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Abstract:

We present an overlapping generations model that examines how the dynamics of income tax compliance among taxpayers influence the evolution of income inequality. We measure income distribution using Gini coefficients for the net wage income, capital income and net aggregate income. The first two coefficients measure within-stage income inequality, whereas the third measures total inter-generational income inequality. The proportion of tax evaders is endogenously time-varying and state-dependent, as determined by adaptively rational equilibrium dynamics (ARED). The long-run equilibrium analytical results replicate (and thus provide a rationale for) several empirical regularities, as well as conceptual and intuitive predictions, related to tax compliance. First, the proportion of non-compliance depends on the tax rate, the expected cost of tax evasion, and the median of the distribution of tax morale across taxpayers, which may be strictly negative, zero, or strictly positive. Second, heterogeneity in tax compliance exhibits persistence. Third, the proportion of non-compliance increases with the tax rate and decreases with the probability of detection, the penalty rate, and the median tax morale. As shown by numerical simulations with plausible parameter values, the relationship between the median tax morale and the Gini coefficients is inverted-U shaped, with the maximum attained at a strictly positive median tax morale. A higher probability of detection reduces the Gini coefficients, albeit modestly, and only when the median tax morale is sufficiently positive, whereas a higher tax rate increases the Gini coefficients over the considered range of plausible parameter values.

Keywords: Tax compliance; heterogeneous behavior; tax morale; discrete choice; income inequality; Gini coefficient.

JEL Codes: C25; E24; H25; O15.

Persistent heterogeneity in tax compliance and income inequality:

A discrete choice approach

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Abstract

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1 Introduction

The government's provision of productive public goods and services to private producers plays an important role in raising the aggregate level of income or its growth rate. If such a provision occurs without user charges on private producers, tax revenues collected from different sources typically become an intertemporally binding constraint on the government's financing of it. Meanwhile, tax compliance by individuals is, in itself, a complex decision that has been shown to be conditioned by both pecuniary and non-pecuniary factors (see, e.g., Alm, Martinez-Vazquez, & Torgler, 2010; Torgler, 2007).

This paper contributes to the literature on tax evasion by presenting an overlapping generations model in which the dynamics of income inequality are primarily driven by the dynamics of income tax compliance across taxpayers. We measure the distribution of income using Gini coefficients for the net wage income, capital rental income, and net aggregate income. Given the model's overlapping-generations structure, in which young and old are the two life stages, the Gini coefficients for net wage income and capital income provide separate measures of within-stage income inequality, whereas the Gini coefficient for net aggregate income captures inter-generational income inequality.

We model the proportion of individuals who do not comply with their legally due tax obligations as endogenously time-varying using a discrete choice framework (Train, 2009), more specifically an adaptively rational equilibrium dynamics (ARED), drawing especially on Brock and Hommes (1997). The deterministic component of the payoff associated with each tax-compliance strategy available to an individual (to comply or not to comply) is a well-defined measure of its performance in the recent past, whereas the random component encompasses idiosyncratic non-pecuniary motivations and proclivities, such as tax morale. The considered motivations and proclivities are assumed to be randomly and independently distributed across taxpayers and over time. Therefore, our paper speaks to the branch of the literature focusing on non-pecuniary (or, more broadly, subjective) motivations in addition to pecuniary (or, more broadly, objective) factors as drivers of the extent to which tax compliance levels are empirically observed, as well as to the relatively sparse branch exploring implications of income tax evasion for income inequality.

As it is inevitably the case in any formal modeling exercise, we abstract from (or control for, to put it in econometric parlance) other determinants of income tax compliance to focus on pecuniary and non-pecuniary motivations featuring the payoff associated with each tax-compliance strategy, for which there is empirical evidence. We also abstract from other channels and mechanisms through which pecuniary and non-pecuniary motivations impact the proportion of non-compliant taxpayers in the population. We likewise abstract from other channels and mechanisms through which changes in the proportion of non-compliant taxpayers affect the Gini measures of income inequality we consider. As perceptively observed by Alm (2019), there are numerous factors that seem likely to affect individual tax compliance behavior, but theoretical models can manage to incorporate only a few. Therefore, the model set forth in this paper follows closely the recommendation by Alm (2019) that fruitful research on the subject needs to recognize that a 'theory' of taxpayer compliance behavior must really consist of a 'full house' of theories and models, each explaining the behavior of different individual taxpayers at different times and places (and each having different distributive implications, we would add).

It is clear that the threat of detection and punishment imposes a pecuniary deterrent to tax non-compliance. Yet empirically observed compliance levels, measured in different ways and employing different methodologies, are often higher than warranted by the level of enforcement per se. One possible reason for such a divergence is that, although the threat of detection and punishment involves pecuniary (or, more broadly, objective) elements such as audits and fines, it also inevitably has a non-pecuniary (or, more broadly, subjective) aspect. A potential tax evader may overestimate (or underestimate, for that matter) the extent to which the institutional enforcement structure to which she is subject represents a threat of detection and punishment to her specifically. Ultimately, it is the threat of detection and punishment in the eyes of a beholder who contemplates evading her legally due tax obligations that influences her decision.

Idiosyncratic non-pecuniary motivations and proclivities can also play another significant role in driving tax compliance, independent of the influence that non-pecuniary factors may have on a taxpayer's perception of the expected threat of detection and punishment. In effect, there is considerable evidence that non-pecuniary motivations or proclivities that form a tax morale offer a plausible explanation for what has been dubbed a puzzle: why there is less tax evasion (or more tax compliance) than could be expected on the basis of pecuniary factors (see, eg., Lubian & Zarri, 2011; Luttmer & Singhal, 2014).

We plausibly conceive of the tax morale of a given subpopulation of taxpayers as either compliance-leaning or non-compliance-leaning, depending on whether the median of the distribution of tax morale across taxpayers is strictly positive or negative, respectively. A key implication of this assumption is that an individual taxpayer may have mixed moral feelings about complying or not with her legally due tax obligations, so, on balance, she will ultimately have either a compliance-leaning or a non-compliance-leaning tax morale. Reasonably, although an individual taxpayer is not in a position to question the legality of the tax obligations levied on her by the government, she may nonetheless perceive her intrinsically non-pecuniary motivations and proclivities towards non-compliance as morally warranted. Thus, the tax morale held by an individual, in the sense proposed in this paper, can reinforce or weaken the pecuniary factors that also determine her tax compliance decision. By allowing for strictly negative values for the median of the distribution of tax morale across taxpayers, we capture substantial non-compliance-leaning behavior (or anti-tax morale), whereby individuals derive positive psychological utility from evasion, a phenomenon documented in contexts characterized by markedly low institutional trust or pronounced perceptions of unfairness (Alm & Torgler, 2006). Conversely, experimental evidence indicates that high levels of intrinsic tax compliance may prevail even in the absence of deterrence, as individuals have been observed to comply with their tax obligations despite zero audit probabilities (Alm, McClelland, & Schulze, 1992). Interestingly, our discrete-choice approach to tax compliance allows us to distinguish between a deepening (intensive margin) and a widening (extensive margin) of each type of overall tax morale (compliance-leaning or non-compliance-leaning) across taxpayers.

In addition to the potential driving factors behind tax compliance (or the lack thereof), the literature has addressed, both theoretically and empirically, the related issue of the distributive implications of tax evasion. It is clear that the importance of collected tax revenues lies in their serving as an effective (though not necessarily efficient or distributively fair) mechanism to finance the provision of productive public services that are essential to private production and income generation, and that, for several reasons, are provided without user charges. Yet the predictions suggested by the theoretical literature and empirical evidence are mixed (see, e.g., Alstadsæter, Johannesen, & Zucman, 2019; Bishop, Formby, & Lambert, 2000; Johns & Slemrod, 2010; Leenders, Lejour, Rabaté, & van 't Riet, 2023). To some extent, given the complex two-way dynamics between tax evasion and income distribution, it is unsurprising that conflicting theoretical results and divergent empirical evidence have emerged regarding whether tax evasion affects income inequality positively or negatively.

As a motivation for this study, Table 1 reports novel estimates from linear fixed-effects regressions examining the association between income inequality, measured by the Gini coefficient (ranging from 0 to 1, with higher values indicating greater inequality), and tax gap annual estimates (measured as the difference between total tax liability and actually collected tax revenue, expressed as a percentage of annual tax revenues) over the period 2000–2022 for a sample of 54 countries. Model 1 controls for income per capita growth and population growth and indicates a positive and statistically significant correlation between the tax gap and the Gini coefficient, suggesting that larger tax gaps are associated with higher income inequality. Model 2 introduces interactions between the tax gap and regional indicators, revealing substantial regional heterogeneity: in North America, higher tax gaps are associated with lower measured inequality; in Europe and Central Asia, the relationship is close to zero; and in Latin America and the Caribbean, it is positive. Model 3 adds fiscal controls, including tax revenue as a share of GDP, and Model 4 combines the fiscal controls with regional interactions. All specifications include country- and year-fixed effects, with standard errors clustered at the regional level. In Models 2 and 4, F-tests reject the null hypothesis of homogeneous coefficients across regions, indicating that the association between tax gaps and income inequality varies significantly across regions. In magnitude, a 1 percentage-point increase in the tax gap is associated with an average change in the Gini coefficient of -0.011 in North America, -0.001 in Europe and Central Asia, and +0.001 in Latin America and the Caribbean. [1]

The overlapping generations framework we propose has the analytically rewarding feature that the dynamics of income inequality are primarily determined by the dynamics of the frequency distribution of income tax compliance strategies across taxpayers. This allows us to explore the implications of individual tax compliance decisions for the distribution of income within life stages of a given generation (and thus within income types) as well as across the population of overlapping generations (and thus across income types) in a given period.

In line with the empirical evidence, the analytical results of the model include persistent heterogeneity in tax compliance behavior across taxpayers as long-run equilibrium configuration. Also consistent with the empirical evidence, tax evasion (measured in our model by the proportion of non-compliant taxpayers in the subpopulation of young individuals, from which both gross and net tax evasion can be inferred) increases with the tax rate and decreases with the probability of detection, the penalty rate, and the median tax morale. We also derive analytical long-run equilibrium results

[1] The magnitude values in Europe and Central Asia and in Latin America correspond to the sum of the estimated coefficients associated with the respective regional interaction terms and the one associated with the benchmark region (North America). When the tax gap is scaled by its within-region standard deviation, a one–standard deviation increase is associated with a change in the Gini coefficient of -0.0137 in North America, -0.0072 in Europe and Central Asia (not statistically significant), and +0.0128 in Latin America and the Caribbean.

	(1) Benchmark	(2) Region Interactions	(3) Fiscal Controls	(4) Fiscal + Region
Tax gap	0.0006** (0.000)	−0.0022*** (0.001)	−0.0002 (0.000)	−0.0110** (0.005)
Inc. per capita growth	−0.0454** (0.018)	−0.0455** (0.017)	−0.0853*** (0.025)	−0.0785*** (0.021)
Pop. growth	−0.1294* (0.065)	−0.1075* (0.063)	−0.2019** (0.083)	−0.1844** (0.078)
Tax gap*ECA		0.0015* (0.001)		0.0103* (0.005)
Tax gap*LAC		0.0034*** (0.001)		0.0119** (0.005)
Tax rev. (% GDP)			−0.0047** (0.002)	−0.0043** (0.002)
Gov. expenditure growth			0.0002 (0.000)	0.0002 (0.000)
Publ. debt growth			−0.0000 (0.000)	−0.0001 (0.000)
n	822	822	356	356
F-test heterogeneity		27.45***		4.08**
p-val heterogeneity		0.000		0.032

Table 1: Linear FE estimates of annual tax gap as a share of annual tax revenues (independent variable) on Gini coefficients (dependent variable) for a sample of 54 countries over 2000–2022. Standard errors clustered at regional level in parentheses. $^{*}\, p < 0.1$, $^{**}\, p < 0.05$, $^{***}\, p < 0.01$. (1): model with an economic and a demographic control. (2): model with an economic and a demographic control and regional interaction terms. (3): model with an economic, a demographic, and three fiscal controls. (4): model with an economic, a demographic, and the fiscal controls, and the regional interaction terms. All specifications include country- and year-fixed effects. The benchmark region is North America. ECA refers to Europe and Central Asia. LAC refers to Latin America and the Caribbean. Fiscal controls include tax revenue as a share of GDP, government expenditures growth, and public debt growth.
Values for the Gini coefficients, annual income per capita growth, population growth, annual tax revenues as a share of GDP, annual government expenditure as a share of GDP, and central government debt as a share of GDP were obtained from World Bank (n.d.). The tax gap estimates for the United States are based on individual income tax and were obtained from Internal Revenue Service (2025). The tax gap estimates for Latin American and Caribbean countries were based on value-added tax and were obtained from Peláez Longinotti (2024). The tax gap estimates for European and Central Asian countries were based on value-added tax and were obtained from European Commission (2023).

on—and illustrate through numerical simulations with plausible parameter values—the impact of a higher median tax morale—and the associated decrease in the proportion of non-compliant taxpayers—on total private savings (and thus the total availability of capital), total public savings (and hence the total provision of productive public services), and, consequently, aggregate output, as well as on the wage rate and the capital rental rate. As shown solely by numerical simulations with plausible parameter values, and suggestively consistent with the novel motivating empirical evidence presented in Table 1, the relationship between the median tax morale and the Gini coefficients for net wage income, capital rental income, and aggregate income is inverted-U shaped in each case, with the maximum attained at a strictly positive median tax morale. To gain further insight, these non-linear effects of the median tax morale on the Gini coefficients are decomposed into their respective components. A higher probability of detection reduces the Gini coefficients, albeit modestly, and only when the median tax morale is sufficiently positive, whereas a higher tax rate raises the Gini coefficients over the considered range of plausible parameter values. Although, owing to several non-linearities, the long-run equilibrium results on the impact of tax evasion on income inequality are obtained through numerical simulations rather than analytically, they can be intuitively traced to the interaction of the underlying mechanisms at play. Therefore, we are able to characterize the economic conditions—specifically, the relative strength of the various effects—under which a decline in the proportion of tax evaders leads, for example, to a reduction in a given Gini measure of income inequality in the long-run equilibrium.

The remainder of this paper is organized as follows. Section 2 describes the model's structure and derives its temporary equilibrium, which we specify as the time horizon over which the proportion of non-compliant taxpayers is predetermined. This section also derives the dynamics of capital formation and the frequency distribution of tax non-compliance strategies across individuals. The dynamic behavior of the economy is explored in Section 3, in which we show that a long-run equilibrium which features heterogeneity in tax compliance strategies exists, is unique, and is a local attractor under plausible conditions. This section also explores, both analytically and through numerical simulations, how a change in the proportion of non-compliant taxpayers affects different Gini measures of income inequality in the long-run equilibrium. Section 4 concludes.

2 Structure of the model

2.1 Temporary equilibrium

The economy is populated by individuals who live for two periods. Young individuals are endowed with one unit of labor when they are born, which is inelastically supplied to firms. Young individuals, therefore, earn wage income and choose to use all of it to inelastically demand a privately produced single and homogeneous good, employing it alternatively either for immediate consumption or for saving and hence investment purposes (to wit, physical capital formation). The government levies a flat tax rate on the wage income received by young individuals. The actual public revenues (which, additionally to the actual tax collection, also include the amount of fines applied on tax evaders who get audited and hence detected), net of the auditing cost, are entirely employed by the government to supply, free of charge, a flow of homogeneous public services which are used without congestion as (essential) productive inputs by firms. Meanwhile, old individuals deliberately remain out of the labor market. As a result of their saving behavior while young, old individuals own the capital stock, which is entirely and inelastically rented to firms under competitive conditions. The resulting capital or rental income received by old individuals (which is tax-exempt, as old individuals were taxed when young) is entirely spent on the immediate consumption of the good.

In addition to making the consumption-saving decision, young individuals also decide whether or not to comply with their legally due tax obligations, given (among other reasons) that it is common knowledge that not all taxpayers are audited. Yet all non-compliant taxpayers who are audited are detected and, as a result, are unable to avoid (through corruption, for example) either being fined or, once fined, paying the full amount of the ensuing fine for income tax evasion. As will be formally explored in the following sections, the resulting behavioral structure of the model features intricate interactions involving the flow of productive public services, the wage rate, the rental rate of capital, the proportion of tax evaders in the subpopulation of young individuals, the average saving rate across young individuals (detected tax evaders pay the ensuing fines out of their wage income devoted to capital formation), the level and distribution of capital formation, and the distribution of income across different types of taxpayers (compliant vs. non-compliant) and different generations in a given period (young vs. old individuals). The two spheres of decision-making by a young individual (saving-consumption choice and tax compliance behavior) are highly intertwined and feature nonlinear feedback effects, in that the tax compliance behavior adopted by a young individual impacts on her expected net income and hence her consumption and savings amounts.

We begin by deriving the optimal saving, taking into account the young individual's type with respect to tax compliance behavior. Individuals are born with no initial wealth other than their labor endowment and leave no bequest for future generations. Let c_{1t} and c_{2t+1} denote the consumption levels of an individual born in period $t \in \mathbb{N}$ when young and old, respectively. A compliant taxpayer, who is identified by the superscript C, is levied a flat tax rate on her wage income.

The first-period budget constraint of a compliant taxpayer born in t is given by:

$$c_{1t}^C = (1 - s_t^C)(1 - \tau)w_t, \tag{1}$$

where $w_t \in \mathbb{R}_{++}$ is the respective wage income in period t (recall that individuals are born endowed with one unit of labor), $\tau \in (0,1) \subset \mathbb{R}$ is the flat tax rate, which is assumed to be exogenously given and constant over time, and $s_t^C \in [0,1] \subset \mathbb{R}$ is the proportion of the compliant taxpayer's after-tax (or disposable) wage income which is saved in period t.[2] As young individuals are equally skilled and the current tax compliance behavior of a young individual does not affect her behavior either in the labor market more generally or on the job more specifically, and hence does not impact on her employment prospects, the wage rate w_t is homogeneous across young individuals. As shown later on, however, in the time span along which the proportion of tax evaders in the subpopulation of young individuals is predetermined (which we dub temporary equilibrium), the real wage is parameterized by such a proportion.

