b) regarding the contextual significance in shaping individual evasion behaviours, heavily influenced by imitative tendencies. We consider the predicted probabilities of those with high/low civic participation. Our results confirm that taxpayers belonging to municipalities with lower civic participation (first quartile of the distribution) have a 5.3% higher chance of not paying car tax.

High Civic Virtue	Av. Probability	Low Civic Virtue
11.02%	12.89%	16.32%

The literature indicates that a stronger sense of civic duty may be associated with higher quality of local or central institutions (for example, Torgler 2003) fostering a trusting relationship between the government and citizens, who may feel represented in their preferences. Likewise, living near the central administration may positively influence tax compliance, as citizens may feel more involved in the decision-making process (see, e.g., Pukeliene and Kažemekaityte 2016). We therefore analyze different levels of evasion in municipalities with different institutional quality and consider comparing the 25% of municipalities with high institutional quality against the 25% with low institutional quality. To rank municipalities by institutional quality, we take into account investments in transport, and the distance from the regional capital, as the analysis in Section 4.2 shows a greater propensity to evade taxation in municipalities not in the proximity of Florence (referred to in the literature as a measure of "power distance", i.e., the perceived distance from decisional centres). The results confirm that areas closer to central administration and with better infrastructures show a lower level of evasion than those in peripheral areas.

High Institutional Quality	Av. Probability	Low Institutional Quality
10.58%	12.89%	15.03%

We finally consider the impact of tax due on the probability of evading taxes. Our analysis in Section 4.3 suggests that higher taxation is associated with more tax evasion. We compare here the highest tax quintile, with amounts of tax due exceeding EUR 665, and the second quintile, with amounts between EUR 93 and 255.[18] The findings indicate a higher likelihood of evasion for exceptionally large tax amounts, with taxpayers evading at more than double the average rate. Conversely, the second quintile of tax amounts, representing the majority of taxpayers, exhibits a non-compliance rate slightly below the average.

Low Tax Amount	Av. Probability	High Tax Amount
11.01%	12.89%	26.48%

5. Conclusions

Despite the fact that car ownership non-compliance is easily identifiable by the local government, a significant proportion of the tax continues to be evaded by taxpayers in the Italian region of Tuscany. This paper identifies and discusses important factors affecting the decision to engage in vehicle tax evasion, an earmarked levy financing regional governments. These factors encompass socio-economic demographic attributes of taxpayers, characteristics of vehicles, and economic environmental factors, as well as the quality of local institutions and citizens' sense of civic responsibility. The empirical analysis corroborates some existing results in the literature showing that tax evasion varies within different groups. Those who are typically characterized by high risk aversion exhibit greater reluctance towards tax evasion, notably the elderly and women. Along with individual socio-economic demographic characteristics, our analysis also indicates that institutional quality and a sense of city duty play an important role in increasing tax compliance (Allam et al. 2023). In addition, our findings suggest that tangible returns in the form of public services and investments from the administration, coupled with the perception of having a greater influence on decision-making processes, can enhance citizen compliance. In future studies of this line of research, it would be very interesting to replicate the estimated model in other Italian areas, as the car ownership tax is very unpopular and the level of evasion of this tax is estimated to be very high in all areas of the country. At present, however, data on evasion and enforcement are very limited, both at the national level and for individual regions.

In this paper, we also consider the fact that the regional administration regularly sends friendly warning letters aimed at promoting tax compliance within the context of the analyzed earmarking taxation. While a comprehensive analysis of friendly warning

policies is not within the scope of our paper, we find evidence that the approach has been effective in encouraging a portion of the population to pay the tax. However, a significant portion of individuals did not perceive themselves at risk of enforcement and did not view the fine as a deterrent to complying with the law. The literature acknowledges the need for a more rigorous and resolute enforcement policy to overcome resistance to policy implementation. While some strategies, particularly nudging policies, and friendly warning communications, are being explored, finding a balance between political consent and public budget constraints may prove challenging for decentralized administrations due to their close proximity to citizens. In future research, it would be interesting to explore whether a nudge *plus* intervention (involving both a subtle prompt to pay the tax, the nudge, and an additional element of reflection, the *plus*) may prove more effective in encouraging tax compliance. Moreover, we plan to extend the present research if information over multiple years becomes available.

Our findings emphasize the importance for local (and central) governments to promote initiatives that cultivate a positive social environment and foster the perception of individual engagement in public decision-making, thereby facilitating the effectiveness of policy implementation. From this standpoint, although earmarking taxation and decentralization may not serve as sole remedies for ensuring compliance, they prove effective in encouraging it.

Appendix A

Table A1. Descriptive statistics of the dataset.

Macro Area	Ariable Name	Description of the Variable	Mean	SD	Min	Max
	Willingness to evade car tax	1 = if taxpayer evades taxes (on all vehicles); 0 = otherwise *	0.13	0.34	0	1
Vehicle variables	Car tax	Car tax due per individual taxpayer	216.1	122.8	18.6	5658
	Average car tax per municipality	Average car tax per municipality	216.2	7.19	193.9	257.9
	Number of cars	No. of cars owned by taxpayer (individual)	1.14	0.38	1	4
	Number of cars (per capita)	Total no. of cars owned by taxpayers/total residents (per municipality)	1.14	0.02	1.1	1.23
	Present car value	Present car value (individual) **	40.58	56.3	0	1600
	Average present car value per municipality	Average present car value per municipality	40.56	3.91	21.62	51.95
	Car age	Car age (individual)	7.19	4.46	0	62
	Average car age per municipality	Average car age per municipality	7.19	0.46	5.99	9.5

Table A1. *Cont.*

Macro Area	Ariable Name	Description of the Variable	Mean	SD	Min	Max
Socio-economic and demographic variables	Taxpayer age	Taxpayer age (individual)	52.47	15.01	0	99
	Average taxpayer age per municipality	Average taxpayer age per municipality	52.45	1.31	48.92	58.53
	Taxpayer income	Taxpayer income (individual)	25,399	31,869	−73,659	10,000,000
	Foreigners	1 = if taxpayer is not Italian (excluding Chinese); 0 = otherwise (base category: Italian)	0.07	0.02	0.03	0.21
	% foreigners	% foreigners in the municipality on total residents	0.07	0.02	0.03	0.21
	Chinese	1 = if taxpayer is Chinese; 0 = otherwise	0.01	0.01	0	0.06
	% Chinese	% chinese in the municipality on total residents	0.01	0.01	0.00	0.06
	Marital status	1 = if taxpayer lives as a couple or married; 0 = otherwise	0.32	0.46	0	1
	Female	1 = if taxpayer is female; 0 = otherwise	0.57	0.50	0	1.00
	% female in municipality	% of females in the municipality on total residents	0.43	0.02	0.31	0.50
	Employee	1 = if taxpayer is an employee; 0 = otherwise	0.50	0.50	0.00	1.00
	Self-employed	1 = if taxpayer is self-employed; 0 = otherwise	0.11	0.31	0.00	1.00
	Retired	1 = if taxpayer is retired; 0 = otherwise	0.28	0.45	0.00	1.00
	Other source of income	1 = if taxpayer has "other" sources of income; 0 = otherwise	0.06	0.24	0.00	1.00
	"Not available" income	1 = if taxpayer has no source of income; 0 = otherwise	0.05	0.21	0.00	1.00
Economic environment variables	Number of firms per capita	Total number of firms/total residents	0.09	0.02	0.03	0.18
	% of firms in tertiary sector	% firms in tertiary sector on total firms	0.10	0.04	0.02	0.29
	Average taxpayer income per municipality	Average taxpayers' income per municipality	36,358	5115	22,247	57,413
	% employed	% employed taxpayers on total residents	47.98	3.45	30.83	56.84
	% self-employed	% unemployed on total residents	7.89	1.84	3.06	14.93
	% retired	% employed taxpayers on total residents	0.29	0.03	0.20	0.49
	% self-employed	% self-employed taxpayers on total residents	0.12	0.02	0.05	0.22
	% other source of income	% taxpayers with other source of income on total residents	0.07	0.01	0.03	0.17
	% unemployed	% unemployed on total residents	0.08	0.02	0.03	0.15

Macro Area	Ariable Name	Description of the Variable	Mean	SD	Min	Max
Institutional variables	% volunteers	% of taxpayers active in the third sector and volunteer opportunities within the municipality	0.11	0.04	0.02	0.41
	Number of parties	Number of political parties that participated in the previous local elections	6.57	3.54	1	15
	% voters	% of voters in the previous local elections	0.79	0.03	0.52	0.85
	Distance from Florence	Distance from the capital Florence (in km)	66.57	44.77	0	198.4
	Tax burden per municipality	Tax burden pro capite per municipality	1026.00	338.1	452.00	3574
	Investment in transports	% of investments on transport per municipality	45	50.99	0	1251
	% Fixed public expenditure	Fixed public expenditure/total expenditures	29.64	5.76	5.63	50.91

Notes: * the terms taxpayers and tax due refer to the earmarking taxation considered in this paper. ** Details provided in Equation (3).

Notes

[1] Brockmann et al. (2016) also mention a third mechanism that reinforces these two, which is the "warm glow of giving" (see Andreoni et al. 1998), which, given the direct influence over their use of money, makes individuals perceive themselves as benefactors of society and makes them feeling kind.

[2] There is a difference between identified and prosecuted, since it is often more difficult at the local scale to recover amounts due to the economic, social and political cost of doing so.

[3] Aci-Quattroruote report, Quattroruote, April 2014.

[4] A specific tax surcharge is due for cars with an engine power exceeding 185 kW, depending on the car's age.

[5] Hereafter, the terms "car" and "vehicle" will be used interchangeably in the paper and refer to car ownership tax evasion.

[6] We have considered in the dataset only those taxpayers on which relevant information was available and who either decided to pay or not to pay the full tax. As shown in Table 2, among those who did not pay, we were also able to further distinguish between late payers and tax evaders.

[7] Once the payment due date has passed, and payment is not received by the local authority, the taxpayer receives a notice to comply with the obligation, the so-called 'friendly warning'.

[8] In this case, a tax return was not present in the administrative archive.

[9] The ASY model takes its name from further development to the Allingham and Sandmo (1972) model suggested by Yitzhaki (1974). Hereafter, we will use the terms 'ASY model' or 'traditional/conventional tax evasion model' interchangeably.

[10] In the first year after the due date, the penalty rate is very low and varies from 0.1% to a maximum of 0.375% (when payment is received after six months to one year of delay). If the taxpayer is classified as a tax evader, a fixed amount of 30% of the tax value, in addition to the tax itself, should be paid.

[11] Unlike income taxation, ownership taxes do not allow people to evade part of the due tax. The taxpayer has only two options: evade the tax or pay the tax honestly.

[12] Evidence on the use of friendly warning messages on tax compliance is controversial. Using social norms and public service messages, Hallsworth et al. (2017) found that reminder letters for overdue tax payments in the UK increased compliance. Similarly, according to De Neve et al. (2021), simplifying the communication of the tax administration and deterrence messages have a positive effect on tax compliance and are more efficient than invoking tax morale. However, other papers find no or insignificant effects of friendly warning messages on tax compliance. Galmarini et al. (2014, p. 22), for example, empirically find that receiving a tax notice (i.e., a friendly warning message) is "insufficient to correct the individual incentive to escape tax authorities". They suggest complementing letters with other policies in order to reinforce the deterrence, such as giving public evidence of evaders and inhibiting loans and bank accounts.

[13] In their study, Perez-Truglia and Troiano (2018) show for example that shaming tax delinquents and friendly warning reminders (varying the salience of financial penalties) increase compliance. However, receiving information on other's non-compliance did not have any impact on tax compliance.

14   In this field experiment, after 30 days of receiving the reminder, all taxpayers who did not comply with their tax liability on property taxes received an additional penalty, which increased by 0.5 percentage points per month up to a maximum of 12%.

15   Many scholars suggest tax morale as being one of the main factors explaining individuals' tax compliance (see (Torgler 2003) and (Luttmer and Singhal 2014) for a taxonomy). Others stress stigma and reputation costs as possible deterrents to tax evasion (see, e.g., Gordon 1989; and Blaufus et al. 2017). Spicer (1986) and Kirchler (2007) emphasized the relevance of 'psychic costs' to determine whether individuals are willing to engage in tax evasion and, more recently, Barile et al. (2022) empirically showed the impact of 'moral hinterland' variables on the willingness to engage in tax evasion and benefit fraud.

16   For each variable, we report the estimated coefficient, the associated standard errors, test statistic, *p*-value and 95% confidence interval. Different measures of R-squared are also reported, indicating the explicative power of the model. The effect of group effects is captured simultaneously with the effect of group-level predictors by the "municipality" variable using a multilevel random effects model.

17   The difference is computed by subtracting the expected probabilities for women and men in different age groups.

18   In this case, we do not consider the lowest quintile, as the small amount of tax due by taxpayers is more likely to lead them to pay late rather than evade the car tax.

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Article

Tax Evasion and Company Survival: A Brazilian Case Study

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Abstract: Enterprises face significant growth and survival challenges in highly competitive markets. Many companies fail to meet their tax obligations, which deprives society of essential resources and often results in tax penalties. This article examines whether companies that receive tax fines for evasion have a longer or shorter life expectancy compared to those that consistently comply with tax regulations. To analyze survival rates, the Kaplan–Meier estimator and Cox regression model were applied, considering factors such company size, sector, location, and tax evasion fines. The study included data from 11,297 firms established in 2017, in Rio Grande do Sul, Brazil. The findings indicate that companies fined for tax evasion had a higher survival rate (69%) compared to those without fines (38%) by 2023. This suggests that fines might serve as a corrective measure, helping companies realign and improve their chances of survival. Additionally, the study shows that medium-sized enterprises face significant challenges, possibly due to exceeding the limits of a simplified tax regime. This study highlights the importance of continued research across different regions and countries to validate these findings and enhance tax administration strategies.

Keywords: tax evasion (H26); semiparametric and nonparametric methods (C14); business economics (M21); development planning and policy (O20); Brazil

1. Introduction

Entrepreneurs typically launch their companies with the expectation of achieving growth and profitability. They are driven by various factors, including demonstrating their abilities and validating their ideas. However, when these expectations are not met, and daily challenges persist alongside ongoing losses, closing the business becomes a likely outcome, particularly during times of crisis. It is expected that fines for tax evasion serve as a warning to correct course. Tax evasion fines are intended to serve as a corrective measure, promoting fair competition in the market and ensuring that revenue is collected for its intended societal purpose. Tax evasion remains a significant issue in both developing and developed countries (Buehn and Schneider 2016; Cebula and Feige 2012; Gamannossi degl'Innocenti and Rablen 2020; Slemrod 2007; Costa et al. 2022).

Hanousek and Palda (2009) identified a positive correlation between production efficiency and fiscal honesty, suggesting that the presence of an underground economy and high tax rates could lead to inefficient producers crowding out efficient ones, despite companies feeling threatened by tax-evading competitors. Porter (2012) argues that not all economic sectors are equally attractive in terms of profitability and the factors that influence it, which is a critical consideration for survival analysis. Sectors with small margins require a high level of efficiency. According to Mazzucato and Kattel (2020), the COVID-19 pandemic has posed unprecedented challenges for governments, from providing support to citizens to assisting struggling businesses.

Studying tax evasion and corporate survival enables us to understand the impacts of government action on the life cycle of companies, thus evaluating the effectiveness

of regulation. It allows for the development of public policies that drive business and economic development, greater compliance, and also greater revenue for the state.

This article examines the survival rates of companies registered with the Finance Secretariat of the State of Rio Grande do Sul (RS). The objective is to measure the survival of companies established in 2017, tracking their performance from 2017 to 2023. The data obtained are officially from the State Revenue Agency, which provides official information that enables the monitoring of these companies throughout the study period. The analysis focuses on differences in survival based on size, sector, region, and fines, with particular attention to whether companies fined by tax authorities have different survival rates compared to those not fined. To achieve this, the Kaplan–Meier technique, the Cox procedure, and Propensity Score Matching were employed. In addition to this introduction, this article is structured as follows: Section 2 outlines the evolution of the tax administration. Section 3 presents a review of the literature on tax evasion and empirical studies of survival analysis. Section 4 details the methodological procedures used in the study. Section 5 presents and analyzes the results. Finally, the concluding section summarizes the study's findings.