Non-compliant taxpayers, identified by the superscript N, choose to evade taxes despite the risk of being audited and consequently detected and fined. The tax compliance choice is treated as an all-or-nothing decision: taxes are either fully paid or fully evaded.[3] The procedure used by the government to audit young individuals and penalize those who evade taxes is described later on in this section, and for now we only anticipate that a non-compliant taxpayer is detected with probability $\varepsilon \in (0,1) \subset \mathbb{R}$, which is an exogenously given parametric constant. When a tax evader is detected, she has to refund the government an amount represented by $\gamma_t w_t$, where $\gamma_t \in (\tau, 1) \subset \mathbb{R}$ is the penalty rate in period t, which is applied to her wage income. The penalty rate is endogenously time-varying due to the government following a reactive behavior in a way that will be specified later on.[4] Yet, no matter how the penalty rate is determined, a non-compliant taxpayer takes it as given. Thus, the budget constraint of a non-compliant taxpayer born in t in her first period of life is represented by $c_{1t}^N = (1 - s_t^N)(1 - \gamma_t)w_t$ with probability ε and $c_{1t}^N = (1 - s_t^N)w_t$ with probability $1 - \varepsilon$. The first-period budget constraint of a non-compliant taxpayer born in t can be expressed as:

$$c_{1t}^N = (1 - s_t^N)(1 - \varepsilon\gamma_t)w_t. \tag{2}$$

[2]The tax rate is strictly lower than the upper bound of the optimal saving rate of a compliant taxpayer, given by $\frac{1}{2+\theta}$, which is achieved with $\tau = 0$, as will be derived shortly. This ensures that compliant taxpayers do not default on their tax obligations.

[3]See Alm, Jackson, and McKee (2009), Bazart and Bonein (2014), and Bazart, Bonein, Hokamp, and Seibold (2016) for evidence from laboratory experiments on tax compliance that the frequency of measures of tax evasion at the individual level, such as the ratio of tax paid to tax owed, not infrequently peaks at zero and one.

[4]While $\gamma_t > \tau$ ensures that a detected tax evader forfeits a larger portion of her wage income than she would have if she had adopted the compliance strategy, $\gamma_t < \frac{1}{2+\theta}$ guarantees that the detected tax evader has enough wage income to fulfill her penalty, given the assumption that non-compliant taxpayers who are fined are unable to avoid paying the full amount of the ensuing fine. This requires that the penalty rate, γ_t, be strictly lower than the upper bound of the optimal saving rate of a non-compliant taxpayer, given by $\frac{1}{2+\theta}$, which is achieved with $\varepsilon = 0$, as will be derived shortly.

In period $t+1$, the individual born in t voluntarily leaves the labor market and retires, and her second-period budget constraint is given by:

$$c_{2t+1}^{i} = \begin{cases} (1+r_{t+1})s_t^C(1-\tau)w_t, & \text{if individual is compliant } (i=C), \\ (1+r_{t+1})s_t^N(1-\varepsilon\gamma_t)w_t, & \text{if individual is non-compliant } (i=N), \end{cases} \tag{3}$$

where r_{t+1} is the rental rate of capital in period $t+1$, which is taken as given by each individual.[5]

Substitution of (1) into (3) yields the lifetime budget constraint faced by a compliant taxpayer:

$$c_{1t}^C + \frac{c_{2t+1}^C}{1+r_{t+1}} = (1-\tau)w_t. \tag{4}$$

Meanwhile, the lifetime budget constraint of a non-compliant taxpayer can be similarly obtained by substituting (2) into (3), which yields:

$$c_{1t}^N + \frac{c_{2t+1}^N}{1+r_{t+1}} = (1-\varepsilon\gamma_t)w_t. \tag{5}$$

Young individuals' preferences can be represented by a logarithmic period utility function. Let $\theta \in \mathbb{R}_{++}$ be the one-period discount rate, which is homogeneous across individuals and generations. A taxpayer of type $i = C, N$, born in period t, chooses c_{1t}^i and c_{2t+1}^i that maximize her lifetime utility given by:

$$u(c_{1t}^i, c_{2t+1}^i) = \ln c_{1t}^i + \frac{1}{1+\theta}\ln c_{2t+1}^i, \tag{6}$$

subject to the intertemporal budget constraint in (4) (if $i = C$) or in (5) (if $i = N$).

The optimal consumption plan of a taxpayer born in t, denoted by (c_{1t}^*, c_{2t+1}^*), satisfies the following first-order condition:[6]

$$\frac{c_{2t+1}^*}{c_{1t}^*} = \frac{1+r_{t+1}}{1+\theta}. \tag{7}$$

Substituting (1) and (3) into (7) yields the optimal saving rate of a compliant taxpayer:

$$s_t^{C*} = \frac{1}{2+\theta}, \tag{8}$$

[5]This is so because, in t, the rental rate of capital in $t+1$ is yet to be determined, while in $t+1$, as in t, the market for renting capital is competitive and therefore suppliers are price takers.

[6]Since the utility function in (6) is strictly concave, the second-order conditions for utility maximization are satisfied, regardless of tax compliance behavior.

which, intuitively, varies negatively with the discount rate.

Analogously, substituting (2) and (3) into (7) results in the optimal saving rate of a non-compliant taxpayer:

$$s_t^{N*} = \frac{1}{2+\theta}, \tag{9}$$

which is the same as that of a compliant taxpayer.

As is well known, the logarithmic specification of the utility function in (6) (which, in the present case, applies to both compliant and non-compliant taxpayers) yields an optimal saving rate that is independent of the rate of return on rented capital.

On the production side of the economy, firms produce the single good using three homogeneous and essential inputs: labor and capital supplied, respectively, by young and old individuals, and a flow of productive public services provided by the government. The amount of the latter is taken as given by firms. Following Barro (1990), we assume that the government provides, free of charge, the flow of public services used as inputs by firms. The financing of such a provision is fully covered by actual public revenues (including tax collections and fines levied on detected tax evaders), net of auditing costs. The product, labor, and capital markets all operate competitively. As mentioned earlier, the market-clearing price of the good is continuously normalized to one. Firms operate subject to the following Cobb-Douglas production function:

$$Y_t = {K_t}^{\alpha} {G_t}^{\beta} {L_t}^{1-(\alpha+\beta)}, \tag{10}$$

where $Y_t \in \mathbb{R}_+$ is the aggregate output production, $G_t \in \mathbb{R}_+$ is the aggregate flow of productive public services, and $K_t \in \mathbb{R}_+$ and $L_t \in \mathbb{R}_+$ are, respectively, the aggregate quantities of capital and labor employed by firms in period t. In addition, $\alpha \in (0,1) \subset \mathbb{R}$ and $\beta \in (0,1) \subset \mathbb{R}$ denote parametric constants satisfying $\alpha + \beta < 1$. As in Barro (1990), a plausible rationale for including G as a separate argument of the production function in (10) is that, for several reasons, private inputs are not close substitutes for public inputs. We also draw on Barro (1990) to specify that the government produces no output and owns no capital. Because the single good can be used for multiple purposes, a reasonable simplifying assumption is that the government purchases a flow of output from firms and then makes it available as productive public services to firms themselves.

Considering that labor and capital are individually paid according to their marginal products, we can make use of (10) and the standard first-order conditions for profit maximization to get:

$$w_t = [1 - (\alpha + \beta)]{K_t}^{\alpha}{G_t}^{\beta}{L_t}^{-(\alpha+\beta)} \tag{11}$$

and

$$r_t = \alpha {K_t}^{\alpha-1}{G_t}^{\beta}{L_t}^{1-(\alpha+\beta)}. \tag{12}$$

Note that the marginal product of labor in (11) and the marginal product of capital in (12) are both calculated by varying L_t and K_t, respectively, while holding G_t constant. Thus, firms assume that changes in the amounts of labor and capital that they employ, and hence changes in their output production, do not affect the flow of productive public services provided to them by the government.

The provision of productive public services to firms is determined in each period by the government budget constraint. Firms fully utilize all such provision in the production process, since they do not face any demand constraint to sell all their profit-maximizing production at the current market price of the good. The government has two sources of revenue: taxes collected from compliant taxpayers and fines imposed on non-compliant taxpayers. In each period, the government incurs a cost to carry out random audits of the subpopulation of young individuals in order to verify their tax compliance behavior. This auditing cost is modeled as an exogenously given constant fraction $\kappa \in (0, 1) \subset \mathbb{R}$ of the fine revenues collected by the government, which consist of fines imposed on detected non-compliant taxpayers, as specified below.

In a given period t, there are L_t young individuals in the economy. The subpopulation of young individuals is continuously normalized to one, so that $L_t = 1$ for all t. A measure $x_t \in [0, 1] \subset \mathbb{R}$ of young individuals, which is liable to vary from one period to the next one (in a fashion fully described later on), chooses to take the risk of following the non-compliance strategy (fully evading due taxes), whereas $1 - x_t$ measures the proportion of young individuals who follow the compliance strategy.

In a given period t, the government manages to successfully audit *ex post* a limited, randomly selected number of taxpayers. In addition to verifying whether a given taxpayer has complied with her legal tax obligations, the government's random audits are effective at uncovering unpaid income taxes in their totality. Since a taxpayer is audited with probability $\varepsilon \in (0, 1) \subset \mathbb{R}$ and a proportion x_t of taxpayers behave in a non-compliant manner, the probability of a non-compliant taxpayer getting caught and inevitably fined is εx_t. The estimated number of non-compliant taxpayers who are audited in t can therefore be written as εx_t. Fines paid by such individuals constitute the fine revenues collected by the government, which, considering the first-period budget constraint of non-compliant taxpayers in (2), their optimal saving rate in (9), and the utility-maximizing behavior of young individuals, can be expressed as $\varepsilon x_t \gamma_t w_t$. The only cost incurred by the government is the auditing cost mentioned above, which is therefore given by $\kappa \varepsilon x_t \gamma_t w_t$, so that κ can be seen as the average auditing cost, i.e., the cost required to obtain one unit of fine revenue.[7] Along with fine revenues, the government receives tax revenues from compliant taxpayers, which, under their first-period budget constraint in (1), can be expressed as $\tau(1 - x_t)w_t$.

In each period, the government uses all actual public revenues to provide productive public services. Thus, the supply of productive public services can be expressed as the sum of the tax revenues collected from compliant taxpayers and the fine revenues collected from detected non-compliant taxpayers, net of the auditing cost:

$$G_t = [\tau(1 - x_t) + (1 - \kappa)\varepsilon \gamma_t x_t]w_t. \tag{13}$$

Given the tax rate and the probability of detecting a tax evader, the government sets the penalty rate in period t to ensure a strictly positive supply of productive public services and a proper reactive response to tax evasion, as detailed shortly. This is implemented using a measure of tax revenue loss, as follows. As the current wage rate is homogeneous and publicly known, the government is able to compute the maximum amount of taxes to be collected in t should all taxpayers adopt the compliance strategy, which is given by τw_t (recall the expression for tax collection from compliant taxpayers in the preceding paragraph and evaluate it at $x_t = 0$). However, the actual tax collection may fall short of that maximum, and when it does, it falls short by the amount of taxes evaded by non-compliant taxpayers, given by $x_t \tau w_t$. As a result, the government can compute the ratio of the latter amount to the former and use it reactively as a measure of tax revenue loss in period t. In fact, this ratio is equal to the proportion of non-compliant taxpayers in the subpopulation of young individuals, since $\frac{x_t \tau w_t}{\tau w_t} = x_t$. Before auditing, therefore, although the government is not able to identify who, if any, the non-compliant taxpayers are (and during the auditing process it identifies a given non-compliant taxpayer with probability $\varepsilon \in (0, 1) \subset \mathbb{R}$) it can indirectly learn the

[7] For general-equilibrium consistency in the overlapping generations framework, we assume that auditing payments are made to an external auditing sector outside the economy's production structure. All revenues received by this sector are fully spent on the immediate consumption of the single good produced in the economy. Hence, auditing costs represent a redistribution of income from audited and fined non-compliant taxpayers to the auditing sector, rather than a net resource loss for the economy.

proportion of tax evaders in the subpopulation of young individuals by computing what hereafter we dub tax-revenue-loss coefficient.

Having computed this measure of tax revenue loss represented by x_t, the government establishes the penalty rate on tax evasion with the complementary purposes of penalizing and discouraging tax evasion as well as of endeavoring to compensate to some extent for the loss of public revenues represented by the evaded taxes. Accordingly, we specify the penalty rate as a strictly increasing function of the tax-revenue-loss coefficient as follows:

$$\gamma_t = \gamma(x_t), \tag{14}$$

where $\gamma'(x_t) > 0$ for all $x_t \in [0, 1] \subset \mathbb{R}$. We further assume that $\gamma(0) > \tau$, so that the lower bound of the penalty rate, which is achieved when $x_t = 0$, ensures that a detected tax evader forfeits a portion of her wage income which is strictly greater than the one she would have if she had adopted the tax-compliance strategy; and that $\gamma(1) < 1$. Given that detected non-compliant taxpayers are unable to default on the payment of the ensuing fine, this second further assumption ensures that even a non-compliant taxpayer fined with the maximum penalty has enough savings both to pay the respective fine and to have in her second life stage a strictly positive (even if arbitrarily small) amount of capital. Note that the fulfillment of the latter condition is required to guarantee that in her second life stage, the considered non-compliant taxpayer receives a strictly positive rental income and hence has strictly positive consumption.

Figure 1 summarizes the logical sequence of key events for young individuals and the government in period t. L_t individuals are born. They are employed by firms and must choose between complying or not complying with their tax obligations. The government levies a flat tax rate on wage income received by young individuals, and actual tax collections enable the government to compute the tax-revenue-loss coefficient and thereby infer the proportion of tax evaders in the subpopulation of taxpayers. The penalty rate to be levied on tax evaders in the random auditing process is set as a strictly increasing function of the tax-revenue-loss coefficient. The ensuing fine is paid in full by detected tax evaders out of their 'savings' (which by now have been converted into investment in capital in this single-good economy), so that the actual saving rate of a non-compliant taxpayer (and therefore how much capital and rental income she has in her second life stage) depends on whether or not she is audited. Yet the penalty rate has both a lower bound (which ensures that a detected tax evader forfeits a larger portion of her wage income than she would have if she had adopted the tax-compliance strategy) and an upper bound (which ensures that a detected tax evader fined with the maximum penalty has enough savings both to pay the respective fine and to have, in her second life stage, a strictly positive amount of capital as source of income). The government, for its part, allocates all actual public revenues (collected taxes and fines), net of the auditing cost, to the provision of a flow of productive public services used as inputs by firms.

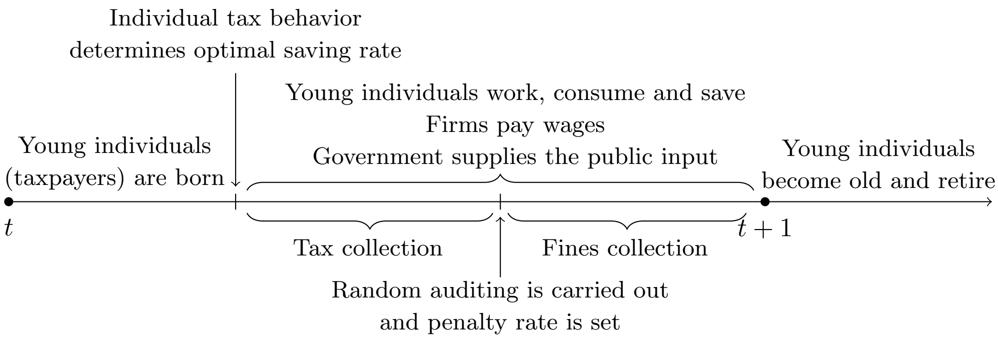


Fig. 1: Logical sequence of key events for young individuals and the government in period t.

Therefore, a change in the penalty rate impacts on actual savings (and hence capital) formation through different channels. Given the wage rate, a higher penalty rate raises fine revenues and, by increasing the supply of productive public services, boosts aggregate output and aggregate saving formation, thereby increasing capital formation. Yet the same increase in the penalty rate reduces the savings of detected tax evaders, thereby reducing capital formation. In any case, the production function in (10) implies that the marginal product of capital is diminishing, so that, all else constant, greater capital formation by young individuals leads to a lower rental rate per unit of capital that they inelastically supply to firms when old.

In any given period t, a temporary equilibrium is reached when all markets clear. In the product market, all Aggregate output is consumed by young and old individuals, or saved and invested by young individuals, with the price of the good freely adjusting to eliminate any excess supply or demand. In the capital market, the rental rate of capital freely adjusts to remove any excess supply or demand, so that the predetermined capital stock, now owned by old individuals, is entirely rented to firms. In the labor market, the wage rate freely adjusts to remove any excess demand for labor by firms.