2. The Evolution of Rio Grande Do Sul Tax Administration

The tax administration of Rio Grande do Sul (RS) has a longstanding and effective tradition of adopting digital solutions to ensure tax compliance. Over time, the RS tax administration has shifted towards a more citizen-centric model, reserving punitive action as a last resort. In a study on the factors influencing tax compliance, Alm (2019) suggests that a combination of approaches—including enforcement, a service-oriented paradigm, and a trust-based paradigm—are all critical to motivating compliance and should be further enhanced. Aberbach and Christensen (2007) observe that, despite the seeming contradiction between the traditional control-based tax systems and newer, customer-friendly approaches, many tax agencies have become increasingly oriented toward customer service in recent decades. Bird (2010) highlights that there is no one-size-fits-all formula that guarantees superior tax administration.

Countries exhibit a wide range of levels of tax compliance, which reflects the effectiveness of their tax administrations, the attitudes of taxpayers, and their government legitimacy. For Bird (2010), the ideal strategy would include rewards for those who comply and penalties for those who do not. According to Yu et al. (2017) and Kumar et al. (2023), the digital divide is one of the most critical issues to the adoption of new technologies.

Therefore, offering simplified and accessible obligations, along with guidance and reminders through various platforms, is essential to increase levels of voluntary compliance. In other words, maintaining close contact with taxpayers is essential.

The foundation of the tax compliance pyramid is composed of taxpayers who want to meet their obligations but require maximum assistance. This group requires maximum assistance, which should be provided through a variety of services and channels (Inter-American Center of Tax Administrations—CIAT 2020). In the light of these trends and the supporting literature, the RS tax administration has adopted a new model, illustrated in Figure 1.

Companies face significant growth and survival challenges in highly competitive markets. Due to various factors, they often fail to meet their tax obligations, depriving society of essential resources, which eventually leads to tax penalties. In response, tax administrations have adopted more taxpayer-friendly approaches. In recent years, several initiatives have been implemented by the RS tax administration. One key transformation was the creation of Shared Services Centers (CSCs), which focus on billing, inspection, and citizen relations.

It is also important to highlight four programs: Develop RS, Cooperative Compliance, tax education, and asset recovery (CIRA). Develop RS interacts with various economic sectors to assess the context, proactively, based on economic–fiscal indicators. It aims to enhance public policies and strategies that boost the state economy and tax collection. The Cooperative Compliance program uses a tax intelligence system that ensures legal

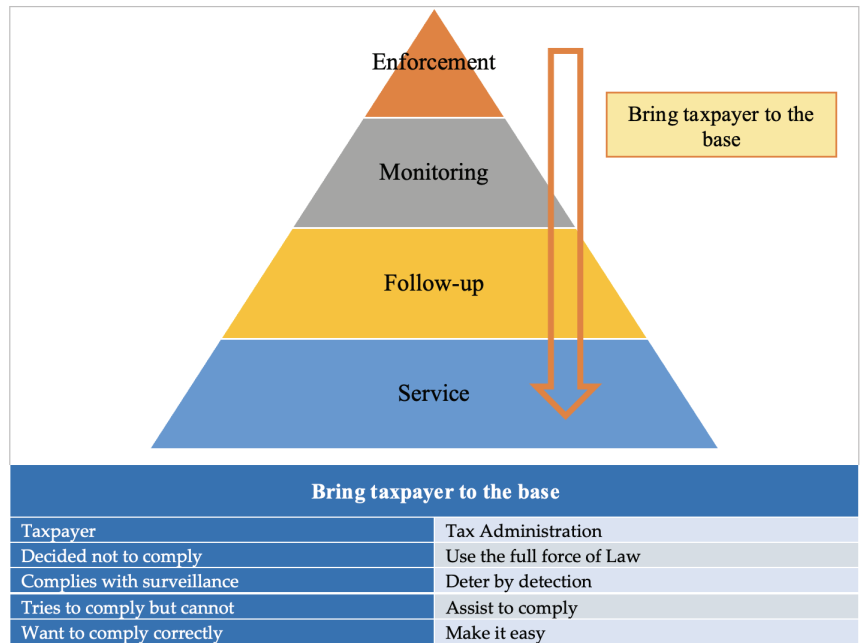certainty for taxpayers through agreed parameters with economic sectors, reducing tax risks and disputes.

Figure 1. Model adopted for RS tax administration. Source: prepared by the authors. (OECD 2004).

The tax education program has registered 3.5 million citizens and incentivizes them to request electronic invoices using their tax number, granting access to prizes and partial tax refunds. This program encompasses a range of initiatives, notably the launch of the *Menor Preço Brasil* in late 2019. This digital tool became crucial during the COVID-19 pandemic, allowing citizens to find nearby products at lower prices, reducing the need for in-person visits, and thereby lowering the risk of contagion (Tonetto et al. 2023b). Two additional programs were implemented at the end of 2021. Devolve-ICMS seeks to return part or all of the consumption tax to lower-income individuals, aiming to eliminate or mitigate the regressive nature of consumption tax (Tonetto et al. 2023a). *Receita Certa*—a cashback program, is conditioned on revenue growth in commerce activity (Tonetto et al. 2024a). These initiatives not only help curb tax evasion but also enhance state revenue, allowing for improved public services.

To further strengthen enforcement, the *CIRA*, which consisted of an Interinstitutional Asset Recovery Committee, was established. This committee integrates the tax administration with the State Attorney General's Office and the Public Ministry. It aims to develop joint activities to combat tax fraud and unfair competition, with a focus on asset recovery and holding offenders administratively, civilly, and criminally liable.

3. The Tax Evasion Literature

According to Abdixhiku et al. (2017), tax evasion is driven by both firm-level and institutional-level variables. Firms with low trust in government and higher compliance costs are more prone to tax evasion. Their study found that firms less visible to tax authorities are more likely to engage in such behavior. Similarly, Ahmadi et al. (2014) studied the effect of tax strategy on tax evasion in the province of Zanjan, Iran. The study designed a questionnaire to study the effects of the following variables: the promotion of tax culture, the lack of belief in tax payment consequences, the filing of false tax statements,

tax exemptions, and the general culture of the community. The results revealed a positive and meaningful relationship between tax evasion and the variables. Baumann and Friehe (2010) demonstrate that a firm's level of activity is determined by its investment, which is affected by tax evasion considerations, thus creating an indirect relationship between firm size and evasion. Given this, the act of deterring tax evasion has other effects in addition to its direct effect on tax revenues. The authors emphasize that stricter tax enforcement may have the undesirable consequence of reducing firm investment.

Alm (2012) argued that beyond standard enforcement policies, tax administration should incorporate strategies from both the service and trust paradigm to capture the complexity of taxpayer behavior. Studies suggest compliance does not increase linearly, and merely increases the probability of detection. Clotfelter (1983) suggested that tax rates should be considered along with enforcement, tax simplicity, and information communication as valid instruments that can influence tax evasion. According to Cuff and Palda (2003), a reduction in the tax base is an obvious social cost of tax evasion, but the cost of the potential replacement in the market of efficient firms by less efficient firms that are better able to evade taxes is less clear. The question remains whether this behavior stems from current tax policies or firm characteristics; it is likely a combination of both.

Dufwenberg and Nordblom (2022) explored how moral concerns influence tax compliance, finding that inspectors' moral concerns often surpass those of the taxpayers. Cebula and Feige (2012) found significant non-compliance with the tax code and the federal income tax evasion in the U.S. The authors discovered that between 18% and 23% of total reportable income may not have been adequately reported to the IRS. Meanwhile, Buehn and Schneider (2016) concluded that tax evasion is decreasing on average, but also individually in 38 OECD countries, between 1999 and 2010. The average size of tax evasion in 1999 was 3.6% of GDP and this value decreases less steadily to 2.5% or 2.8% of official GDP in the years 2009 and 2010.

An article by Gamannossi degl'Innocenti and Rablen (2020) provided a theoretical advancement by demonstrating a link between network centrality in a social network and tax evasion. In a context in which tax authorities are investing in technology that seeks to build social networks, it shows that information from the network can allow a better prediction of revenue benefits in the case of carrying out an audit on a specific taxpayer. For a tax authority that is unfamiliar with the use of the social network, the study reveals strong initial revenue gains from acquiring relatively small amounts of information from the network.

Dabla-Norris et al. (2019) emphasized that tax evasion negatively impacts a country's revenue and development, which often distorts competition. Their study portraying the self-reported share of declared income as a proxy for tax evasion suggests that productivity improvements could reduce tax evasion. According to Dabla-Norris et al. (2020), tax compliance costs tend to be disproportionately higher for small and young businesses. The authors examined how tax administration quality affects firm performance, showing that a better tax administration helps level the playing field between small and large firms. They build a tax administration quality index based on information from the tax administration diagnostic assessment tool, where the results show that better tax administration mitigates the productivity disparity of small and young companies in relation to larger and older companies.

Elffers et al. (1987) conducted a survey on tax evasion behavior in the Netherlands and found no significant correlation between scores and self-reports of tax evasion behavior. The results were rather disappointing as the self-reports were obtained under conditions that should have maximized their veracity. An additional analysis indicated that attitudes, norms, and personality variables are correlated with admitted tax evasion and actual behavior patterns. Almunia and Lopez-Rodriguez (2018) analyze the behavior of large companies in Spain with revenues greater than EUR 6 million. The results indicate that companies strategically remain below this threshold to avoid stricter tax inspections. They suggest there could be substantial gains from extending tighter tax monitoring to smaller

companies. Bérgolo et al. (2017), seeking to understand how companies react to audits, conducted a large-scale experiment with Uruguay's tax authority, where 20,440 letters were sent to small and medium-sized companies. The authors found that providing information about audits has significant effects on tax compliance. They indicate that this is due to an alternative risk model based on sentiment, where messages about audits generate fear and reduce the probability of neglect. A study by Harju et al. (2024) on tax audits and tax returns in Finland points to an immediate and persistent increase in profits reported by audited companies compared to non-audited companies. The authors also found that labor costs also increased, suggesting a general underreporting of operations. They also highlight the increased likelihood of bankruptcy of non-compliant companies after audits.

Kaplanoglou and Rapanos (2015) explore the determinants of voluntary and mandatory tax compliance among Greeks, which varied based on the level of trust individuals place in the government and the authority of tax institutions. The study shows that trust enhances voluntary compliance while power results in forced compliance. Interestingly, in conditions of high trust, the power of tax authorities does not increase voluntary compliance and can even reduce it when trust is low. In these cases, power might be seen as illegitimate, especially in the post-crisis period, which eroded trust in institutions and undermined the trust paradigm as a whole. This highlights the delicate balance between trust and authority in shaping tax behavior, suggesting that tax administrations must focus on building trust to enhance voluntary compliance, especially after periods of crisis.

Kahneman and Tversky (1979), in their critique of the utility theory, introduced the prospect theory, which explains how individuals make decisions under risk and uncertainty, where people undervalue probable outcomes in favor of certain ones. This leads to risk aversion in situations involving potential gains and risk-seeking behavior when facing certain losses. Costa et al. (2022) analyzed how decision-making can influence the effectiveness of behavioral interventions to increase tax compliance. They concluded that applying behavioral economics can effectively improve tax compliance.

According to Fehr et al. (2015), awareness or knowledge of how one's behavior affects others can significantly influence decision-making. However, evidence suggests that people often have little or no knowledge of whether their actions positively or negatively impact society. Economic incentives can affect willingness when individuals are aware of the issue but are unwilling to change. Positive or negative incentives can be an effective tool in addressing this situation, as demonstrated by offering amnesty to tax offenders in exchange for delayed compliance. Marchese (2009) examined the effects of monetary incentives on tax evasion within competitive markets. Initiatives encouraging consumers to act as auditors can increase the perceived risk of audits. However, the author cautions that, depending on market dynamics, this could lead to "market revenge" through price increases.

According to Slemrod (2007), variations in compliance with duty and honesty can explain part of the heterogeneity in evasion between individuals. The author highlights deterrence as a powerful factor influencing evasion decisions, considering significant differences in compliance rates between taxable items, which closely correlate with detection rates.

Skinner and Slemrod (1985) examined several economic aspects of tax evasion and policies to improve tax compliance. They argued that the costs of tax evasion include violations of horizontal equity, vertical equity, and efficiency. The tax authorities have several options to address this, including enforcement changes, penalties, tax simplification, and reduced marginal rates. While increases in enforcement can generate more revenue, it also comes at a substantial cost. Raising penalties may create inequities between those who are caught and those who evade detection. The authors advocate for tax simplification as a way to reduce loopholes that are breeding grounds for tax evasion. Sandmo (2005) explores the challenges in developing optimal taxation models in the presence of tax evasion. He identifies indirect tax evasion as a potential issue, especially in the sale of final goods and services to consumers. The tax evasion decision may be influenced by a taxpayer's perceptions of the behavior of others. When tax evasion becomes more widespread, it may

be seen as more socially acceptable, lowering the perceived risk of detection. This is a good reason to try to control dropout. Relaxing policy measures in this area could trigger mechanisms that lead to a much lower level of tax compliance schemes.

Yamen et al. (2023) investigate the impact of digitalization on tax evasion and examine how corruption moderates this relationship. The findings show a negative and significant relationship between tax evasion and the digitalization of businesses and people, with digitalization proving highly effective in reducing tax evasion, particularly in low-income countries and countries with high levels of corruption. According to the author, investing in technology can increase tax revenues and enhance government efficiency in resource allocation. Pyle (1991) examines two key questions in the literature. Firstly, why do individuals avoid their tax obligations, and secondly, what policies should governments implement to reduce or eliminate evasion? The author highlights the high costs of combating tax evasion and concludes that many studies contain significant flaws. Given the difficulty in determining a socially optimal level of evasion, Pyle suggests that governments are likely to adopt suboptimal policies aimed at curbing tax evasion. Yet, there remains a considerable debate over the creation of effective policies in this area.

Empirical Survival Case Studies

According to Instituto Brasileiro de Geografia e Estatistica—IBGE (2023), an analysis of company survival from 2017 to 2021 revealed that for companies created in 2016, the overall survival rate was 78.0% after one year of operation (2017) and it fell to 43.0% after five years (2021). They found a direct relationship between size and survival; that is, the larger the size of the entity, the higher the survival rate. The survival rate of the smallest companies was 38.0%, followed by 53.8% for medium companies, and 69.4% for bigger companies.

An OECD (2015) study underscores the challenges small and medium-sized enterprises face in securing financing, and the tax system plays a dual role, sometimes supporting and sometimes hindering these enterprises. Furthermore, it highlights that there is a tendency for debt to the detriment of social capital. According to the OECD (2015), younger companies have a higher failure rate than older ones, with over half of companies failing by their fifth year. A study by Resende et al. (2016) highlights the positive role played by company size in survival and the negative influence exerted by the minimum efficiency scale and the suboptimal scale. A study by Conceição et al. (2018) identified that companies created in 2007 and opting for *Simples Nacional* had a 30% lower chance of survival compared to non-opting companies. A study by Rodas Céspedes et al. (2020) on company survival rates in RS from the period 2007–2013 showed higher survival rates in companies with more employees. In this study, smaller companies had the lowest survival rate, equivalent to 34% in year 7. Mata and Portugal (1994) found that in Portuguese industrial companies, one-fifth of companies closed during their first year, and only 50% survived for four years or more.