Let (w_t^*, r_t^*) be the vector of market-clearing factor prices that, together with the price of the good, which is normalized to one, establishes the temporary equilibrium in a given period t. We will now show that such an equilibrium is well-defined and parameterized by the proportion of non-compliant taxpayers in the subpopulation of young individuals and the capital stock, which are predetermined variables in a given period t.[8]

Using the labor market equilibrium condition, given by the equality between labor demand (derived from the first-order condition for the profit-maximizing choice of labor) and labor supply ($L_t = 1$), along with (1) and (2) evaluated at the optimal savings levels in (8) and (9), and accounting for (14), we use (13) to obtain the supply of productive public services in the temporary equilibrium in period t:

$$G_t^* = \phi(x_t) w_t^*, \tag{15}$$

where

$$\phi(x_t) \equiv \tau(1 - x_t) + (1 - \kappa)\varepsilon\gamma(x_t)x_t. \tag{16}$$

Note that the supply of productive public services in (15) takes strictly positive values for any proportion of non-compliant taxpayers x_t, since $w_t^* \in \mathbb{R}_{++}$ and $\phi(x_t) > 0$ for all $x_t \in [0, 1] \subset \mathbb{R}$, given that $\tau \in (0, 1) \subset \mathbb{R}$, $\kappa \in (0, 1) \subset \mathbb{R}$, $\varepsilon \in (0, 1) \subset \mathbb{R}$ and $\gamma(x_t) \in (\tau, 1) \subset \mathbb{R}$ for all $x_t \in [0, 1] \subset \mathbb{R}$.

We can substitute (15) into (11) to express the temporary equilibrium wage rate in period t as a function of the proportion of non-compliant taxpayers and the capital stock:

$$w_t^* = [1 - (\alpha + \beta)]^{\frac{1}{1-\beta}} K_t^{\frac{\alpha}{1-\beta}} \left[\phi(x_t)\right]^{\frac{\beta}{1-\beta}} \equiv w(K_t, x_t), \tag{17}$$

which is also strictly positive for any $x_t \in [0, 1] \subset \mathbb{R}$.

Substituting the latter expression into (15) yields the flow of productive public services in the temporary equilibrium in period t:

$$G_t^* = \phi(x_t) w(K_t, x_t) \equiv g(K_t, x_t). \tag{18}$$

[8]It is worth noting that the temporary equilibrium price in each factor market is stable. Specifically, diminishing marginal products of capital and labor, as implied by equation (10), ensure that the demands for capital and labor are downward sloping in their respective markets. Since the supply of each factor is predetermined and perfectly inelastic (and thus vertical), any excess demand (supply) leads to an increase (decrease) in the corresponding factor price.

Finally, recalling that $L_t = 1$, using now the temporary equilibrium conditions in (17) and (18) along with (12), the rental rate of capital in the temporary equilibrium in period t is given by:

$$r_t^* = \alpha {K_t}^{\alpha-1} \left[\phi(x_t) w(K_t, x_t)\right]^{\beta} \equiv r(K_t, x_t). \tag{19}$$

2.2 State transition: capital formation and decision-making on tax-compliance strategy

In line with our assumption that old individuals leave no bequest of any kind, we assume that the capital stock fully depreciates after one period of use in production. Therefore, the capital stock in period $t+1$, denoted by K_{t+1}, is fully determined by the actual savings of young individuals in period t. Considering the homogeneity of the wage rate across young individuals and using the optimal saving rate in (8), the amount of savings realized by compliant taxpayers in period t is given by $(1-x_t)s_t^{C^*}(1-\tau)w_t^* = \frac{1-\tau}{2+\theta}(1-x_t)w_t^*$. Meanwhile, using the optimal saving rate in (9), the amount of savings realized by detected non-compliant taxpayers is given by $s_t^{N^*}\big(1-\gamma(x_t)\big)w_t^*\varepsilon x_t = \frac{1-\gamma(x_t)}{2+\theta}\varepsilon x_t w_t^*$, while that realized by undetected non-compliant taxpayers is given by $s_t^{N^*}w_t^*(1-\varepsilon)x_t = \frac{1}{2+\theta}(1-\varepsilon)x_t w_t^*$. The amount of savings realized by all non-compliant taxpayers together can therefore be expressed as $\frac{\left(1-\varepsilon\gamma(x_t)\right)}{2+\theta}x_t w_t^*$. Recall that the number of individuals born in each period t, and who live for two periods, t and $t+1$, is a constant normalized to one. Given that young individuals born in period t do not incur any cost in carrying capital to period $t+1$, we get the following capital formation dynamics:

$$K_{t+1} = \frac{1-\tau}{2+\theta}(1-x_t)w_t^* + \frac{1-\varepsilon\gamma(x_t)}{2+\theta}x_t w_t^*, \tag{20}$$

which can be written as:

$$K_{t+1} = \varphi(x_t) w(K_t, x_t), \tag{21}$$

where $w(K_t, x_t)$ is determined by (17) and

$$\varphi(x_t) \equiv \frac{1}{2+\theta}\left\{(1-\tau)(1-x_t) + \big[1-\varepsilon\gamma(x_t)\big]x_t\right\}. \tag{22}$$

Note that $\varphi(x_t) > 0$ for all $x_t \in [0,1] \subset \mathbb{R}$, under the assumptions posited earlier that $\theta \in \mathbb{R}_{++}$, $\tau \in (0,1) \subset \mathbb{R}$, $\varepsilon \in (0,1) \subset \mathbb{R}$, and $\gamma(x_t) \in (\tau, 1) \subset \mathbb{R}$ for all $x_t \in [0,1] \subset \mathbb{R}$.

Having derived the equation for capital formation in (21), we now focus on the dynamics of the frequency distribution of tax compliance strategies across taxpayers, which we specify as an adaptively rational equilibrium dynamics (ARED), following Brock and Hommes (1997). Taxpayers are described as using a stochastic discrete-choice model, along the lines of Manski and McFadden (1981), to choose a tax-compliance strategy from a finite set of available strategies, a choice interpreted as a purposive economic act based on an adaptively rational decision. The deterministic component of the payoff of each tax-compliance strategy is a well-defined measure of its performance in the recent past, and the resulting dynamics across strategy choices are interestingly coupled to the equilibrium dynamics of the other endogenous variables. In light of our model's purpose, an analytically rewarding feature of incorporating a discrete choice framework is that the dynamics of the frequency distribution of tax compliance strategies across taxpayers become key determinants of the dynamics of our macroeconomic variables of interest, particularly the distribution of income. As described later, the latter is measured using Gini coefficients for net wage income, rental income, and overall net income.

In a given period t, taxpayers choose in a decentralized and uncoordinated way between complying or not complying with their legally due income tax obligations. In formal terms, a taxpayer born in period t chooses and actually implements one of the tax compliance strategies contained in the choice set represented by $\{C, N\}$. Drawing upon the literature on discrete choice modeling (see, e.g., Manski, 1993; McFadden, 2001; Train, 2009), taxpayers are supposed to have well-defined preferences over the set of available tax compliance strategies, and such preferences are represented by a payoff function which is additive in two components:

$$\pi(\omega_{jt}) = \pi^d(\omega_{jt}) + \mu(\omega_{jt}), \tag{23}$$

where $\omega_{jt} \in \{C, N\}$ is the type of the j-th taxpayer born in t, which is defined by the tax-compliance strategy chosen and implemented by her in period t; $\pi^d(\omega_{jt})$ denotes a deterministic component associated with pecuniary and hence observable motivations of taxpayer j based on a lagged performance measure; and $\mu(\omega_{jt})$ stands for a random component associated with non-pecuniary and hence unobservable motivations and proclivities of taxpayer j.

Recall that young individuals are wage-takers, and they all receive the same wage compensation, and make consumption, saving (and hence capital formation), and tax compliance decisions taking the rate of return on rented capital as given. Consequently, all taxpayers born in period t face the same factor price vector (w_t^*, r_t^*), the elements of which are represented by the expressions in (17) and (19), respectively. As all individuals born in period t have the same preferences with respect to first and second-period consumption, the indirect utilities of compliant and non-compliant taxpayers differ in value only to the extent that the tax rate, τ, differs in value from the expected cost of the tax non-compliance strategy, which is formed adaptively in period t using information from period $t-1$, and is given by $\varepsilon\gamma(x_{t-1})$.[9] Thus, it is reasonable that a key element to feature as the deterministic component of each type of payoff function in (23) is the expected cost of the respective tax-compliance strategy:

$$\pi^d(\omega_{jt}) = \begin{cases} -\upsilon(\tau) & , \text{ if } \omega_{jt} = C, \\ -\upsilon\big(\varepsilon\gamma(x_{t-1})\big) & , \text{ if } \omega_{jt} = N, \end{cases} \tag{24}$$

where $\upsilon'(\cdot) > 0$ over the domain of its arguments.

Meanwhile, the random component of the payoff function in (23) can be interpreted as reflecting idiosyncratic non-pecuniary motivations and proclivities, such as tax morale. The presence and importance of tax morale as another determinant of tax compliance behavior has been largely documented in a variety of studies (see, e.g., Alm, 2019; Cummings, Martinez-Vazquez, McKee, & Torgler, 2009; Lubian & Zarri, 2011; Luttmer & Singhal, 2014; Pickhardt & Prinz, 2014). More broadly, there is considerable evidence that the decision an individual makes regarding whether or not to comply with her legally due tax obligations goes well beyond a simple amoral cost-benefit calculation predicated exclusively on narrowly defined pecuniary considerations. Tax morale is, in some sense, a portmanteau term encompassing a wide array of motivations and proclivities that affect tax compliance unrelated to strict cost-benefit reasoning and typically non-pecuniary and/or socially determined. In our specification of the random component of the payoff function in (23), tax morale broadly denotes an intrinsic motivation either to comply or not with legally due tax obligations. We reasonably consider that such motivations and proclivities regarding tax compliance are idiosyncratically non-pecuniary and therefore heterogeneous across taxpayers, and randomly and independently determined across individuals and over time. More precisely, we specify the random

[9] Using (6), (8), (9), and (14), the indirect utilities of compliant and non-compliant taxpayers can then be formally expressed, respectively, as follows:

$$u({c_{1t}^C}^*, {c_{2t+1}^C}^*) = \ln\left(\frac{(1+\theta)(1-\tau)w_t^*}{2+\theta}\right) + \frac{1}{1+\theta}\ln\left(\frac{(1+r_t^*)(1-\tau)w_t^*}{2+\theta}\right)$$

and

$$u({c_{1t}^N}^*, {c_{2t+1}^N}^*) = \ln\left(\frac{(1+\theta)(1-\varepsilon\gamma(x_{t-1}))w_t^*}{2+\theta}\right) + \frac{1}{1+\theta}\ln\left(\frac{(1+r_t^*)(1-\varepsilon\gamma(x_{t-1}))w_t^*}{2+\theta}\right).$$

It is straightforward to check that these indirect utilities differ in value from each other if, and only if, $\tau \neq \varepsilon\gamma(x_{t-1})$. As a result, a payoff-maximizing tax-compliance strategy is also a cost-minimizing one and vice versa.

component $\mu(\omega_{jt})$ in the payoff function in (23) as a realization of a continuous random variable with support on the whole real line. However, the subjective views held by taxpayers are homogeneous in one important respect: it is adaptively rational that the deterministic component of the payoff to each tax-compliance strategy is represented by that strategy's expected cost, as specified in (24).

As our specification in (23) assumes that both strategies available to taxpayers feature a random component, the association of that component with tax morale and its heterogeneity across taxpayers imply that, in principle, a given taxpayer may ambivalently hold both compliance-leaning and non-compliance-leaning motivations and proclivities. Therefore, we plausibly and more inclusively consider that an individual taxpayer may have mixed moral feelings with respect to complying or not with her legally due tax obligations, so that it is on balance that she ultimately has either a compliance-leaning tax morale or a non-compliance-leaning one. In the context of the model, although a young individual is not in a position to question the legality of the tax obligations imposed on her by the government, she may nevertheless perceive her intrinsic non-pecuniary motivations and proclivities towards non-compliance as morally warranted. In effect, our approach to tax compliance based on a discrete choice framework allows treating the taxpayers in the model as heterogeneous along two dimensions in regard to tax morale, which are whether, on balance, an individual taxpayer has a compliance-leaning or a non-compliance-leaning tax morale, and how strongly the tax morale of an individual taxpayer leans towards compliance or non-compliance. Of course, there may be taxpayers for whom compliance-leaning motivations and proclivities offset non-compliance-leaning ones, resulting in what we dub a neutral tax morale. For these taxpayers, as a result, what is decisive in the payoff function in (23), in the end, is the deterministic component specified in (24).

Our discrete choice approach allows us to differentiate between a deepening (intensive margin) and a widening (extensive margin) of each type of tax morale (compliance-leaning or non-compliance-leaning) across taxpayers. Suppose that the overall tax morale across taxpayers is compliance-leaning. Given the proportion of each type of individual tax morale on balance (compliance-leaning or non-compliance-leaning) across taxpayers, an increase in the average extent of taxpayers' leanings towards compliance on balance raises the overall compliance-leaning tax morale along the intensive margin. Alternatively, suppose that the overall tax morale across taxpayers is non-compliance-leaning. Given the average extent of taxpayers' leanings towards non-compliance, an increase in the proportion of taxpayers for whom the tax morale is, on balance, non-compliance-leaning raises the overall non-compliance-leaning tax morale along the extensive margin.

In a given period t, a taxpayer j chooses and implements a certain tax-compliance strategy if such a strategy is expected to yield a payoff which is greater than or equal to the payoff associated with the alternative strategy, $\pi(\omega'_{jt})$. Formally, the chosen strategy $\omega_{jt} \in \{C, N\}$ has to satisfy the following payoff-maximizing condition:

$$\pi(\omega_{jt}) \geq \pi(\omega'_{jt}), \quad \forall\, \omega'_{jt} \in \{C, N\}. \tag{25}$$

Using (23), the payoff-maximizing condition in (25) can be written as follows:

$$\pi^d(\omega_{jt}) - \pi^d(\omega'_{jt}) \geq \mu(\omega'_{jt}) - \mu(\omega_{jt}), \quad \forall\, \omega'_{jt} \in \{C, N\}. \tag{26}$$

It follows from the inequality in (26) that for any taxpayer j, a strategy ω_{jt} may not be the chosen one in a given period t even if the value of the deterministic component of the payoff associated with it is strictly greater than the value of the deterministic component of the payoff associated with the alternative strategy, that is, even if $\pi^d(\omega_{jt}) - \pi^d(\omega'_{jt}) > 0$. The intuitive reason is that the value of the random component of the payoff associated with strategy ω'_{jt} may be strictly greater than the value of the random component of the payoff associated with strategy ω_{jt}, and to an extent that more than offsets the advantage to strategy ω_{jt} given by $\pi^d(\omega_{jt}) > \pi^d(\omega'_{jt})$.

As an illustrative example of the role of tax morale in reducing tax non-compliance, consider the tax non-compliance strategy as the benchmark for the following comparison. Using (23) and (24), even if it is the case that $\tau > \varepsilon\gamma(x_{t-1})$, so that $\pi^d(\omega_{jt} = N) - \pi^d(\omega'_{jt} = C) = \upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_{t-1})\big) > 0$, taxpayer j nonetheless chooses to comply with her legally due tax obligations in period t if her idiosyncratic non-pecuniary motivations and proclivities are such that $\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_{t-1})\big) < \mu(\omega'_{jt} = C) - \mu(\omega_{jt} = N)$. Yet note that the existence of a taxpayer j for whom such a strict inequality favoring the compliance strategy payoff-wise is satisfied is an event which occurs with a given probability. This is because, on the one hand, those idiosyncratic non-pecuniary motivations and proclivities are represented by a random variable which is independent and identically distributed, and on the other, a non-compliant taxpayer is audited with probability $\varepsilon \in (0, 1) \subset \mathbb{R}$. However, our broader conception of tax morale also allows it to impact negatively on tax compliance. In effect, even if it is the case that $\varepsilon\gamma(x_{t-1}) > \tau$, so that $\pi^d(\omega'_{jt} = C) - \pi^d(\omega_{jt} = N) = \upsilon\big(\varepsilon\gamma(x_{t-1})\big) - \upsilon(\tau) > 0$, taxpayer

j chooses not to comply with her legally due tax obligations in period t if her idiosyncratic non-pecuniary motivations and proclivities are such that $\upsilon\big(\varepsilon\gamma(x_{t-1})\big) - \upsilon(\tau) < \mu(\omega_{jt} = N) - \mu(\omega'_{jt} = C)$.

Consequently, a key implication of our discrete choice approach to tax compliance is that two taxpayers belonging to the same generation t, and hence facing the same objective economic conditions, including the same tax system and the same amount of tax burden, may well choose to behave differently with respect to complying or not with their tax obligations. A taxpayer whose tax morale, on balance, leans toward compliance may behave compliantly even if the value of the deterministic component of the payoff from not complying is strictly greater than that of the deterministic component of the payoff from complying. Conversely, a taxpayer whose tax morale, on balance, favors non-compliance (due, for example, to her seeing the tax system as too unfair) may behave in a non-compliant manner even if the value of the deterministic component of the payoff from not complying is strictly smaller than that of the deterministic component of the payoff from complying.

Drawing on the ARED approach proposed in Brock and Hommes (1997), we are able to address decision-making regarding tax compliance strategies by accounting for both idiosyncratic non-pecuniary motivations and proclivities, and deterministic factors. The consideration of the latter by the decision maker requires the use of recent, objective information to determine the (expected) cost associated with each strategy, as represented in (24). In a given period t, although the presence of the random component in (23) precludes determining each taxpayer's behavioral choice, we can nonetheless infer the probability with which taxpayer j chooses not to comply with her legally due tax obligations, which from (24)-(26) is given by:

$$Prob\left(\pi(\omega_{jt} = N) \geq \pi(\omega'_{jt} = C)\right) = P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_{t-1})\big)\right), \tag{27}$$

where $P : \mathbb{R} \to (0,1) \subset \mathbb{R}$ denotes the cumulative distribution function of the random variable $\mu(\omega'_{jt} = C) - \mu\big(\omega_{jt} = N\big)$ embedded in (27), which is considered to be continuously differentiable with $P'(\cdot) > 0$ over its support. As a result, the probability with which taxpayer j chooses to comply with her tax obligations in period t is simply given by $1 - P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_{t-1})\big)\right)$.

As all taxpayers born in a given period t face the same expected cost associated with each tax-compliance strategy, the determinants of which are τ and $\varepsilon\gamma(x_{t-1})$, represented in (24), they share the same deterministic component in their respective payoff functions. However, taxpayers born in a given period t are heterogeneous with respect to the expected payoff associated with each strategy, owing to their holding idiosyncratic non-pecuniary motivations and proclivities regarding tax compliance. In order to synchronize the dynamics of the proportion of non-compliant taxpayers with the dynamics of the capital stock in (21), we make use of the choice probability in (27) to determine the proportion of taxpayers born in a given period $t+1$ who choose to behave as tax evaders (type N), thus specifying the following ARED:

$$x_{t+1} = P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_t)\big)\right). \tag{28}$$

Therefore, for any cumulative distribution function of the random variable embedded in (27), as well as for any specific format of the function $\upsilon(\cdot)$ in (24) yielding $\upsilon'(\cdot) > 0$, we then have that $\frac{\partial x_{t+1}}{\partial \tau} = P'(\cdot)\upsilon'(\tau) > 0$ and $\frac{\partial x_{t+1}}{\partial \varepsilon} = -P'(\cdot)\upsilon'\big(\varepsilon\gamma(x_t)\big)\gamma(x_t) < 0$. Given that the tax rate τ represents the cost associated with the compliance strategy, the higher the tax rate, the higher the proportion of non-compliant taxpayers in period $t+1$, holding all else constant. Meanwhile, as the respective expected punishment $\varepsilon\gamma(x_t)$ represents the expected cost associated with the non-compliance strategy, the higher the expected probability of detection, given by ε, the lower the proportion of non-compliant taxpayers in period $t+1$, holding all else constant. Additionally, it follows from (28) that $\frac{\partial x_{t+1}}{\partial x_t} = -P'(\cdot)\upsilon'\big(\varepsilon\gamma(x_t)\big)\varepsilon\gamma'(x_t) < 0$, meaning that, holding all else constant, a change in the proportion of non-compliant taxpayers in period t alters the expected punishment in period $t+1$, which in turn induces a change in the proportion of non-compliant taxpayers in period $t+1$ in the opposite direction. In other words, there is strategic substitutability in taxpayers' decisions to evade taxation. The dynamic of the proportion of non-compliant taxpayers is therefore in and of itself stable.

Note that the effects of parametric shifts explored in the preceding paragraph are mediated only by changes in the deterministic components of the payoffs associated with the available strategies, which is, of course, due to the exogenous nature of the idiosyncratically non-pecuniary motivations and proclivities featuring the random components of those payoffs. Yet it follows from the ARED in (28) that the proportion of non-compliant taxpayers in a given period $t+1$ also depends on those random components, as reflected by the cumulative distribution function of the random variable $\mu(\omega'_{jt} = C) - \mu\big(\omega_{jt} = N\big)$ embedded in (27).

The state transition of the economy is determined by the two-dimensional map consisting of the capital formation dynamics in (21) and the ARED in (28), the state space of which is represented by $\Theta \equiv \big\{(K_t, x_t) \in \mathbb{R}^2 : K_t > 0, 0 \leq x_t \leq 1\big\}$.

3 Dynamic behavior of the economy

The model set forth in the preceding section features the dynamics of the proportion of non-compliant taxpayers crucially affecting the dynamics of the capital stock and the provision of productive public services, thereby ultimately determining the level and distribution of aggregate income. For a given proportion of non-compliant taxpayers x, the penalty rate γ levied on tax evaders impacts on the provision of productive public services by affecting the actual tax and fines revenues collected by the government. Yet as detected tax evaders pay the ensuing fines out of their 'savings' (which by now have been converted into capital in this single-good economy), the penalty rate also impacts on capital formation. As specified in Section 2.2, the proportion of non-compliant taxpayers varies over time, as each taxpayer chooses a tax-compliance strategy taking into account both the pecuniary and the non-pecuniary benefits and costs of each available strategy. For given values of the tax rate τ and the probability ε with which a taxpayer is audited, the expected cost associated with the non-compliance strategy depends on the penalty rate, $\gamma(x)$, which is increasing in the proportion of non-compliant taxpayers. Therefore, there is a two-way relationship between the penalty rate and the proportion of taxpayers who become tax evaders. A long-run equilibrium configuration is characterized by stationary values for both the proportion of non-compliant taxpayers in the ARED specification in (28) and the capital stock in (21), and thereby for the level and distribution of aggregate income.

In the following proposition, we establish the existence and uniqueness of the long-run equilibrium of the dynamic system given by (21) and (28).

Proposition 1 (Existence and uniqueness of a long-run equilibrium) *For a given vector of parameters* $(\theta, \alpha, \beta, \tau, \varepsilon, \kappa)$*, the two-dimensional map consisting of* (21) *and* (28) *has a unique fixed point which is given by* (K^*, x^*)*, with* $K^* = \left[\big(1-(\alpha+\beta)\big)\big(\varphi(x^*)\big)^{1-\beta}\big(\phi(x^*)\big)^{\beta}\right]^{\frac{1}{1-(\alpha+\beta)}} \in \mathbb{R}_{++}$ *and* $x^* \in (0,1) \subset \mathbb{R}$ *defined implicitly by* $x^* = P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right)$.

Proof: See Appendix A. □

Therefore, the long-run equilibrium configuration is characterized by heterogeneity in tax compliance behavior, with compliant taxpayers coexisting with non-compliant ones. The proportion of non-compliant taxpayers in the long-run equilibrium is determined by both deterministic factors (the tax rate, the probability of detection, and the penalty rate) and intrinsic non-pecuniary motivations and proclivities that are randomly distributed across taxpayers (such as tax morale). Meanwhile, per (16) and (22), the capital stock in the long-run equilibrium is determined by the same random and deterministic factors (in the case of the latter, both separately and through the proportion of non-compliant taxpayers) in addition to the one-period discount rate, θ, and the exponents (factor elasticities) in the production function in (10), α and β.

A natural question that arises concerns whether the dynamics described in (21) and (28) can take the economy to the unique long-run equilibrium configuration established in Proposition 1 starting from a sufficiently small neighborhood of x^* (which can of course include either $x = 0$ or $x = 1$). The answer is yes, as formally established in the following proposition.

Proposition 2 (Stability properties of the long-run equilibrium) *For a given vector of parameters* $(\theta, \alpha, \beta, \tau, \varepsilon, \kappa)$*, the unique long-run equilibrium* (K^*, x^*) *of the two-dimensional map consisting of* (21) *and* (28) *exhibits the following dynamic properties:*

i. If $\varepsilon P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*) < 1$*, the long-run equilibrium* (K^*, x^*) *is a local attractor.*

ii. When $\varepsilon P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*) = 1$*, a flip (or period-doubling) bifurcation occurs at the long-run equilibrium* (K^*, x^*)*.*

Proof: See Appendix B. □

Accordingly, consistent with the empirical evidence, heterogeneity in tax compliance behavior across taxpayers may exhibit considerable persistence over time, insofar as it can arise as a stable long-run equilibrium resulting from the interaction between the frequency distribution of tax compliance strategies among taxpayers and the level and distribution of aggregate income. Under this possibility, applying the implicit function theorem to the long-run equilibrium condition in Appendix A2 allows us to derive the following comparative statics results for the long-run equilibrium:

$$\frac{\partial x^*}{\partial \tau} = \frac{P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'(\tau)}{1 + \varepsilon P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)} > 0 \tag{29}$$

and

$$\frac{\partial x^*}{\partial \varepsilon} = \frac{-P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma(x^*)}{1 + \varepsilon P' \left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) \upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)} < 0. \tag{30}$$

As expected, in the stable long-run equilibrium, a decrease (increase) in the tax rate or an increase (decrease) in the probability of detection leads to a decrease (increase) in the proportion of non-compliant taxpayers.

To derive further comparative statics of the stable long-run equilibrium, additional structure is required in the choice probability in (27). Specifically, we assume that non-pecuniary motivations and proclivities are logistically distributed across individuals born in a given generation:

$$P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x_t)\big)\right) = \frac{1}{1 + e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}}. \tag{31}$$

The functional form above introduces two new parameters: $\lambda \in \mathbb{R}_{++}$, which, following Brock and Hommes (1997), denotes the *intensity of choice*, and in the present context is the intensity with which an individual taxpayer reacts to a change in relative net benefit; and $m \in \mathbb{R}$, which can be seen here as the median tax morale of a given generation.

Considering the equilibrium condition in (A2) and the logistic distribution in (31), and applying the implicit function theorem, we obtain the following results:

$$\frac{\partial x^*}{\partial \lambda} = \frac{\left[\upsilon(\tau) - \upsilon(\varepsilon\gamma(x^*)) - m\right] e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}}{\left\{1 + e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}\right\}^2 + \lambda\varepsilon\gamma'(x^*)\upsilon'(\varepsilon\gamma(x^*))e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}} \tag{32}$$

and

$$\frac{\partial x^*}{\partial m} = \frac{-\lambda e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}}{\left\{1 + e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}\right\}^2 + \lambda\varepsilon\gamma'(x^*)\upsilon'(\varepsilon\gamma(x^*))e^{-\lambda\left[\upsilon\left(\tau\right) - \upsilon\left(\varepsilon\gamma(x^*)\right) - m\right]}} < 0. \tag{33}$$

As shown in (32), the proportion of tax evaders in the stable long-run equilibrium varies positively with the intensity of choice if $\upsilon\left(\tau\right) - \upsilon\big(\varepsilon\gamma(x^*)\big) > m$. Therefore, for example, for any deterministic payoff differential in favor of the non-compliance strategy, $\upsilon\left(\tau\right) > \upsilon\big(\varepsilon\gamma(x^*)\big)$, the proportion of tax evaders in the long-run equilibrium intuitively varies positively with the intensity of choice, unless the median tax morale leans sufficiently toward compliance to offset the deterministic payoff advantage of the non-compliance strategy. Meanwhile, the proportion of tax evaders in the long-run equilibrium varies negatively with the intensity of choice if $\upsilon\left(\tau\right) - \upsilon\big(\varepsilon\gamma(x^*)\big) < m$. Thus, for example, for any deterministic payoff differential in favor of the compliance strategy, $\upsilon\left(\tau\right) < \upsilon\big(\varepsilon\gamma(x^*)\big)$, the proportion of tax evaders in the long-run equilibrium intuitively varies negatively with the intensity of choice, even if the median tax morale is non-compliance-leaning ($m < 0$), provided it is not strong enough to offset the deterministic payoff disadvantage of the non-compliance strategy.

As shown in (33), changes in the median tax morale of taxpayers induce changes in the opposite direction in the proportion of tax evaders in the stable long-run equilibrium. Regardless of whether the tax morale of a given generation is initially non-compliance-leaning ($m < 0$), compliance-leaning ($m > 0$), or compliance-neutral ($m = 0$), a higher median tax morale implies a lower proportion of tax evaders in the long-run equilibrium. Since the median tax morale may vary exogenously, it follows that a higher value of the median (which might as well correspond to a less negative level) leads to a lower proportion of tax evaders in the long-run equilibrium.

As indicated in case (*ii*) in Proposition 2, it is possible that a flip (or period-doubling) bifurcation occurs at the long-run equilibrium (K^*, x^*). This is a bifurcation in which the considered system switches to a new dynamic behavior featuring twice the period of the original system when a small smooth change is experienced by one or more of its parameter values. When a parameter crosses a critical threshold, the system undergoes a flip (period-doubling) bifurcation, producing two points such that applying the dynamics to one yields the other. The equilibrium loses stability, and the system oscillates between these points, forming a period-2 cycle in which a previously stable single-point outcome 'flips' back and forth each period; as the parameter continues to change in the same direction, further period-doubling can occur, leading to cycles of period 4, 8, and, eventually, chaotic behavior. Therefore, the dynamic behavior of the economy modeled in this paper may also be marked by fluctuating heterogeneity in tax compliance behavior, with the level and distribution of income undergoing endogenous fluctuations as well.

4 Implications of tax evasion for income distribution

The analytical framework set forth in this paper allows us to provide a logically consistent description of the mechanisms through which changes in income tax evasion impact on several measures of income distribution over the long run. The distinction among taxpayers coexisting in the unique, locally attracting long-run equilibrium x^* established in case (*i*) in Proposition 2 (compliant, undetected non-compliant, and detected and fined non-compliant) allows us to determine the respective shares of net wage income accruing to each taxpayer type, as well as the associated rental income received by the elderly. This, in turn, makes it possible to fully characterize the distribution of each category of income and the resulting net aggregate income. More generally, this framework allows us to examine the long-run equilibrium implications of individual tax compliance decisions for the distribution of income both within the life stages of a given generation (and thus across taxpayer types) and across overlapping generations (and thus across net income types). Therefore, the measures of income distribution computed herein are based exclusively on individual income net of taxes and fines.

We start by computing the within-stage Gini coefficients for the subpopulations of young and old individuals in the polymorphic long-run equilibrium established in Proposition 1. Each of these coefficients measures the dispersion in net wage income (appropriated by young individuals) and capital rental income (appropriated by old individuals) in the long-run equilibrium for a given distribution of idiosyncratic non-pecuniary motivations and proclivities toward tax compliance within the generation born in a given period. Table 2 summarizes the share of each taxpayer type within the young life stage of a given generation and the corresponding net income of each type of individual—net wage when young and return on capital rented to firms when old—in the long-run equilibrium.

Taxpayer type (i)	Share in young stage	Net income when young (y_1^i)
Compliant ($i = C$)	$\sigma_C = 1 - x^*$	$y_1^C = (1-\tau)w(K^*, x^*)$
Undetected non-compliant ($i = UN$)	$\sigma_{UN} = (1-\varepsilon)x^*$	$y_1^{UN} = w(K^*, x^*)$
Detected non-compliant ($i = DN$)	$\sigma_{DN} = \varepsilon x^*$	$y_1^{DN} = [1-\gamma(x^*)]w(K^*, x^*)$
		Gross (and net) income when old (y_2^i)
Old individuals		$y_2^C = \left[\frac{1+r(K^*,x^*)}{2+\theta}\right] y_1^C$ $y_2^{UN} = \left[\frac{1+r(K^*,x^*)}{2+\theta}\right] y_1^{UN}$ $y_2^{DN} = \left[\frac{1+r(K^*,x^*)}{2+\theta}\right] y_1^{DN}$

Table 2: Share of each taxpayer type within the young life stage and the corresponding net income of each type of individual—net wage when young and return on capital rented to firms when old—in the long-run equilibrium.

The net wage income Gini coefficient (i.e., the within-stage Gini coefficient for the subpopulation of young individuals) is given by:[10]

$$G_1 = \frac{\sum_{i\in\mathcal{S}}\sum_{i'\in\mathcal{S}}\sigma_i\sigma_{i'}\left|y_1^i - y_1^{i'}\right|}{2\sum_{i\in\mathcal{S}}\sigma_i y_1^i}, \qquad \mathcal{S} = \{C, UN, DN\} \tag{34}$$

where σ_i and $\sigma_{i'}$ represent, respectively, the shares of taxpayers of types $i \in \mathcal{S}$ and $i' \in \mathcal{S}$ in the young life stage in the long-run equilibrium, and y_1^i and $y_1^{i'}$ denote the corresponding net income of each type of taxpayer when young, as summarized in Table 2. The fully expanded expression for

[10] Given the homogeneity of the wage rate, w, the rate of return on rented capital, r, and the one-period discount rate, θ, across individuals belonging to the same generation, the capital rental income Gini coefficient (i.e., the within-stage Gini coefficient for the subpopulation of old individuals), computed as in (34), but using y_2^C, y_2^{UN} and y_2^{DN}, instead of y_1^C, y_1^{UN} and y_1^{DN}, yields the same result as the net wage income Gini coefficient, expressed in (C13). The intuitive reason is that individuals who are young in period t become old in period $t+1$. As shown in Table 2, the gross (and net) income when old for each type of taxpayer is given by the respective net wage income when young multiplied by the (common) compounded future value of the fraction of net wage income saved when young, which is the term shown in brackets.

the net wage income Gini coefficient in (34), incorporating all relevant substitutions, is reported in (C13) in Appendix C.

Although capital rental income received by old individuals is not taxed, persistent heterogeneity in the tax compliance strategies individuals adopt in their young life stage creates dispersion in the incomes earned by taxpayers across overlapping generations. Specifically, in a given period t in which there is heterogeneity in tax compliance behavior, income inequality arises among young individuals born in t and among young individuals born in $t-1$ who are old in t. In both cases, this constitutes within-stage inequality, as it pertains to the same life stage, although across two different generations. Consequently, income inequality arises also across all individuals of overlapping generations coexisting in t. This overall overlapping-generations income inequality is measured by what we term the net aggregate income Gini coefficient, defined as:

$$G_2 = \frac{\sum_{i \in \mathscr{S}} \sum_{i' \in \mathscr{S}} \sum_{\iota=1,2} \sum_{\iota'=1,2} \sigma_i \sigma_{i'} \left| y_\iota^i - y_{\iota'}^{i'} \right|}{2 \sum_{i \in \mathscr{S}} \sum_{\iota=1,2} \sigma_i y_\iota^i}, \qquad \mathscr{S} = \{C, UN, DN\} \tag{35}$$

where y_2^i and $y_2^{i'}$ denote the corresponding net income of each taxpayer of types $i \in \mathscr{S}$ and $i' \in \mathscr{S}$ when old.