Audretsch and Mahmood (1995) argued that specific establishment characteristics influence risk exposure, and the ownership structure can substantially shape a company's probability of survival. According to Agarwal and Audretsch (2001), the relationship between company size and the probability of survival is shaped by technology and the industry's life cycle stage. Tonetto et al. (2024b) applied a survival analysis for small businesses during the COVID-19 pandemic in Rio Grande do Sul, Brazil. The authors highlight a relation between size and survival for small businesses in the simplified tax system, with higher resilience in companies with higher annual revenues. However, survival rates were worse in the metropolitan areas; de Cezaro Eberhardt and Fochezatto (2024) highlighted that being located in a metropolitan region increases the chance of overcoming crises by 95%. Metropolitan areas demonstrated better resilience during the 2008 global financial crisis, particularly in job recovery, likely due to economies of agglomerations and better infrastructure.

4. Methods

Survival analysis is one of the most commonly applied statistical techniques, particularly the Kaplan–Meier estimator (Kaplan and Meier 1958), and is often used in conjunction with the Cox model (Cox 1972). The response variable in survival analysis is the time until the occurrence of an event of interest, referred to as the "failure time," which in this context is the closure of a company. Colosimo and Giolo (2021) state that survival analysis aims to determine the probability of survival and the risk of closure of a group of companies, with time and other known factors as covariates serving as determinants. According to Carvalho et al. (2011), survival analysis is particularly used for addressing cases where the event's likelihood is not constant over time.

The main characteristic of the database is the presence of censorship, which in this case refers to companies that survived. Without censored data, other statistical techniques, such as regression analysis, could be applied. However, the Kaplan–Meier method has limitations when working with small samples, competitive censorship, or long-term projections. Additionally, it does not account for covariates, which is why the Cox model is often used in combination. Govindarajulu and D'Agostino (2020) point out that the assumption that censorship must be independent of the real time of the event has often been underestimated in survival analyses. The author highlights the evolution that the Cox model brought with semiparametric analysis.

In this study, we aim to investigate the extent to which fines for tax evasion in RS have impacted the survival of companies over the past seven years. The data for this analysis were sourced from the Revenue Agency of RS, covering the period from 2017 to 2023. Our focus is on companies established in 2017 and registered in the RS state system. It is important to note that the Brazilian economy underwent a unique crisis in 2015 and 2016, characterized by high inflation (exceeding 10%) and a recession, which was linked to a political crisis culminating in the impeachment of the president. Economic recovery began in 2017, and by 2018, the macroeconomic indicators showed improvement. However, in 2020, the Brazilian economy faced the repercussions of the pandemic, leading to logistical instability in the supply of products on both local and global scales, and inflation re-emerged as a significant concern. To alleviate the economic impact, several measures were implemented, including budgetary support for individuals and businesses, the postponement of tax payments, and the suspension of active debt collection processes and tax litigation.

Companies were categorized into three brackets based on their size. The first bracket comprises the small businesses under simplified tax regulations. The second and third bands consist of companies subject to standard tax regulations with medium-sized companies defined as those with annual revenues below BRL 20 million, while large-sized companies have annual revenues above this threshold. Additionally, economic activities were classified according to the National Classification of Economic Activities (CNAE), and condensed into six primary sectors.

The main analysis focuses on companies fined for undeclared taxes compared to those not fined. Companies that report the correct amount of the obligation, but for some reason did not make the payment on the correct date, are not considered evaders. According to Alm (2019), "tax evasion" consists of illegal and intentional actions taken by individuals to reduce their legally due tax obligations.

The fined companies are 1027 in a sample of 23,796. Using Propensity Score Matching with a ratio of 1 to 10, we reduce distance by factors like size, sector, and region. Thus, we kept 11,297 companies to analyze (Table 1).

Furthermore, we analyzed survival by geographic location. The state of Rio Grande do Sul is divided into nine functional regions (Estado do Rio Grande do Sul 2011). The study also uses Cox's semiparametric technique, with the purpose of testing the effect of size, sector of activity, and region.

Table 1. Control and treated groups.

	Control	Treated	Total
All	22,949	1027	23,976
Matched PSM	10,270	1027	11,297
Unmatched	12,679	0	12,679

Source: Compiled by the authors.

The survival function is defined as the probability of an observation not failing until a certain time t, that is, the probability of an observation surviving time t. This is written as follows:

$$S(t) = P\ (T \geq t) = 1 - F(t) \tag{1}$$

where S(t) is the survival function; t is the non-negative random variable; and T is the maximum time that t can reach. The cumulative distribution function is defined as the probability of an observation not surviving time t, i.e.,

$$F(t) = 1 - S(t) \tag{2}$$

The survival function is equal to 1 at the beginning of the period, and as time passes, it tends to decrease or remain constant. The failure rate function $\lambda(t)$ is useful for describing the lifetime distribution of companies, as it describes the way in which the instantaneous failure rate changes over time.

$$\lambda(t) = S(t) - S\ (t + \Delta t)\ \Delta t\ S(t) \tag{3}$$

The increasing nature of the function indicates that the company's failure rate rises over time. In total, this study analyzed 9350 companies, with an event occurring in 5403 (58%); 3947 companies were censored (42%).

Survival analysis refers to the probability of a company surviving after a certain time; if formulated by risk analysis, it refers to the risk of a company closing after having survived a certain period (Carvalho et al. 2011). The risk function can be obtained from the survival function:

$$H(t) = \frac{f(t)}{S(t)} \tag{4}$$

The estimation is performed using the maximum likelihood method. For Kaplan–Meier, the probability of survival at moment tj is estimated by the number of survivors at that moment, $[R(t_j) - \Delta N(t_j)]$, divided by the number of establishments at risk up to that moment $R(t_j)$:

$$\hat{S}_{km}(t) = \prod_{j:t_j \leq t} R(tj)\frac{R(t_j) - \Delta N(t_j)}{R(t_j)} = \prod_{j:t_j \leq t} 1 - \frac{\Delta N(t_j)}{R(t_j)} \tag{5}$$

The function can be represented according to strata originating from the classification of covariates, thus being able to evaluate the survival of subgroups, which may present important variations. The Log-rank hypothesis test is used to evaluate these subgroups. The null hypothesis is that the risk is the same for each extract.

To estimate the effects of covariates, Cox modeling is used. This model adopts proportional risks, that is, the risk of closing a company does not vary over time in relation to another company. The Cox model estimates proportional failure rates according to Equation (6).

$$\alpha(X) = \alpha 0\ (t)\ \exp\ \{X'\beta\} \tag{6}$$

The vector X with p is a covariate, the vector β with p is an unknown parameter, and $\alpha(X)$ is the failure rate function. This can be tested by a graphical approach or by the

Schoenfeld Residuals Test (Schoenfeld 1982). The variables used in this model are described in Table 2.

Table 2. Variables used in the study.

Acronyms	Description	Minimum	Maximum	Source
ID	Anonymized	1	11,297	SEFAZ/RS
time	Time to event	1	7	SEFAZ/RS
status	0 = censured, 1 = event	0	1	SEFAZ/RS
region	Functional region	1	9	SPGG/RS
size	Small, medium, large	1	3	SEFAZ/RS
sector	Sector of activity	1	6	IBGE
AL	0 = no, 1 = notified evasion	0	1	SEFAZ/RS
Al_mode	0 = not fined, 2 = evasion not declared, 3 = formal, 7 = transit	0	7	SEFAZ/RS
IntALS1	Interaction AL and size small	0	1	SEFAZ/RS
IntALS2	Interaction AL and size medium	0	1	SEFAZ/RS
IntALS3	Interaction AL and size large	0	1	SEFAZ/RS
Habitual	No/yes	0	2	SEFAZ/RS
Fine100k	Fine of BRL 100 thousand or more	0	1	SEFAZ/RS
TTFFE	Time to first fine of evasion	0	7	SEFAZ/RS
PMCRS	Retail sales volume index in December/RS	114.8	126.5	IBGE
IntRate	Average year Interest rate goal in Brazilian economy	3.02	13.42	BCB
Av_Unemployment	Average of unemployment rate in the year	8.04	13.5	BCB

Source: Prepared by the authors. Note: AL means "*Auto de lançamento*"; it is an official document that constitutes the tax credit and places the taxpayer as a debtor. Note2: Time 1 = 2017; 2 = 2018; 3 = 2019; 4 = 2020; 5 = 2021; 6 = 2022; 7 = 2023. Functional region 1 = Metropolitan, Jacuí Delta, Sinos; 2 = Taquarí and Rio Pardo Valleys; 3 = Mountains; 4 = North Coast; 5 = South; 6 = Campaign and West Frontier; 7 = Missions, Northwest Frontier; 8 = Central, Middle, and High Uruguay; 9 = Northeast, North, and Production. Sector 1 = agriculture, livestock, and forestry; 2 = processing industries; 3 = construction; 4 = business, motor vehicle repair; 5 = financial intermediation, insurance, and pension; 6 = education and health, and others.

Table 3 shows the numbers of companies fined for different types of tax irregularity, and by size. The formal irregularity generally arises from failure to send information that is not directly related to the payment of taxes. This fine is not considered in this study as evasion. The fine for the non-declaration of taxes is always based on a previous audit that determined the situation and notified the taxpayer for payment or dispute. The transit fine is for transporting goods without the corresponding tax document. It is considered in this study as evasion together with the previous one.

Table 3. Number of firms by irregularity and value average fine in BRL.

Type of Irregularity	Small Size-Simples	Medium Size	Large Size	Total	Evasion	Average Value of Fine
Formal	192	970	17	1179		3705.91
Tax not declared	64	254	45	363	363	1,265,492.82
Transit without tax invoice	287	340	37	664	664	10,679.26
Total	543	1564	99	2206	1027	

Source: Compiled by the authors. Note: The value average is based on the maximum value of fines for each firm, because some firms have more than one fine. The small size is made up of companies under the simplified taxation regime (Simples).

5. Results and Discussion

The global analysis represented in Figure 2a shows the survival percentage year by year, since 2017. In 2023, only 41% of firms were operating. The companies were separated in terms of size into large ones with revenues exceeding BRL 20 million per year (around USD 4 million), medium ones with annual revenues less than BRL 20 million, and the small ones included in the simplified tax regime covers up to BRL 4.8 million per year (about USD 960 thousand). Some medium-sized companies could probably have opted for the simplified regime but did not.

(a) General survival curve   (b) Survival curve by size
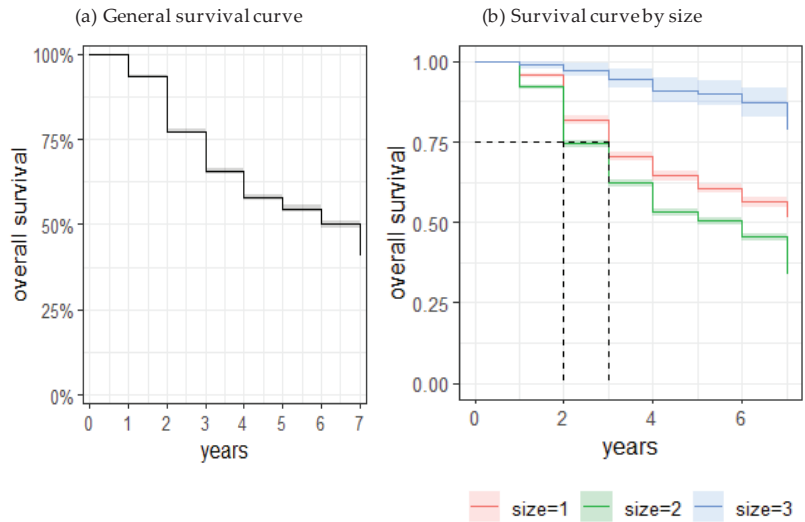
Time n	2017=1	2018=2	2019=3	2020=4	2021=5	2022=6	2023=7
Risk n.	11297	10561	8736	7425	6525	6172	5646
Event	736	1825	1311	900	353	526	1048
Survival	93.5%	77.3%	65.7%	57.8%	54.6%	50.0%	40.7%
Small Size 1	95.8%	81.7%	70.5%	64.5%	60.6%	56.3%	51.7%
Medium Size 2	92.1%	74.3%	62.3%	53.1%	50.4%	45.4%	33.7%
Large Size 3	99.1%	97.3%	94.6%	91.1%	90.2%	87.1%	78.6%

Figure 2. Kaplan–Meier survival curve, by size of business in RS, 2017–2023. Source: Compiled by the authors.

Figure 2b shows that the largest companies, with revenues equal to or above BRL 20 million, have the highest survival rate (79%). The smallest companies, under the simplified tax system, have a survival rate in the last year of 52%. The medium companies are the most affected, with only 34% surviving to year 7. This result contradicts the idea of a linear and positive relationship between size and survival.

Analyzing the first quartile of companies that close their activities, we can see that this occurs in the second year for size 2, and in the third year for size 1 companies. The figure shows the greater resilience of the largest companies.

The analysis by sectors of economic activity (Figure 3) shows a standard survival in four sectors below 40%, and a better rate in processing industries (46%) and agriculture (60%).

Figure 4 is a comparison of companies fined for taxes that were not declared by the tax administration and companies that were not fined. The companies fined only have fines that represent evasion, even in cases that occurred in truck transit. The failure in formal obligations is not included. The survival curve shows an astonishing result, where the fined companies have a survival rate of 69%, which is way better than companies that were not fined; companies that were not fined have survived at a rate of just 38% in the 7th year. This result suggests that fiscal action serves as a warning to correct course. Regarding the interaction of sizes and fine, it is important to highlight that the effect of fines in small and large companies is much bigger than in the medium ones. In relation to the type of fine, the survival of companies with a formal fine is similar to companies that were not fined. This often indicates merely bureaucratic errors in the company's accounting and tax

management. However, the companies fined in transit had a better survival rate (74%) than the ones caught in audit procedures (60%).

The interactions between the variables size and fine (AL) show a greater survival rate for companies that were fined, which is almost the double for small (S1 = 82%) and large (S3 = 87%) companies. The medium size has a smaller effect (Table A1).

Figure 5 shows that the habitual evaders, i.e., companies with two or more fines that are considered evasions (not declared or in transit), have a better survival rate (58%) compared with companies without habitual evasions (40%). Surprisingly, the ones fined with the heaviest fines have a better survival rate (66%).

Regarding the time when the fine occurs, Table 4 shows the number of evasions of fines by year and by type. The first year, when a company just opened (2017), and the fourth year (2020), when COVID-19 starts, were the years with less fines, as expected. The year 2020 had several moments of lockdowns, so the inspection of taxes in transit was restricted. This table is important as it shows that the audit procedures keep a reasonable proportion by year. The survival rate for companies fined in the first year is 65%, falling sharply in the second and third years (47%, 53%), and rising steadily after. Companies fined only in the last year had the best survival rate, probably due to their maturity.
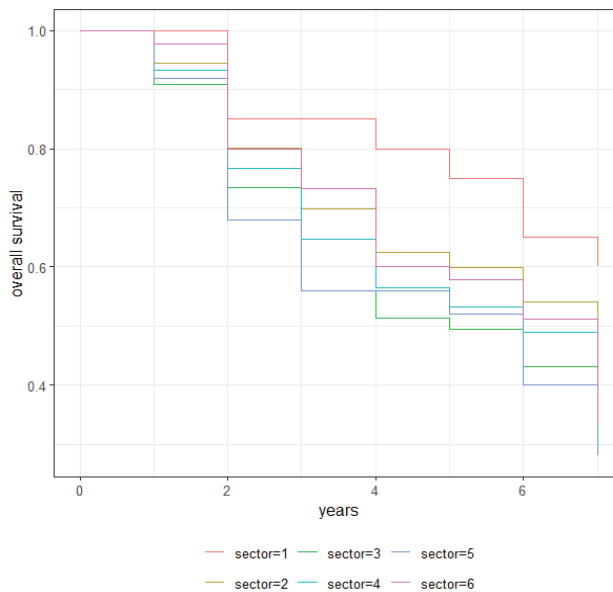
Sectors/Time	1	2	3	4	5	6	7
1-Agriculture, livestock, forestry		85.0%		80.0%	75.0%	65.0%	60.0%
2-Processing industries	94.4%	80.1%	69.8%	62.5%	59.9%	54.1%	46.0%
3-Construction	90.8%	73.4%	56.0%	51.4%	49.5%	43.1%	33.9%
4-Business, motor vehicle repair	93.2%	76.6%	64.7%	56.5%	53.2%	48.9%	39.4%
5-Financial intermediation, insurance, pension	92.0%	68.0%	56.0%		52.0%	40.0%	28.0%
6-Education and health, and others	97.8%	80.0%	73.3%	60.0%	57.8%	51.1%	33.3%