A major transmission channel through which non-compliance affects the net aggregate income Gini coefficient in the long run is, intuitively, via the relative price of the production factors. As summarized in Table 2, this relative price is endogenously determined by the distribution of tax compliance strategies across taxpayers. Over a given period, undetected non-compliant taxpayers accumulate greater savings than other taxpayers; consequently, the capital stock available for output production in the subsequent period is higher than it would have been had all taxpayers complied with their legally due tax obligations. This raises the common wage rate at which the next generation of taxpayers (of all types) is compensated (recall from (11) that the marginal product of labor, and hence labor demand, varies positively with the capital stock), while declining the rate of return on rented capital (recall from (12) that the marginal product of capital, and hence capital demand, varies negatively with the capital stock).

As shown in Appendix C, the net aggregate income (or overlapping-generations) Gini coefficient can be decomposed into three components: the *scaled within-stage* component gathers the terms that capture income dispersion as measured by the common within-stage Gini coefficient for the subpopulations of young ($\iota = 1$) and old ($\iota = 2$) individuals, with this component defined as one-half of the corresponding within-stage Gini coefficient, G_1. The *compounding* and the *overlapping-generational cross-strategies* components, in turn, measure distinct forms of inter-generational income dispersion.

The former collects the terms that measure the dispersion in the incomes of taxpayers of the same type who belong to different generations, i.e., the dispersion arising from compounding a taxpayer's net income at the rate of return on rented capital $r(K^{*}, x^{*})$. The latter measures inter-generational income dispersion across tax compliance strategies and arises from the heterogeneity in tax compliance strategies in the long-run equilibrium. The fully expanded expression for each component of the net aggregate income or overlapping-generations Gini coefficient in (35), incorporating all relevant substitutions, is reported in Appendix C.

The impact of parametric variations on the Gini coefficients defined above depends on the parameters governing deterministic payoffs and on the distribution of idiosyncratic non-pecuniary motivations and proclivities within a given generation, as these factors are critical in shaping young individuals' strategic choices regarding tax compliance. Owing to the complexity of the expressions defining the Gini coefficients in (34)-(35), or their fully expanded counterparts in (C13)-(C20) in Appendix C, numerical simulations are required to obtain comparative static results for these income distribution measures. To conduct such numerical simulations, it is necessary to specify the forms of the penalty rate function in (14) and the deterministic utility function $\upsilon(\cdot)$ in (24). With respect to the penalty rate in (14), we assume it to be a strictly increasing linear function of the tax-revenue-loss coefficient, which is equal to the proportion of tax evaders, as shown earlier:

$$\gamma(x_t) = a + (b - a)x_t, \tag{36}$$

where $a \in \mathbb{R}_{++}$ and $b \in \mathbb{R}_{++}$ are parametric constants such that $\tau < a < b < 1$. Note that $\gamma(0) = a > \tau$, $\gamma(1) = b < 1$ and $\gamma'(x_t) = b - a > 0$ for all $x_t \in [0, 1] \subset \mathbb{R}$, properties that satisfy the constraints imposed on the function in (14). Turning to the function $\upsilon(\cdot)$ in (24), we assume it to take the form of the identity function:

$$\upsilon(\tau) = \tau \quad \text{and} \quad \upsilon\big(\varepsilon\gamma(x_{t-1})\big) = \varepsilon\gamma(x_{t-1}). \tag{37}$$

Based on the logistic specification in (31) and the functional forms specified in (36)–(37), the local stability condition stated in (B12) in Appendix B can be expressed equivalently as follows:[11]

$$P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\varepsilon\gamma'(x^*)=\frac{\lambda}{4}sech^2\left(\frac{\lambda\big[\tau-\varepsilon\big(a+(b-a)x^*-m\big)\big]}{2}\right)\varepsilon(b-a)<1. \quad (38)$$

Given that $sech^2(\cdot)\in(0,1]\subset\mathbb{R}$ over its entire domain, it then follows that, for $0<\varepsilon<1$ and $0<\tau<a<b<1$, as previously assumed, $\frac{\lambda}{4}sech^2(\cdot)\varepsilon(b-a)\leq\frac{\lambda}{4}\varepsilon(b-a)$ for all $(\lambda,\varepsilon,a,b)\in\mathbb{R}^4_+$. Therefore, if $\frac{\lambda}{4}\varepsilon(b-a)<1$, the stability condition in (38) is satisfied.

Even with the simple functional forms in (36) and (37), the logistic specification in (31) precludes the derivation of a closed-form solution for x^* from the long-run equilibrium condition in (A2). More generally, the complexity of the expressions defining the Gini coefficients in (34)-(35), or their fully expanded counterparts in (C13)–(C20) in Appendix C, requires the use of numerical simulations to derive comparative static results for these income distribution measures.

Accordingly, we solve the model numerically under a benchmark parametric specification and examine the effects of parametric variations on the separate Gini coefficients G_1 and G_2, as defined in (C13)–(C20) in Appendix C, given the functional forms specified in (31), (36), and (37). Unless otherwise indicated, in the numerical analyses conducted below we assign benchmark values to the following parameters: the discount rate and the elasticity of aggregate output with respect to capital take the standard values of $\theta=0.01$ and $\alpha=0.36$, respectively; the elasticity of aggregate output with respect to productive public spending is set to $\beta=0.13$;[12] the income tax rate is $\tau=0.25$, which corresponds approximately to the average income tax rate in the United States in 2022; the probability of detection of a non-compliant taxpayer in a given generation is set to $\varepsilon=0.02$;[13] the intensity of choice is $\lambda=4$;[14] the auditing cost κ is set to represent 5% of fine revenues; and, finally, for the penalty rate function in (36), we set $a=0.26$ and $b=0.99$. From (38), it suffices to have $\lambda<\frac{4}{\varepsilon(b-a)}=\frac{4}{0.02(0.99-0.26)}\simeq 274$ for the stability condition to hold, which is empirically plausible given the reference values of the key parameters involved. In all the numerical simulations reported subsequently, the stability condition in (38) was verified. Using (36)–(37) and

[11] In (38), we exploit the well-established relationship between the probability density function of the logistic distribution specified in (31) and the hyperbolic secant function:

$$P'\left(\tau-\varepsilon\big(a+(b-a)x^*-m\big)\right)=\frac{\lambda e^{-\lambda\left(\tau-\varepsilon\left(a+(b-a)x^*-m\right)\right)}}{\left(1+e^{-\lambda\left(\tau-\varepsilon\left(a+(b-a)x^*-m\right)\right)}\right)^2}=\frac{\lambda}{4}sech^2\left(\frac{\lambda\big[\tau-\varepsilon\big(a+(b-a)x^*-m\big)\big]}{2}\right).$$

[12] The choice of β is based on the mean productivity of public capital computed by Núñez-Serrano and Velázquez (2017) and is consistent with the original estimates of Barro (1990).

[13] Experimental studies employ audit probabilities in the range 0.01–0.10 to reflect realistic enforcement conditions (Alm et al., 1992), and survey treatments emphasize that empirically plausible detection probabilities are low (Alm, 1999).

[14] See Lux (2009), Train (2009), Cornea-Madeira, Hommes, and Massaro (2019), and Kukačka and Sacht (2023) for a range of plausible values for the intensity of choice parameter. A general conclusion in the empirical literature is that the estimated intensity of choice parameter is context-dependent, reflecting features of the decision environment and the information structure.

the parameters' benchmark values specified above, it follows that the pecuniary payoff differential $d \equiv \tau - \varepsilon[a + (b - a)x_{t-1}] = 0.25 - 0.02[0.26 + (0.99 - 0.26)x_{t-1}]$ is strictly positive and attains its maximum value $d \simeq 0.25$ at $x_{t-1} = 0$. Moreover, subsequent numerical simulations indicate that the long-run equilibrium is $x^* \simeq 1$ for $m \lesssim -2.1$ and $x^* \simeq 0$ for $m \gtrsim 2.5$.

With respect to the median tax morale, we consider a range of values encompassing a compliance-leaning tax morale ($m > 0$), a neutral tax morale—neither compliance- nor noncompliance-leaning on balance ($m = 0$)—and a noncompliance-leaning tax morale ($m < 0$). Specifically, to calibrate the median tax morale, we center the range of interest at $m = 0.25$, corresponding to the point at which the median tax morale offsets the calibrated pecuniary payoff differential $d \simeq 0.25$. We plausibly specify the interval $m \in [-0.5, 1.0] \in \mathbb{R}$, symmetric around $m = 0.25$, to capture heterogeneity in non-pecuniary motivations and proclivities favoring tax compliance, as documented in the behavioral literature. As found in Alm et al. (1992) and Alm and Torgler (2006), tax compliance is often higher than predicted by standard approaches that focus exclusively on the pecuniary payoff differential, suggesting that $m > d$ represents the empirically most relevant case. However, by considering strictly negative values of the median tax morale, we account for considerable non-compliance-leaning, or anti-tax morale behavior, whereby taxpayers derive positive psychological utility from evasion, as discussed in Section 2.2—a phenomenon observed in environments characterized, for example, by substantially low institutional trust or pronounced perceptions of unfairness (Alm & Torgler, 2006). This range spans a broad spectrum of tax morale, from intrinsically motivated evaders to intrinsically honest taxpayers, while preserving a median tax morale consistent with the fine balance between pecuniary and non-pecuniary incentives for tax compliance. The negative lower bound accounts for anti-tax behavior, or expressive dissent found in low-trust environments, while the upper bound represents the high levels of intrinsic tax compliance observed in experimental settings where individuals comply with their tax obligations despite zero audit probabilities (Alm et al., 1992).

Figure 2 shows how the proportion of non-compliant taxpayers in the long-run equilibrium, x^*, varies with different combinations of median tax morale and intensity of choice (m, λ) (left panel) and how the same proportion varies with the median tax morale for three specific values of the intensity of choice (right panel). The proportion of non-compliant taxpayers in the long-run equilibrium varies negatively with median tax morale, m, across the entire range considered in Figure 2. Indeed, as formally demonstrated in (33), this negative relationship holds for any value of m. The seemingly horizontal line segments in the right panel of Figure 2 in fact correspond to values of x^* that asymptotically approach the value of either zero or one. Moreover, the same

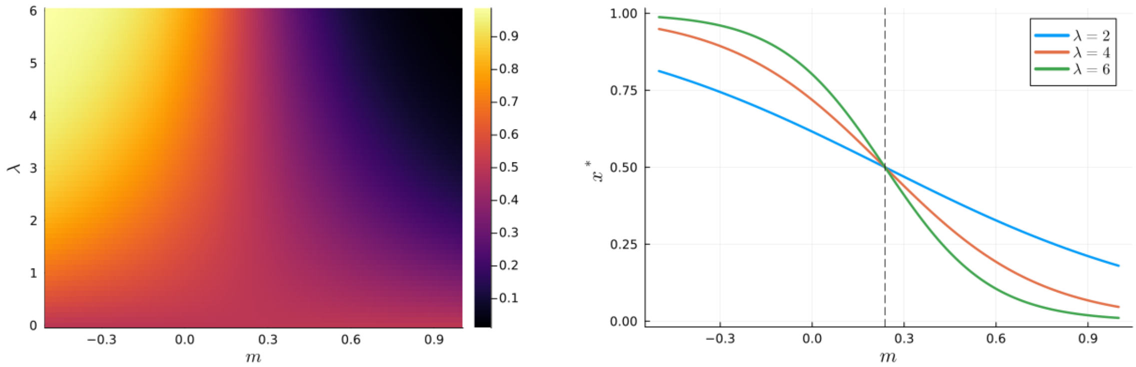
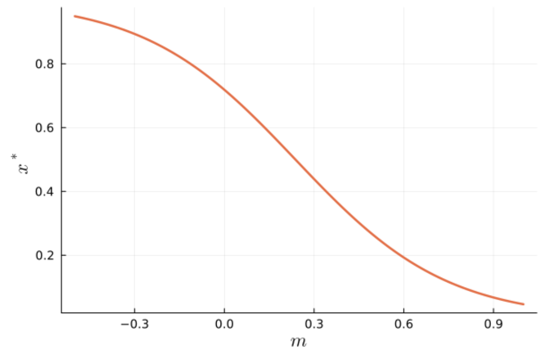


Fig. 2: Proportion of non-compliant taxpayers in the long-run equilibrium (x^*) for different combinations of median tax morale (m) and intensity of choice (λ).

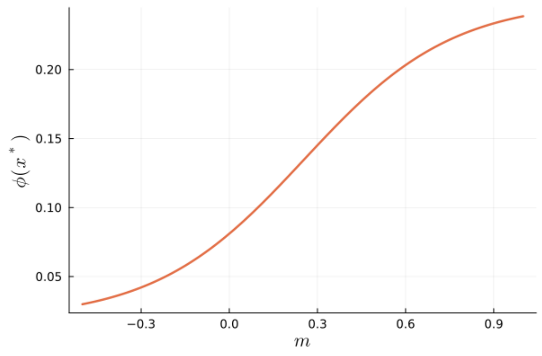
panel shows that, among the values considered, higher levels of the intensity of choice parameter, λ, lead the negative relationship under consideration to become increasingly nonlinear, approaching an inverted S-shaped logistic curve. As shown in the left panel of Figure 2, the level of λ also affects the value of x^* associated with a given level of m. Specifically, for values of m above (below) the threshold represented by $m \simeq 0.25$, lower (higher) values of λ are associated with higher values of x^*. In fact, we know from (32) that, all else constant, the proportion of tax evaders in the long-run equilibrium increases (decreases) with the intensity of choice λ when $\tau - \varepsilon\gamma(x^*) > m$ (resp. $\tau - \varepsilon\gamma(x^*) < m$)—recall that, in calibrating the median tax morale, we centered the relevant range at $m = 0.25$, where the median tax morale offsets the calibrated pecuniary payoff differential $\tau - \varepsilon\gamma(x^*) \equiv d \simeq 0.25$.

Figure 3 illustrates how the long-run equilibrium values of several endogenous variables respond to changes in the median tax morale, as mediated by the long-run equilibrium proportion of tax evaders, which is reproduced in panel (a) of Figure 3 for convenience and ease of reference. As shown in panel (b), a higher median tax morale, by reducing the proportion of tax evaders x^*, raises the provision of productive public services per wage unit, as it follows from (15) that the elasticity of such provision with respect to x^*, which is defined as $E_{\phi x^*} \equiv \phi'(x^*)\frac{x^*}{\phi(x^*)}$, is strictly negative for the parameters' reference values, since $\phi'(x^*) = -\tau + (1-\kappa)\varepsilon[a + 2(b-a)x^*] < 0$ for all $x^* \in (0,1) \subset \mathbb{R}$. Intuitively, this implies that the increase in tax revenue resulting from a decline in the proportion of tax evaders, x^*, induced by a higher median tax morale, outweighs the corresponding decrease in fines revenue.

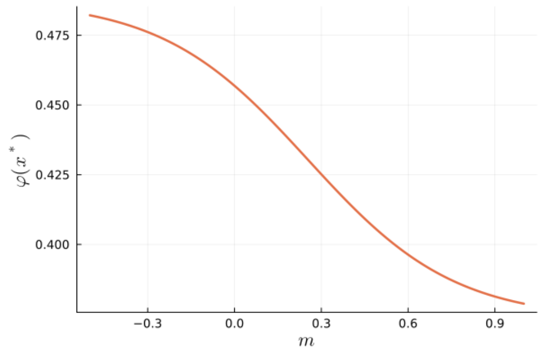
Meanwhile, a higher median tax morale, by reducing the proportion of tax evaders, x^*, also decreases private savings per unit of wage income, as shown in panel (c). Accordingly, considering that (8)–(9) determine that the optimal saving rate is identical across all taxpayers, from (22) we



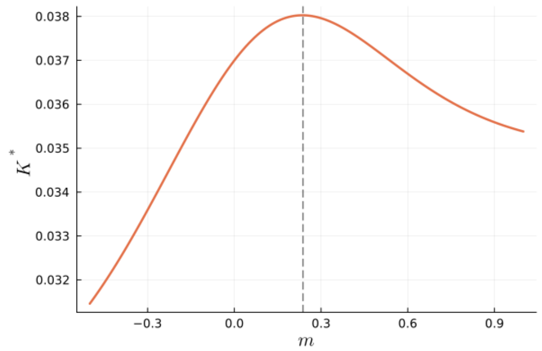
(a) Proportion of tax evaders



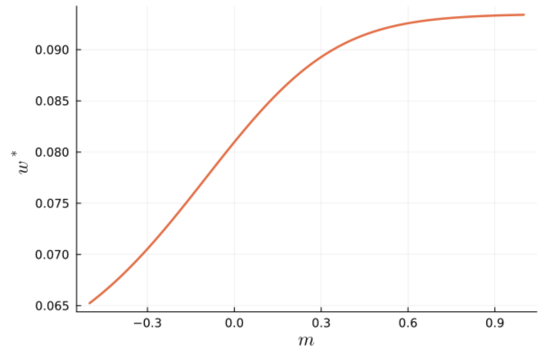
(b) Productive public services per wage unit



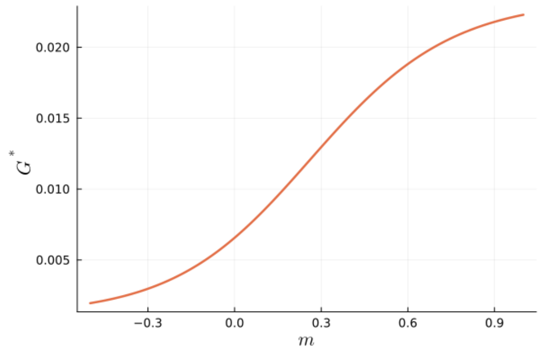
(c) Private savings per wage unit



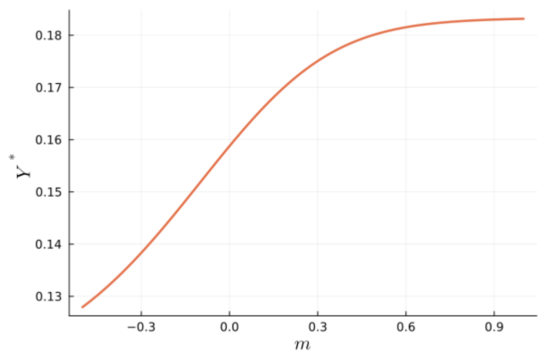
(d) Capital stock



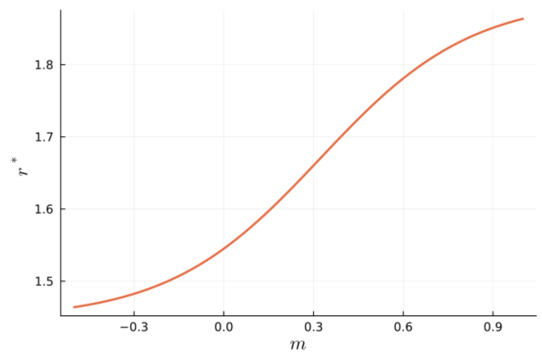
(e) Wage rate



(f) Productive public services



(g) Aggregate output



(h) Capital rental rate

Fig. 3: Long-run values of selected endogenous variables for different values of median tax morale m.

have that, for the parameters' reference values, $\varphi'(x^*) = \frac{1}{2+\theta}\{\tau - \varepsilon[a + 2(b-a)x^*]\} > 0$ for all $x^* \in (0,1) \subset \mathbb{R}$. It follows that a lower proportion of tax evaders, x^*, increases the total savings of compliant taxpayers by an amount that exceeds the corresponding decrease in the total savings of non-compliant taxpayers. Consequently, the elasticity of private savings per wage unit with respect to x^*, defined as $E_{\varphi x^*} \equiv \varphi'(x^*)\frac{x^*}{\varphi(x^*)}$, is strictly positive for all $x^* \in (0,1) \subset \mathbb{R}$.