Figure 3. Kaplan–Meier survival curve, by activity sector, 2017–2023. Source: Compiled by the authors.
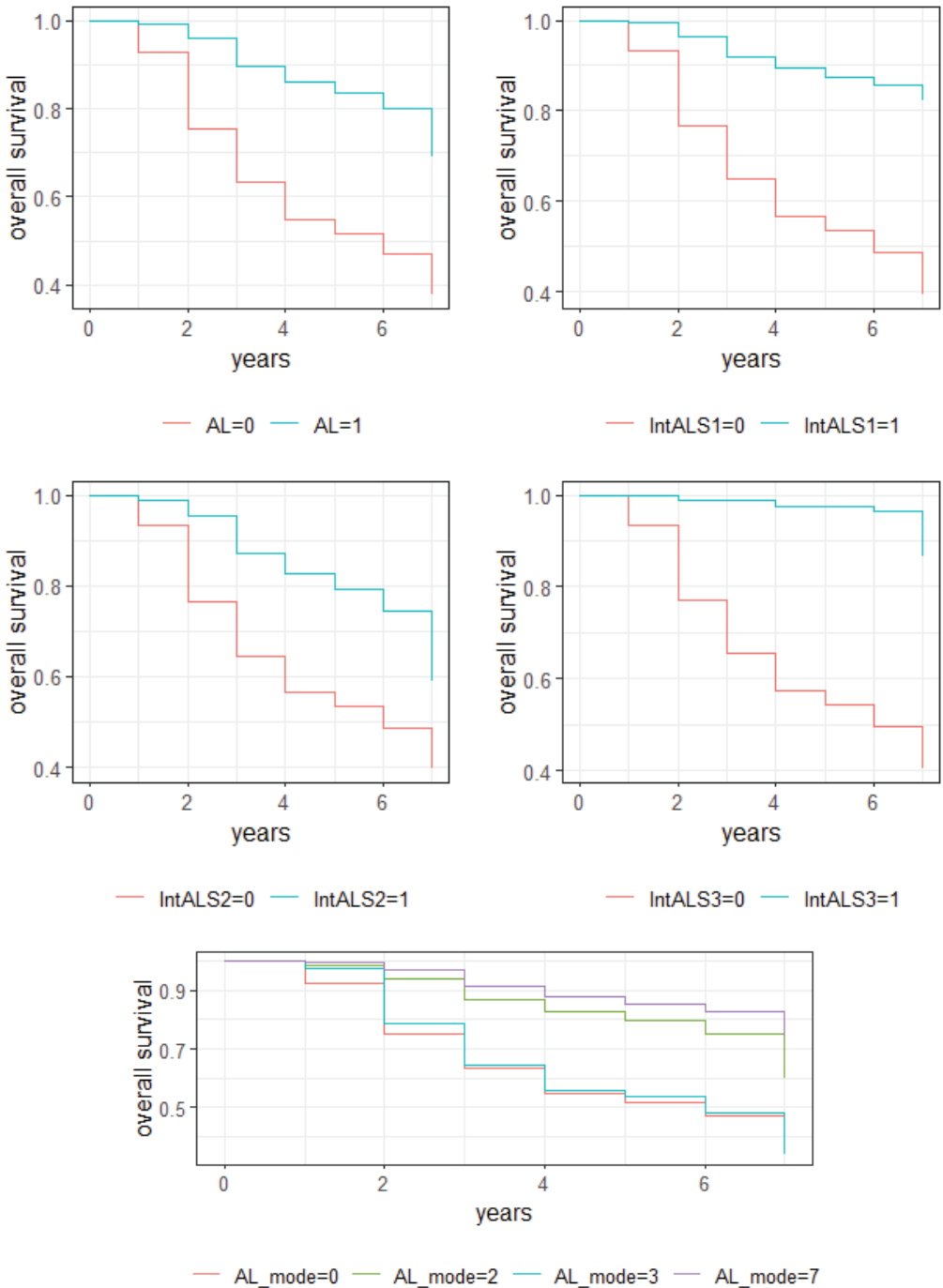
Figure 4. Kaplan–Meier survival curve, by company fined or not fined, and interaction between sizes and fines, and type of fines, 2017–2023. Source: Compiled by the authors. Note: AL = 0 not fined, AL = 2 evasion not declared, AL = 3 formal fine, AL = 7 fine in transit.
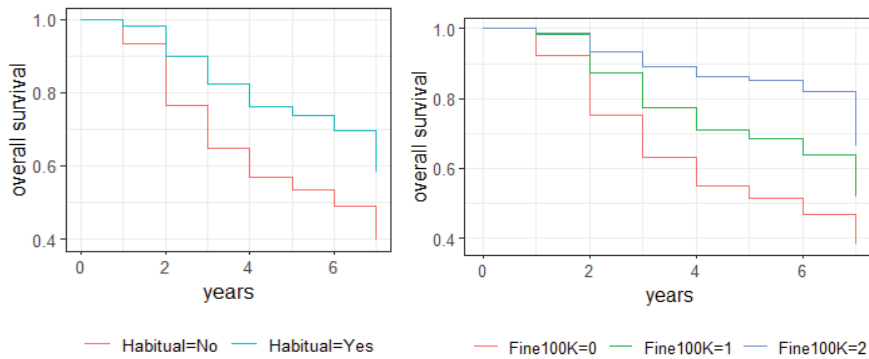
Figure 5. Kaplan–Meier survival curve for habitual evaders and fined over BRL 100 thousand. Source: Compiled by the authors. Note: Fine 100 K = 1 are firms that are fined but below BRL 100,000.00. FINE100K = 2 are firms that are fined BRL 100,000.00 or above.

Table 4. Time to first fine of evasion.

Time to Fine (Years)	Not Declare	In Transit	Evasion	Survival Rate 7th Year
1	21	48	69	65%
2	65	123	188	47%
3	54	130	184	53%
4	20	45	65	71%
5	65	91	156	75%
6	82	123	205	82%
7	56	104	160	93%
Total	363	664	1027	

Source: Compiled by the authors.

All the Log-rank tests validate the results presented. Unlike the Kaplan–Meier procedure, where the time variable determines the survival and/or risk of survival of establishments, the Cox model assesses the risk of closure based on the influence of one or more explanatory variables. In this case, these variables include the small size companies, tax fines, its regional location, and its economic activity. The selection of these three variables is based on the literature, similar empirical studies, tests validations, and depends on the availability of information.

Figure 6 highlights the agriculture sector, the metropolitan region, and small companies that were not fined, which serves as the reference group. The construction and financial intermediation and insurance and pension sectors are significant, with increases in the probability of an event of 119% and 182%, respectively. The region analysis shows that all regions are significant, and the metropolitan area has a better performance. Region 9, which represent the Northeast, North, and Production, has a reduction in the probability of a firm closing their doors of 36%. The other regions have a reduced probability of 25% on average. The smallest companies that are fined for evasion have a better position too. The probability of an event is reduced in 79% in relation to other companies.