Panel (d) shows how the capital stock in the long-run equilibrium, K^*, varies for different values of median tax morale, m, a relation which depends on the elasticity of K^* with respect to x^*, which, given (A3), is defined as $E_{K^*x^*} \equiv \frac{\partial K^*}{\partial x^*}\frac{x^*}{K^*} = \frac{\beta}{1-(\alpha+\beta)}E_{\phi x^*} + \frac{1-\beta}{1-(\alpha+\beta)}E_{\varphi x^*}$. For the parameters' reference values, the sign of $E_{K^*x^*}$ depends on the balance between two effects that influence capital formation in opposing directions, $E_{\phi x^*} < 0$ and $E_{\varphi x^*} > 0$. As shown in panel (d), the capital stock in the long-run equilibrium increases with m only when a higher median tax morale, by reducing the proportion of tax evaders x^*, leads to an expansion in productive public services per wage unit that exceeds the contraction in private savings per wage unit, given that total private savings are fully transformed into capital in this single-good economy. This occurs when $m \lesssim 0.25$. When $m \gtrsim 0.25$, however, the contraction in private savings per wage unit resulting from a decrease in the proportion of tax evaders, x^*, induced by a higher median tax morale, exceeds the expansion of productive public services per wage unit, causing the long-run equilibrium capital stock to decline as m increases.

The sign of the elasticity of the long-run equilibrium wage rate w^* with respect to x^*, which, given (17), is defined as $E_{w^*x^*} \equiv \frac{\partial w^*}{\partial x^*}\frac{x^*}{w^*} = \frac{\beta}{1-(\alpha+\beta)}E_{\phi x^*} + \frac{1-\alpha}{1-(\alpha+\beta)}E_{\varphi x^*}$, also depends on the transmission channels $E_{\phi x^*} < 0$ and $E_{\varphi x^*} > 0$. For the parameters' reference values, it follows that $E_{w^*x^*} < 0$ for all $x^* \in (0,1) \subset \mathbb{R}$. As a result, a higher median tax morale, by reducing the proportion of tax evaders, x^*, raises the wage rate, as shown in panel (e). Since both the provision of productive public services per wage unit in panel (b) and the wage rate in panel (e) increase with m, the total provision of productive public services in the long-run equilibrium, shown in panel (f) and defined by $G^* = \varphi(x^*)w^*$ in (18), also unambiguously rises with m.

Considering the constant-returns-to-scale production function in (10), and recalling that labor employment, L_t, is normalized to one, aggregate output (and thus output per capita) in the long-run equilibrium can be expressed as $Y^* = (K^*)^\alpha(G^*)^\beta$. Panel (g) shows that output initially increases with m at an accelerating rate because both K^* and G^* rise with m when $m \lesssim 0.25$. However, for $m \gtrsim 0.25$, a higher median tax morale reduces the long-run equilibrium capital stock, thereby slowing the rate at which output increases with m. Finally, as shown in panel (h), the capital rental rate in the long-run equilibrium increases with m, since its elasticity with respect to x^*, defined by $E_{r^*x^*} \equiv \frac{\partial r^*}{\partial x^*}\frac{x^*}{w^*} = -E_{\varphi x^*}$ in (19), is strictly positive for all $x^* \in (0,1) \subset \mathbb{R}$ under the reference parameter values.

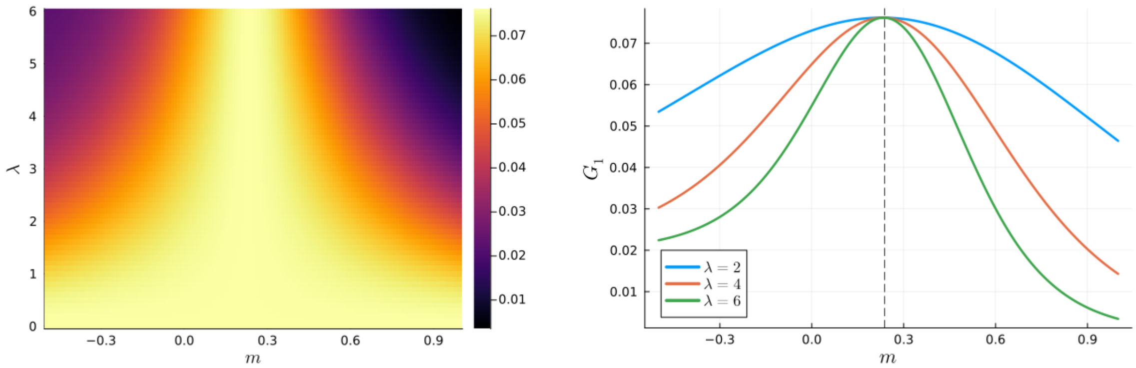


Fig. 4: Within-stage Gini coefficient in the long-run equilibrium (G_1) for different combinations of median tax morale (m) and intensity of choice (λ).

Figure 4 illustrates how the long-run equilibrium value of the net wage income Gini coefficient (i.e., the within-stage Gini coefficient for the subpopulation of young individuals), G_1, varies with different combinations of median tax morale and intensity of choice (m, λ) (left panel) and how the same Gini coefficient varies with median tax morale for three specific values of the intensity of choice (right panel). Recall from the discussion following (34) that the rental income Gini coefficient (i.e., the within-stage Gini coefficient for the subpopulation of old individuals) is also equal to G_1, as given in its fully expanded form in (C13). As shown in the right panel, whether G_1 varies positively or negatively with m depends on whether m is below or above the threshold $m \simeq 0.25$, respectively. Therefore, the highest G_1 occurs at a level of m for which tax morale within a given generation is compliance-leaning. Nonetheless, for values of m above this threshold, higher values of m are associated with lower values of G_1. Note that the seemingly horizontal line segments in the right panel of Figure 2 when $\lambda = 6$ correspond to values of G_1 that asymptotically approach the value of either 0.02 or zero (recall that the long-run equilibrium is $x^* \simeq 1$ for $m \lesssim -2.1$ and $x^* \simeq 0$ for $m \gtrsim 2.5$).[15] Therefore, the associated value of G_1 is intuitively lower in the former case (when all taxpayers comply with their tax obligations) than in the latter (when all taxpayers do not comply). Together with the related result illustrated in Figure 2 that x^* varies negatively with m for any value of the latter, it follows that a lower value of x^* arising from a higher value of m will be associated with a lower value of G_1 only if tax morale is sufficiently compliance-leaning, that is, if m exceeds

[15]Note that when $x^* \to 1$ ($x^* \to 0$), it follows that $G_1 \to \varepsilon$ ($G_1 \to 0$). This strictly positive lower bound for the common net wage and capital rental income Gini coefficient stems from the fact that, in the long-run equilibrium where all taxpayers adopt the non-compliant strategy ($x^* = 1$), a fraction $\varepsilon \in (0,1) \subset \mathbb{R}$ is detected and fined.

the corresponding threshold $m \simeq 0.25$. Meanwhile, as shown in both panels of Figure 4—but more inclusively in the left panel—the level of λ, among the values considered, affects the value of G_1 corresponding to a given level of m. Specifically, except at the threshold $m \simeq 0.25$, lower values of λ are associated with higher values of G_1.

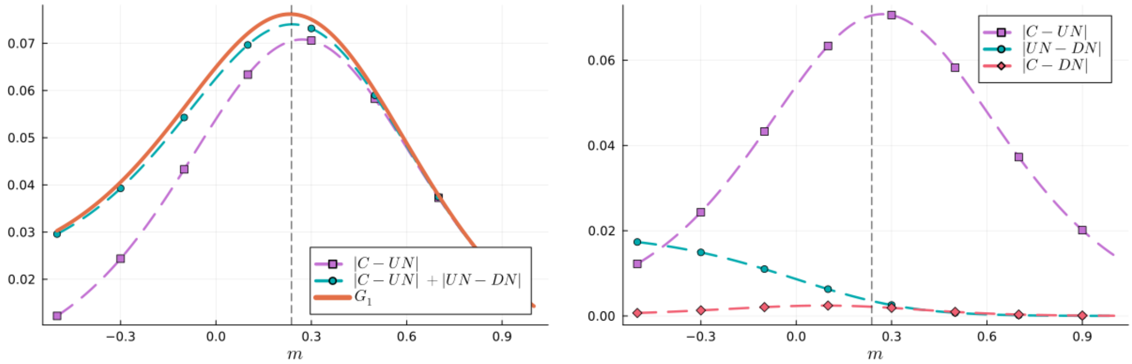


Fig. 5: Left panel: Accumulated contributions to G_1 from the absolute income differentials between compliant taxpayers and undetected non-compliant taxpayers ($|C–UN|$), between undetected and detected non-compliant taxpayers ($|UN–DN|$), and between compliant taxpayers and detected non-compliant taxpayers ($|C–DN|$) as median tax morale (m) varies. Right panel: Absolute, non-accumulated contributions of each component to G_1 as m varies.

Figure 5, where $\lambda = 4$, draws on the terms of (34) and its fully expanded counterpart in (C13) in Appendix C to present an informative decomposition of the effects of varying levels of median tax morale on the common within-stage Gini coefficients of net wage and capital rental income in the long-run equilibrium, G_1. In the left panel, for example, at $m = 0$, the dashed violet line with square markers indicates the value that G_1 would take if the sole source of inequality were the absolute income differential between compliant and undetected non-compliant taxpayers ($|C - UN|$). The dashed blue line with circle markers, in turn, indicates the accumulated value that G_1 would take if the absolute income differentials between compliant and undetected non-compliant taxpayers ($|C - UN|$), and between undetected and detected non-compliant taxpayers ($|UN - DN|$) were the only sources of inequality. Therefore, at $m = 0$, the remaining contribution to G_1 comes from the absolute income differential between compliant and detected non-compliant taxpayers ($|C - DN|$). In the right panel, meanwhile, at $m = 0$, each line represents the absolute, non-accumulated contribution of the corresponding source of inequality to G_1. As in Figure 4, G_1 attains its highest value at a threshold level of m for which tax morale is compliance-leaning ($m \simeq 0.25$), now displayed in the left panel. As confirmed in the right panel of Figure 4, when median tax morale lies well below this threshold, the absolute income differential between undetected and detected non-compliant taxpayers ($|UN - DN|$) accounts for the majority of common net income inequality at both young and old life stages. As median tax morale approaches the threshold from below, however, the majority of this inequality becomes increasingly accounted for by the absolute income differential between compliant and undetected non-compliant taxpayers ($|C - UN|$). As further confirmed in the right panel of Figure 5, when median tax morale exceeds the threshold given by $m \simeq 0.25$, virtually the entire decline in G_1 as m increases is intuitively attributable to a reduction in the absolute income differential between compliant and undetected non-compliant taxpayers ($|C - UN|$).

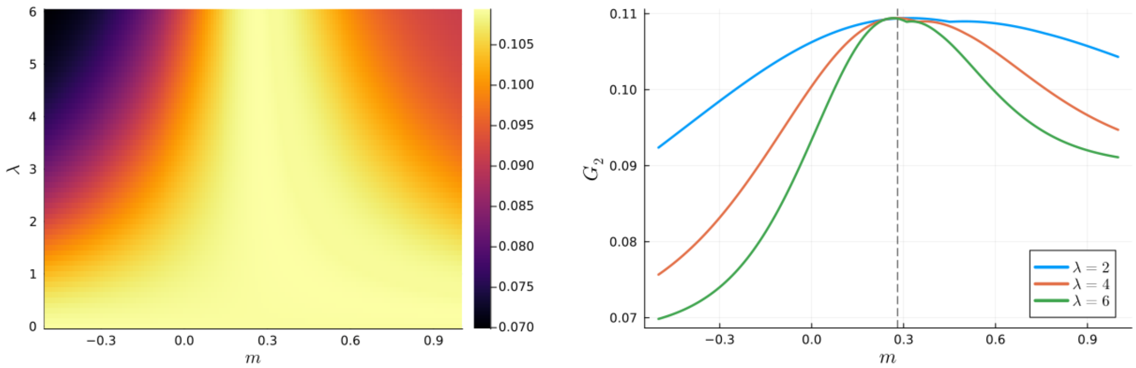


Fig. 6: Net aggregate income Gini coefficient in the long-run equilibrium (G_2) for different combinations of median tax morale (m) and intensity of choice (λ).

Figure 6 illustrates how the long-run equilibrium value of the net aggregate income Gini coefficient (i.e., the Gini coefficient for the population of young and old individuals coexisting in a given period, or for overlapping generations) varies across different combinations of median tax morale and intensity of choice (m, λ) (left panel) and how the same Gini coefficient varies with median tax morale for three specific values of the intensity of choice (right panel). As with the common within-stage Gini coefficient for the subpopulations of young and old individuals in the long-run equilibrium, G_1, whether the net aggregate income Gini coefficient, G_2, as specified in (35) and—after substituting (C17)–(C19)—its fully expanded counterpart in (C20) in Appendix C, varies positively or negatively with m depends on whether m lies below or above a critical threshold $m \simeq 0.28$, respectively. As a result, G_2 attains its highest value at a level of m for which tax morale is compliance-leaning. However, for values of m above this threshold, further increases in m are associated with lower values of G_2. Note that the seemingly horizontal line segments in the right panel of Figure 6 when $\lambda = 6$ in fact correspond to values of G_2 that approach those associated with either $x = 0$ or $x = 1$ (recall that the long-run equilibrium is $x^* \simeq 1$ for $m \lesssim -2.1$ and $x^* \simeq 0$ for $m \gtrsim 2.5$). Note that the corresponding value of G_2 is slightly higher in the former case—when all taxpayers comply with their tax obligations—at approximately 0.05, than in the latter—when none of the taxpayers comply) at approximately 0.03. Together with the result illustrated in Figure 2 that x^* varies negatively with m for any value of the latter, it follows that a lower value of x^* arising from a higher value of m will be associated with a lower value of G_2 only if tax morale is sufficiently compliance-leaning, that is, if m lies above the threshold $m \simeq 0.28$. Meanwhile, as shown in both panels of Figure 6—but more inclusively in the left panel—the level of λ, among the values considered, affects the value of G_2 corresponding to a given level of m. Specifically, except at the threshold $m \simeq 0.28$, lower values of λ are associated with higher values of G_2.

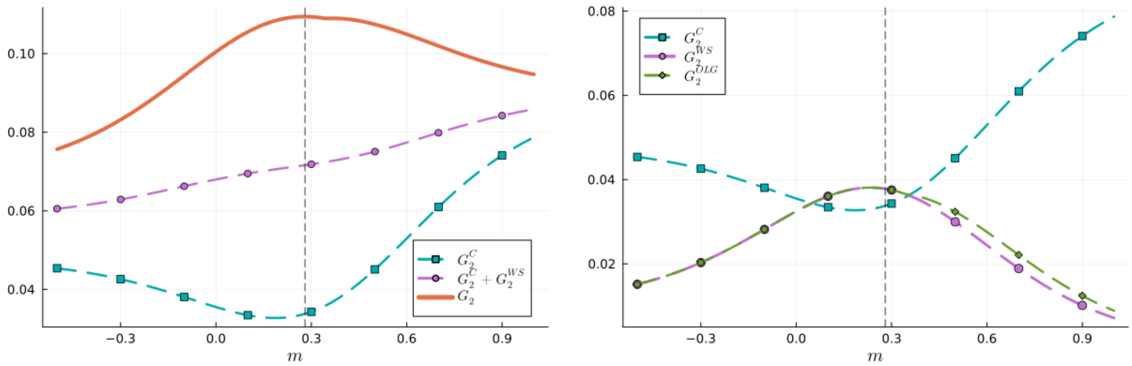
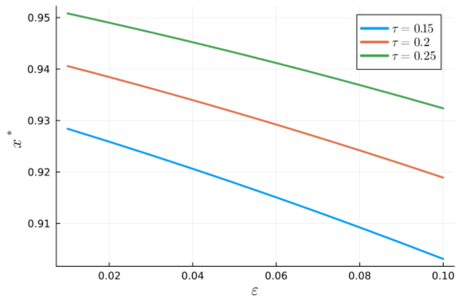


Fig. 7: Left: Accumulated contributions to G_2 from the inter-generational dispersion in the net aggregate income coming from the compounding of a taxpayer's net income at the rate of return on rented capital (compounding component, G_2^C), the income dispersion measured by the common within-stage Gini coefficient for the subpopulations of young and old individuals multiplied by one-half (scaled within-stage component, G_2^{WS}), and the inter-generational income dispersion across tax compliance strategies (overlapping-generational cross-strategies component, G_2^{OLG}). Right panel: Absolute, non-accumulated contributions of each component to G_2 as m varies.

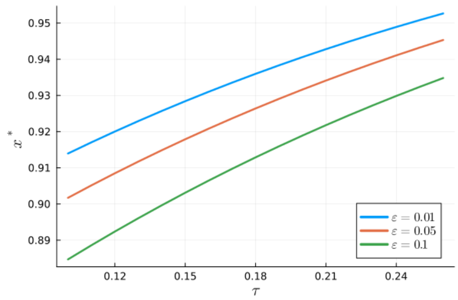
Figure 7, where $\lambda = 4$, draws on the terms of (35) and their fully expanded counterparts (C17)–(C19) in Appendix C to present an informative decomposition of the effects of different levels of median tax morale on the net aggregate income Gini coefficient, G_2. In the left panel, for example, at $m = 0$, the dashed blue line (marked with squares) indicates the value that G_2 would take if the sole source of inequality were the inter-generational dispersion in the net aggregate income coming from the compounding of a taxpayer's net income at the rate of return on rented capital (the compounding component, G_2^C). The dashed violet line (marked with circles), in turn, indicates the accumulated value that G_2 would take if the income dispersion measured by the common within-stage Gini coefficient for young and old individuals multiplied by one-half (the scaled within-stage component, G_2^{WS}) and the compounding component were the only sources of inequality. The remaining contribution to G_2 therefore comes from inter-generational income dispersion across tax compliance strategies (the overlapping-generational cross-strategies component, G_2^{OLG}). In the right panel, meanwhile, at $m = 0.7$, for example, each line represents the absolute, non-accumulated contribution of the corresponding source of inequality to G_2. Note that G_2 attains its highest value at a threshold level of the median tax morale at which tax morale is compliance-leaning, as shown in the left panel. As illustrated in the left panel of Figure 7 and corroborated by the right panel, when median tax morale lies below this threshold, the contribution to G_2 attributable to inter-generational dispersion in net aggregate income arising from the compounding of a taxpayer's net income at the rate of return on rented capital (the compounding component) decreases with m. By contrast, the contributions associated with income dispersion as measured by the common within-stage Gini coefficient for net wage and capital rental income multiplied by one-half (the scaled within-stage component), as well as with inter-generational income dispersion across tax compliance strategies (the cross-strategies component), both increase with m. When median tax morale exceeds the threshold, the contribution to G_2 attributable to the compounding component increases with m, whereas the contributions associated with the scaled within-stage component and the overlapping-generational cross-strategies component both decrease with m.

Figure 8 reports the comparative statics of the proportion of non-compliant taxpayers and the Gini coefficients G_1 and G_2 in the long-run equilibrium with respect to the probability of detection, ε, and the income tax rate, τ. We set $\lambda = 4$ and $m = -0.5$, thereby characterizing a generation with, on balance, non-compliance-leaning tax morale. Panel (a) shows that the proportion of non-compliant taxpayers in the long-run equilibrium decreases with the probability of detection, whereas panel (b) shows that it increases with the income tax rate, consistent with the analytical results in (30) and (29), and with the literature (Alm, 2019). For a given value of ε, higher values of τ among those considered are associated with higher levels of x^*. Conversely, for a given value of τ, lower values of ε among those considered correspond to higher values of x^*. The common within-stage Gini coefficient for net wage income and capital rental income, G_1, is increasing in ε (panel (c)) and slightly increasing in τ (panel (d)) across their respective plausible ranges. Moreover, for a given value of ε (resp. τ), higher values of τ (resp. ε) within the considered range correspond to higher levels of G_1.

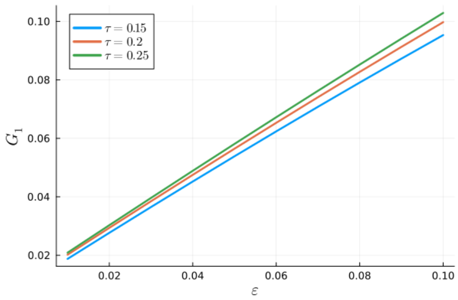
To facilitate interpretation of the result shown in panel (c) of Figure 8, recall from (C13) that G_1 is intuitively independent of the long-run equilibrium real wage rate, $w(K^*, x^*)$, since this wage rate is common to all taxpayer types. As reported in Table 2, an increase in ε, by lowering x^*, raises the share of compliant taxpayers, σ_C, and thereby increases their total net wage income.



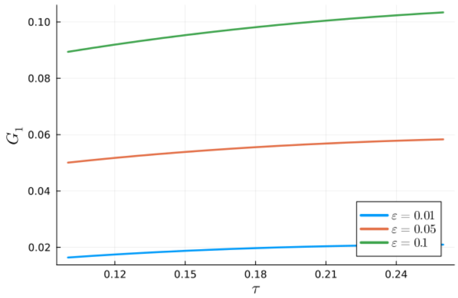
(a) Proportion of tax evaders in the long-run equilibrium x^* for different probabilities of detection ε.



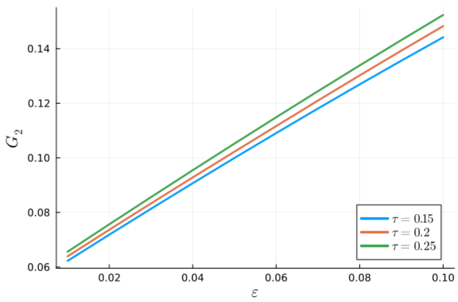
(b) Proportion of tax evaders in the long-run equilibrium x^* for different tax rates τ.



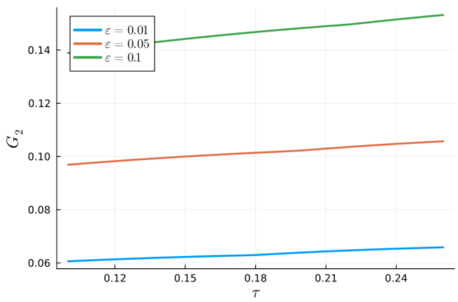
(c) Within-stage Gini coefficient G_1 for different probabilities of detection ε.



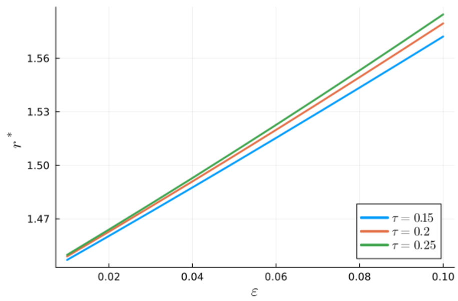
(d) Within-stage Gini coefficient G_1 for different tax rates τ.



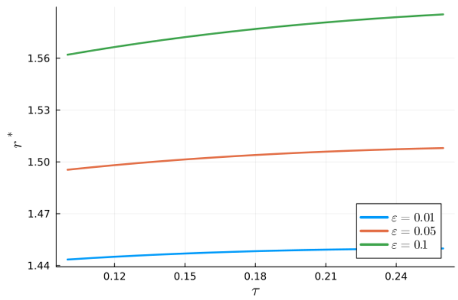
(e) Net aggregate income Gini coefficient G_2 for different probabilities of detection ε.



(f) Net aggregate income Gini coefficient G_2 for different tax rates τ.



(g) Capital rental rate in the long-run equilibrium r^* for different probabilities of detection ε.



(h) Capital rental rate in the long-run equilibrium r^* for different tax rates τ.

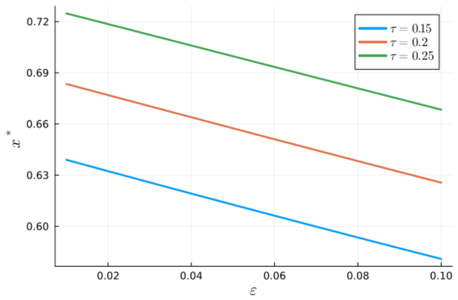
Fig. 8: Comparative statics for non-compliance-leaning tax morale ($m = -0.5$).

This channel contributes to greater dispersion in net wage income across taxpayers within a given generation. The same increase in ε, together with the associated decline in x^*, reduces the share of undetected non-compliant taxpayers, σ_{UN}, and thereby lowers their total net wage income. This effect contributes to a reduction in net wage income dispersion across taxpayers within a given generation. Meanwhile, the same increase in ε, together with the associated decline in x^*, exerts opposing effects on the share of detected non-compliant taxpayers, σ_{DN}. At the same time, the net wage income of an individual detected non-compliant taxpayer, y_1^{DN}, increases as a result of the reduction in the penalty rate, γ. Accordingly, the total net wage income of detected non-compliant taxpayers may either increase or decrease, thereby contributing to either an increase or a reduction in net wage income dispersion across taxpayers within a given generation. Consequently, the positive relationship between ε and G_1 shown in panel (c) reflects the dominance of the dispersion-increasing effect(s) over the dispersion-reducing effect(s).

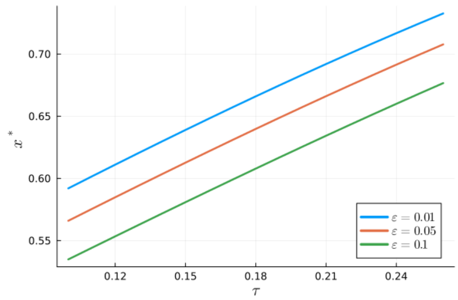
To facilitate interpretation of the result depicted in panel (d) of Figure 8, note from Table 2 that an increase in τ, by raising x^*, reduces both the share of compliant taxpayers, σ_C, and the net wage income of an individual compliant taxpayer, y_1^C, thereby jointly lowering the total net wage income of compliant taxpayers. This contributes to a reduction in net wage income dispersion across taxpayers within a generation. The same increase in τ and the associated rise in x^* increases the share of undetected non-compliant taxpayers, σ_{UN}, and thereby raises their total net wage income. This effect contributes to an increase in net wage income dispersion across taxpayers within a given generation. Meanwhile, the same increase in τ and the associated rise in x^* increases the share of detected non-compliant taxpayers σ_{DN}, although the net wage income of an individual detected non-compliant taxpayer declines owing to the higher penalty rate, γ. Accordingly, the total net wage income of detected non-compliant taxpayers may increase or decrease, thereby contributing to either an expansion or a contraction of net wage income dispersion across taxpayers within a given generation. Consequently, the modestly positive relationship between τ and G_1 depicted in panel (d) reflects the predominance of dispersion-increasing effect(s) relative to dispersion-reducing effect(s).

In Figure 8, analogous to panels (c) and (d) for G_1, the net aggregate income Gini coefficient, G_2, increases with ε (panel (e)) and exhibits a slight increase with τ (panel (f)) across their respective plausible ranges. Furthermore, for a given value of ε (resp. τ), higher values of τ (resp. ε) within the considered range are associated with higher levels of G_2. In addition, for all values of ε within the considered range and for all values of τ examined in panel (e), G_2 strictly exceeds G_1. Similarly, for all values of τ within the considered range and for all values of ε examined in panel (f), G_2 also strictly exceeds G_1. Therefore, in both cases, the net aggregate income Gini coefficient is strictly greater than the common within-stage Gini coefficient for net wage income and capital rental income. Despite the similarity in shape between G_1 and G_2 in the respective panels—which is partially explained by the fact that G_1 constitutes part of a component of G_2—a comparison of (34) and (35), or more explicitly of their fully expanded forms incorporating all relevant substitutions in Appendix C, reveals that the determination of G_2 involves several additional effects that are absent in G_1. Recall from (C13) in Appendix C that G_1 is intuitively independent of the long-run equilibrium real wage rate, $w(K^*, x^*)$, since this wage rate is common to all taxpayer types. Similarly, G_1, which also represents the within-stage Gini coefficient for the subpopulations of old individuals in the long-run equilibrium, is intuitively independent of the long-run equilibrium rental rate of capital, $r(K^*, x^*)$, as this rate is common to all old individuals. However, (C18)–(C19) in Appendix C shows that two of the components of G_2 depends on $r(K^*, x^*)$ in complicated ways. The compounding component captures the dispersion in incomes of taxpayers of the same type across different generations, that is, the variation resulting from the accumulation of a taxpayer's net income at the rate of return on rented capital, $r(K^*, x^*)$. In contrast, the overlapping-generational cross-strategies component measures inter-generational income dispersion across tax compliance strategies, reflecting the heterogeneity in tax compliance behavior in the long-run equilibrium. Nevertheless, for the parameter values set for the simulated results presented in panels (g) and (h), the long-run equilibrium capital rental rate, $r(K^*, x^*)$, is increasing in ε and τ. Furthermore, for a given value of ε (resp. τ), higher values of τ (resp. ε) within the considered range are associated with higher levels of $r(K^*, x^*)$. In sum, the long-run equilibrium results depicted in Figure 8 indicate that higher values of ε are associated with a lower proportion of tax evaders and higher values of G_1, G_2, and $r(K^*, x^*)$. Conversely, higher values of τ are associated with increases—albeit modest in certain cases—in each of these variables.

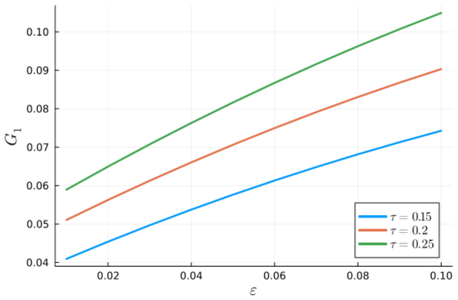
Figure 9 reports the comparative statics of the share of non-compliant taxpayers and the Gini coefficients G_1 and G_2 in the long-run equilibrium, with respect to the probability of detection, ε, and the income tax rate, τ, for $\lambda = 4$ and $m = 0$. This parametrization characterizes a generation whose tax morale is, on balance, neither biased toward compliance nor toward non-compliance. As in the case of $m = -0.5$, panel (a) indicates that x^* declines as the probability of detection increases, whereas panel (b) shows that x^* rises with the income tax rate. These patterns are consistent with the analytical results derived in (30) and (29), respectively. For a given value of ε, higher values of τ within the range considered are associated with higher levels of x^*. Conversely, for a given value of τ, lower values of ε within the range considered correspond to higher levels of x^*. The common



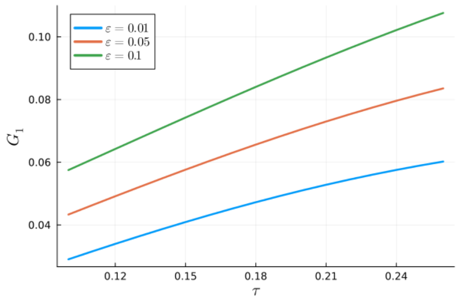
(a) Proportion of tax evaders in the long-run equilibrium x^* for different probabilities of detection ε.



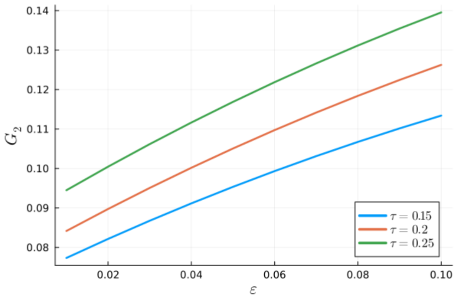
(b) Proportion of tax evaders in the long-run equilibrium x^* for different tax rates τ.



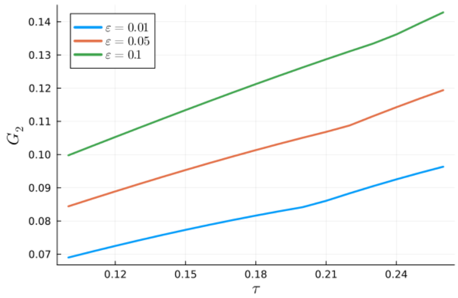
(c) Within-stage Gini coefficient G_1 for different probabilities of detection ε.



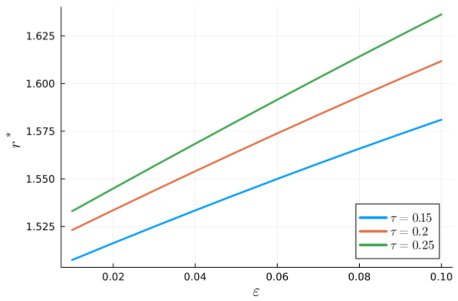
(d) Within-stage Gini coefficient G_1 for different tax rates τ.



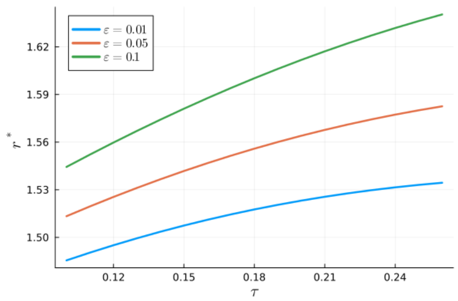
(e) Net aggregate income Gini coefficient G_2 for different probabilities of detection ε.



(f) Net aggregate income Gini coefficient G_2 for different tax rates τ.



(g) Capital rental rate in the long-run equilibrium r^* for different probabilities of detection ε.



(h) Capital rental rate in the long-run equilibrium r^* for different tax rates τ.

Fig. 9: Comparative statics for neutral tax morale ($m = 0$).

within-stage Gini coefficient for net wage income and capital rental income, G_1, increases with ε (panel (c)) and τ (panel (d)) over their plausible range. Moreover, for a given value of ε (resp. τ), higher values of τ (resp. ε) within the considered range correspond to higher levels of G_1.