Table 5 presents the risk proportionality test, whose null hypothesis admits the proportionality of risks between establishments as time increases. Of the three variables tested, region, sector of economic activity, and interaction of small companies with fines confirm the proportional risk.
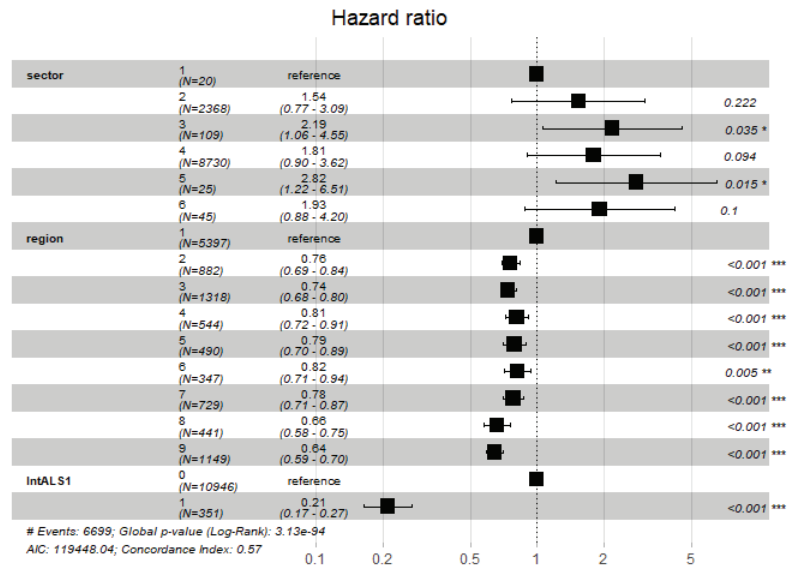
Figure 6. Forest graph by all variables. Source: Compiled by the authors. Note: Signif. codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5. Proportionality risk test in Cox regression.

Variables	chisq	df	p
sector	4.1	5	0.54
region	8.78	8	0.36
IntALS1	1.11	1	0.29
GLOBAL	13.85	14	0.46

Source: Compiled by the authors.

According to Greiner (1998), companies progress through several stages of challenges or crises as they grow, developing a model based on the maturity and size of the organization. He identifies five main dimensions of this growth process: the age and size of an organization, its stages of evolution and revolution, and the growth rate of its industry. Greiner posits that companies that survive a crisis typically undergo four to eight years of continuous growth without major economic setbacks.

Eisenhardt and Martin (2000) conclude that long-term competitive advantage lies in resource configurations rather than dynamic capabilities. According to di Petta et al. (2018), in the Resource-Based View (RBV) theory, the objective of managers is to explore the productive resources controlled by the company. Coase (1937) argues that companies emerge and grow by organizing production in a way that minimizes transaction costs. The firm will continue to grow as long as it does not exceed the costs of conducting transactions in the market or with another firm. According to Churchill and Lewis (1983), many companies remain in the survival phase for some time, achieving reasonable returns before eventually closing down when the owner gives up or retires.

Regarding the findings on survival rates, companies that were fined for tax evasion showed better survival rates compared to those that were not fined. This suggests that the tax administration model in Rio Grande do Sul is efficient, as it presents a survival rate of 69%, significantly higher than the 38% for companies not fined. Thus, enforcement appears to be aligned with voluntary compliance. Davidsson and Wiklund (2006) emphasize that firm growth is a crucial for economic development, asserting that firms, unlike biological individuals, can change and transform in numerous ways. The model proposed by Fehr

et al. (2015) is suitable for guiding the evolution of tax compliance through education, punishment, and reward, with the study indicating that punishment was effective.

For Cuff and Palda (2003), there was a question to be clarified, namely whether tax evasion behavior results from current tax policies or from company characteristics, or both. Our study confirms that this occurs in both cases, due to the results of the interaction variable of evasion with small companies in the simplified taxation regime. Furthermore, the same effect found by Almunia and Lopez-Rodriguez (2018) may be occurring in our case study in RS, that is, many companies seek to remain below the revenue limit of the simplified taxation regime to optimize their results. The results we found contradict Harju et al.'s (2024) suggestion that there is a higher probability of bankruptcy for audited companies.

Our study presents unexpected results regarding company size. The categorization of smaller companies, followed by medium and large companies, did not demonstrate a positive linear correlation with survival for companies in RS during the observed period. The analysis suggests that the difficulties faced by medium-sized companies in Brazil may stem from surpassing the limit of the simplified tax regime, the challenges posed by Greiner model (delegation, coordination, etc.) in terms of growth, or a combination of both factors. This indicates a need to modify the limits of simplified taxation and to facilitate a smoother transition to higher revenue thresholds. Additionally, there is a pressing need for enhanced support services for medium-sized companies.

6. Conclusions

This study aimed to determine whether companies fined for tax evasion have a longer or shorter lifespan compared to those that comply with tax obligations. The Kaplan–Meier estimator and Cox regression model were used to analyze the survival rates of companies based on size, sector, and tax evasion fines. The variables used were company size (small, medium, large), sector of activity, geographic location, and tax evasion fines. Data were collected from the State Revenue Agency of Rio Grande do Sul, covering 11,297 companies established in 2017.

The key findings indicate that the survival rate decreases over time, with a significant drop in the early years and the first year of COVID-19. In 2023, 41% of the companies survived, showing a decline from the initial 94% survival rate in 2017. Regarding company size, the large companies (annual revenue > BRL 20 million) had the highest survival rate (79% in 2023), as expected; small companies under the simplified tax system had a survival rate of 52%, while medium-sized companies had the lowest survival rate (34%). The finding contradicts the notion of a linear and positive relationship between size and survival. Medium-sized companies face significant challenges, possibly due to exceeding the simplified tax regime limits or management issues as per the Greiner growth model. The relevance of the simplified tax regime option is confirmed in Conceição et al. (2018). However, the sector analysis shows that agriculture and industry sectors had higher survival rates (60% and 46%, respectively). Regarding the fines, companies that were fined have better survival rates (69%) compared to those that were not fined (38%). Fines in the transit of goods present a major effect. The medium-sized companies that were fined show a lower effect in survival rates. The companies that are habitually fined have a better survival rate, and the highest fines also have the same effect.

The Cox analysis highlights that the metropolitan area has the worst survival rate. All other regions present better chances of firm survival. Region 9, including the Northeast, North, and Production, has a reduction in the probability of a firm closing of 36%, which is the best location. The main subject of this research, the effects of tax evasion fines, surprisingly, reveals that companies fined for tax evasion had higher survival rates. Small companies fined for tax evasion show a 79% increase in the probability of survival. This suggests that fines might act as a corrective measure, helping companies realign and improve their chances of survival. It shows that tax fines do not tend to lead companies to close their doors.

The results emphasize the effectiveness of the tax compliance pyramid model in improving corporate resilience, corroborating the importance of improving the tax authorities' relationship with the taxpayer. This study highlights the importance of continued research across different regions and countries to validate these findings and improve tax administration strategies. Futures lines of research should explore the effects noticed in medium-sized companies, which perhaps come from the stage of company growth, or the tax regime applied, or even of the structure of governance, familiar or not. Another necessary line of research is to verify whether companies are looking for ways to remain below the simplified regime's revenue limit of BRL 4.8 million, either by reporting less revenue or by creating holding companies.

This research provides valuable insights into the relationship between tax compliance and company survival, offering a robust foundation for future studies and policy development.

Appendix A

Table A1. Survival rates by evasion, type of fine, and interaction of size and evasion.

Time		1	2	3	4	5	6	7
Evasion/Not	AL = 0	93%	76%	63%	55%	52%	47%	38%
	AL = 1	99%	96%	90%	86%	84%	80%	69%
Type of fine	AL = 0	93%	75%	63%	55%	52%	47%	38%
	AL = 2 Evasion	99%	94%	87%	83%	80%	75%	60%
	AL = 3 Formal Fine	98%	79%	65%	56%	54%	48%	34%
	AL = 7 Evasion in transit	99%	97%	91%	88%	86%	83%	74%
Interaction Size/Evasion	IntALS1 = 0	93%	77%	65%	57%	54%	49%	39%
	IntALS1 = 1	99%	96%	92%	90%	88%	86%	82%
	IntALS2 = 0	93%	76%	65%	56%	53%	49%	40%
	IntALS2 = 1	99%	95%	87%	83%	79%	74%	59%
	IntALS3 = 0	93%	77%	66%	58%	54%	50%	40%
	IntALS3 = 1		99%		98%		96%	87%

Source: Compiled by the authors.

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