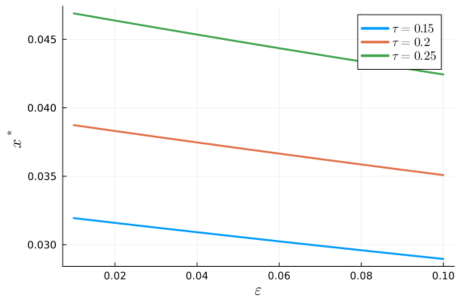
To interpret the result depicted in panel (c) of Figure 9, note from Table 2 that, as in the case of Figure (8), an increase in ε lowers x^*, which raises the share of compliant taxpayers, σ_C, and thereby raises their total net wage income. This channel contributes to an expansion of net wage income dispersion across taxpayers within a given generation. The same increase in ε, together with the associated decline in x^*, reduces the share of undetected non-compliant taxpayers, σ_{UN}, and thereby lowers their total net wage income. This effect contributes to a reduction in net wage income dispersion across taxpayers within a given generation. Meanwhile, the same increase in ε and the associated decline in x^* exert opposing effects on the share of detected non-compliant taxpayers, σ_{DN}. At the same time, the net wage income of an individual detected non-compliant, y_1^{DN}, increases owing to the reduction in the penalty rate, γ. As a result, the total net wage income of detected non-compliant taxpayers may either increase or decrease, thereby contributing to either an increase or a reduction in net wage income dispersion across taxpayers within a given generation. Therefore, in the case of Figure (8), the positive relationship between ε and G_1 shown in panel (c) reflects the dominance of the dispersion-increasing effect(s) over the dispersion-reducing effect(s).

To facilitate interpretation of the result depicted in panel (d) of Figure 9, note from Table 2 that, as in the case of Figure (8), an increase in τ, by raising x^*, reduces the share of compliant taxpayers, σ_C, and the net wage income of an individual compliant taxpayer, y_1^C, thereby jointly lowering the total net wage income of compliant taxpayers. These joint effects contribute to a reduction in net wage income dispersion across taxpayers within a given generation. The same increase in τ and the resulting rise in x^* increases the share of undetected non-compliant taxpayers, σ_{UN}, and thereby raises their total net wage income, which contributes to an increase in net wage income dispersion across taxpayers within a given generation. Meanwhile, the same increase in τ and the resulting rise in x^* increases the share of detected non-compliant taxpayers, σ_{DN}, although the net wage income of an individual detected non-compliant taxpayer declines owing to the higher penalty rate, γ. It follows that the total net wage income of detected non-compliant taxpayers may increase or decrease, thereby contributing to either an expansion or a contraction of net wage income dispersion across taxpayers within a given generation. Thus, the positive relationship between τ and G_1 in panel (d) reflects the dominance of the dispersion-increasing effect(s) over the dispersion-reducing effect(s).

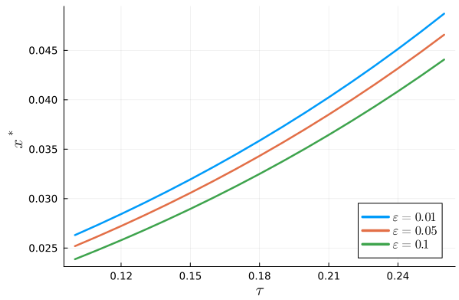
In Figure 9, as in Figure 8 for $m = -0.5$, panel (e) shows that the response of the net aggregate income Gini coefficient, G_2, to changes in ε is qualitatively similar to that of G_1, in that both responses are positive. However, comparison of (34) and (35), together with their fully expanded expressions in Appendix C, indicates that G_2 is shaped by several additional effects not present in G_1, and for all values of ε and τ within the considered ranges, G_2 strictly exceeds G_1; that is, the net aggregate income Gini coefficient consistently exceeds the common Gini coefficient for net wage income and capital rental income. The response of G_2 to variations in τ, as illustrated in panel (f), is qualitatively similar to that of G_1, with a modest distinction: there exists a threshold level of τ beyond which G_2 increases with τ at an increasing rate, further highlighting the additional effects influencing G_2 relative to G_1. Moreover, for all values of τ within the considered range and for all values of ε under consideration, G_2 strictly exceeds G_1; that is, the net aggregate income Gini coefficient is strictly greater than the common Gini coefficient for net wage income and capital rental income.

In Figure 9, as in Figure 8 for $m = -0.5$, despite the similarity in shape between G_1 and G_2 in the respective panels—which reflects that G_1 constitutes part of a component of G_2—a comparison of (34) and (35), or of their fully expanded forms in Appendix C, shows that G_2 is influenced by additional effects absent in G_1. As indicated in (C13) in Appendix C, G_1 is independent of the long-run equilibrium real wage rate, $w(K^*, x^*)$, and the long-run equilibrium rental rate of capital, $r(K^*, x^*)$, as these rates are uniform across all taxpayer types. In contrast, (C18)–(C19) in Appendix C shows that two components of G_2 intuitively depend on $r(K^*, x^*)$: the compounding component captures income dispersion across generations due to accumulation at the capital rental rate, while the overlapping-generational cross-strategies component reflects inter-generational income variation arising from heterogeneity in tax compliance strategies. For the parameter values used in panels (g) and (h), $r(K^*, x^*)$ increases with both ε and τ, and for a given ε (resp. τ), higher τ (resp. ε) is associated with higher $r(K^*, x^*)$. Overall, the long-run equilibrium results in Figure 9 indicate that higher ε is associated with a lower proportion of tax evaders and higher G_1, G_2, and $r(K^*, x^*)$, while higher τ corresponds to increases in each of these variables.

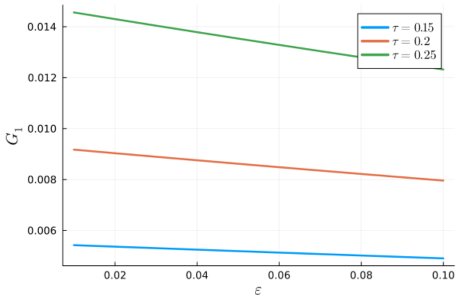
Finally, Figure 10 reports the comparative statics of the proportion of non-compliant taxpayers and the Gini coefficients G_1 and G_2 in the long-run equilibrium with respect to the probability of detection, ε, and the income tax rate, τ. We set $\lambda = 4$ and $m = 1.0$, thereby characterizing a generation with, on balance, non-compliance-leaning tax morale. As in the cases of $m = -0.5$ and $m = 0$ depicted in Figures 8 and 9, respectively, panel (a) shows that x^* decreases with the



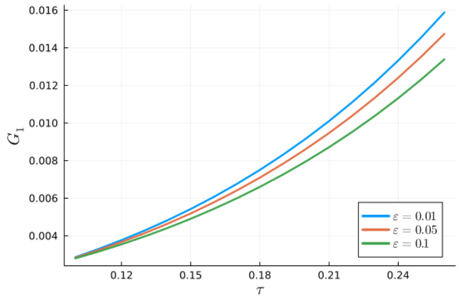
(a) Proportion of tax evaders in the long-run equilibrium x^* for different probabilities of detection ε.



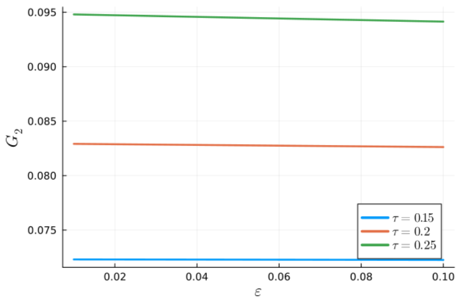
(b) Proportion of tax evaders in the long-run equilibrium x^* for different tax rates τ.



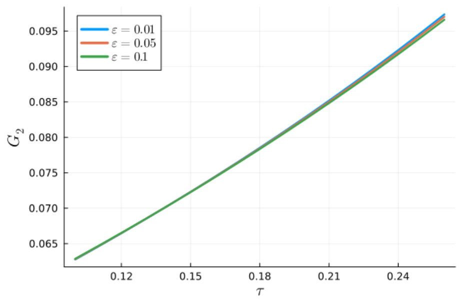
(c) Within-stage Gini coefficient G_1 for different probabilities of detection ε.



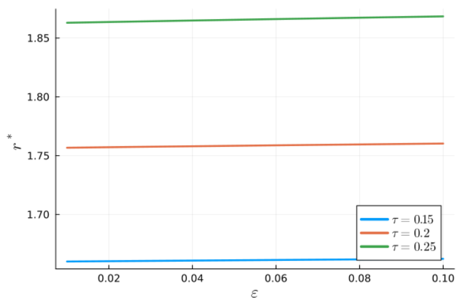
(d) Within-stage Gini coefficient G_1 for different tax rates τ.



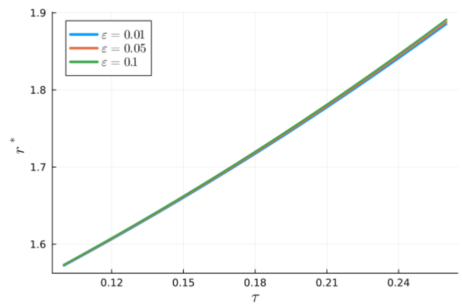
(e) Net aggregate income Gini coefficient G_2 for different probabilities of detection ε.



(f) Net aggregate income Gini coefficient G_2 for different tax rates τ.



(g) Capital rental rate in the long-run equilibrium r^* for different probabilities of detection ε.



(h) Capital rental rate in the long-run equilibrium r^* for different tax rates τ.

Fig. 10: Comparative statics for compliance-leaning tax morale ($m = 1$).

probability of detection, while panel (b) shows that it increases with the income tax rate. However, in contrast to the cases of $m = -0.5$ and $m = 0$, x^* increases with the income tax rate at an increasing rather than a decreasing rate. Nevertheless, for a given value of ε, higher values of τ within the considered range are associated with higher levels of x^*. Conversely, for a given value of τ, lower values of ε correspond to higher values of x^*, and this relationship becomes more pronounced as τ increases. In contrast to the cases of $m = -0.5$ and $m = 0$ depicted in Figures 8 and 9, respectively, the common within-stage Gini coefficient for net wage income and capital rental income, G_1, decreases with ε over its plausible range (panel (c)), although only slightly, while it increases with τ over its considered range (panel (d)), and does so at an increasing rate throughout that range. Moreover, for a given value of ε in panel (c), higher values of τ within the considered range are associated with higher levels of G_1; conversely, for a given value of τ in panel (d), higher values of ε within the considered range are intuitively associated with lower levels of G_1.

To interpret the result depicted in panel (c) of Figure 10, note from Table 2 that, as in Figures 8 and 9, an increase in ε lowers x^*, thereby increasing the share of compliant taxpayers, σ_C, and thus raising their total net wage income. This channel tends to expand net wage income dispersion across taxpayers within a given generation. At the same time, the increase in ε, together with the associated decline in x^*, reduces the share of undetected non-compliant taxpayers, σ_{UN}, thereby lowering their total net wage income and contributing to a reduction in within-generation net wage income dispersion. The same change in ε and x^* has opposing effects on the share of detected non-compliant taxpayers, σ_{DN}, while the net wage income of a detected non-compliant individual, y_1^{DN}, increases owing to the reduction in the penalty rate, γ. Consequently, the total net wage income of detected non-compliant taxpayers may either increase or decrease, contributing to either an expansion or a contraction of within-generation income dispersion. The negative—though modest—relationship between ε and G_1 in panel (c) of Figure 10 therefore reflects the dominance of the dispersion-reducing effect(s) over the dispersion-increasing effect(s).

To facilitate interpretation of panel (d) of Figure 10, recall from Table 2 that, as in Figures 8 and 9, an increase in τ raises x^*, reducing the share of compliant taxpayers, σ_C, and the net wage income of an individual compliant taxpayer, y_1^C, thereby jointly lowering the total net wage income of compliant taxpayers and contributing to a reduction in within-generation net wage income dispersion. The same increase in τ and the resulting rise in x^* increase the share of undetected non-compliant taxpayers, σ_{UN}, and their total net wage income, which expands within-generation net wage dispersion. Simultaneously, the rise in τ increases the share of detected non-compliant taxpayers, σ_{DN}, although the net wage income of an individual detected non-compliant taxpayer declines due to the higher penalty rate, γ, so that their total net wage income may increase or decrease, producing opposing effects on net wage dispersion. Thus, the strong positive relationship between τ and G_1 in panel (d) reflects the dominance of the dispersion-increasing effect(s) over the dispersion-reducing effect(s).

In Figure 10, in contrast to the cases of $m = -0.5$ and $m = 0$ depicted in Figures 8 and 9, respectively, the net aggregate income Gini coefficient, G_2, decreases with ε over its plausible range (panel (e)), although only slightly, while it increases with τ over its considered range (panel (f)). Moreover, for a given value of ε in panel (e), higher values of τ within the considered range are associated with higher levels of G_1; conversely, for a given value of τ in panel (f), higher values of ε within the considered range were checked to be associated with lower levels of G_1. In contrast to the cases of $m = -0.5$ and $m = 0$ depicted in Figures 8 and 9, respectively, the response of the net aggregate income Gini coefficient, G_2, to changes in ε is qualitatively opposite to that of G_1, in that the two responses have contrary signs. Nevertheless, for all values of ε and τ within the ranges considered in panels (e) and (f), respectively, G_2 strictly exceeds G_1; that is, the net aggregate income Gini coefficient consistently surpasses the common Gini coefficient for net wage income and capital rental income. Moreover, as discussed in relation to Figures 8 and 9, G_2 is influenced by additional effects absent in G_1. As indicated in (C13) in Appendix C, G_1 is independent of the long-run equilibrium real wage rate, $w(K^*, x^*)$, and the long-run equilibrium rental rate of capital, $r(K^*, x^*)$, since these rates are uniform across all taxpayer types. In contrast, (C18)–(C19) in Appendix C indicates that two components of G_2 depend on $r(K^*, x^*)$: the compounding component captures income dispersion across generations arising from accumulation at the capital rental rate, while the overlapping-generational cross-strategies component reflects inter-generational income variation due to heterogeneity in tax compliance strategies. For the parameter values used in panels (g) and (h), $r(K^*, x^*)$ increases with both ε (though only slightly in this case) and τ, and for a given ε (resp. τ), higher τ (resp. ε, as verified) is associated with higher $r(K^*, x^*)$. Overall, the long-run equilibrium results in Figure 10 indicate that higher ε is associated with a lower proportion of tax evaders, lower G_1 and G_2, and higher $r(K^*, x^*)$, whereas higher τ corresponds to increases in each of these variables.

As a final comment, we would argue that the non-linear relationship between tax morale and inequality, as measured by the net aggregate income Gini coefficient, G_2, generated by the numerical simulations and illustrated in Figures 6 and 7, aligns with the heterogeneity observed in the empirical estimates in Table 1. Specifically, those regressions indicate that the association between the tax gap and the Gini coefficient varies substantially across regions, with both the sign and magnitude of the effect differing between North America, Europe and Central Asia, and Latin America and the Caribbean. This evidence supports the prediction of the model developed in this paper that the relationship between tax compliance and income inequality is not necessarily monotonic, as economies with different baseline levels of tax morale may occupy different segments of the curves in the right panel of Figure 6. Furthermore, the positive association between larger tax gaps and higher income inequality—as measured by the Gini coefficient—in the benchmark specification of Table 1 is consistent with the model's key mechanisms, in which lower intrinsic tax compliance or stronger reliance on material payoff amplifies net aggregate income dispersion, moving economies upwards along the curves in the right panel of Figure 5.

5 Conclusion

The impact of individual tax compliance decisions on the distribution of income across different segments of a given population has important policy implications. The model developed in this paper enables us to examine how persistent tax evasion affects the distribution of income both across different types of taxpayers within a given generation—conditional on their tax-compliance strategies—and across overlapping generations in the long-run equilibrium. In an environment in which only wage income is taxed, we demonstrate that the income distribution shaped by tax compliance decisions undertaken when individuals are young persists both qualitatively and quantitatively into old age, when these individuals earn only capital rental income that is exempt from taxation. The model further permits identification of the channels through which tax evasion influences income inequality, both within the stages of a given generation (young and old) and across overlapping generations.

In line with the empirical evidence, the analytical results of the model include persistent heterogeneity in tax compliance behavior across taxpayers as long-run equilibrium configuration. Also consistent with the empirical evidence, tax evasion (measured in our model by the proportion of non-compliant taxpayers in the subpopulation of young individuals, from which both gross and net tax evasion can be inferred) increases with the tax rate and decreases with the probability of detection, the penalty rate, and the median tax morale. We also derive analytical long-run equilibrium results on—and illustrate through numerical simulations with plausible parameter values—the impact of a higher median tax morale—and the associated decrease in the proportion of non-compliant taxpayers—on total private savings (and thus the total availability of capital), total public savings (and hence the total provision of productive public services), and, consequently, aggregate output, as well as on the wage rate and the capital rental rate. As shown solely by numerical simulations with plausible parameter values, and suggestively consistent with the novel empirical evidence presented in this paper, the relationship between the median tax morale and the Gini coefficients for net wage income, capital rental income, and aggregate income is inverted-U shaped in each case, with the maximum attained at a strictly positive median tax morale. To gain further insight, these non-linear effects of the median tax morale on the Gini coefficients are decomposed into their respective components. Moreover, a higher probability of detection reduces the Gini coefficients—albeit modestly—and only when the median tax morale is sufficiently positive, whereas a higher tax rate increases the Gini coefficients over the considered range of plausible parameter values.

Appendix A Existence and uniqueness of a long-run equilibrium with heterogeneity in tax compliance strategies across taxpayers

A long-run equilibrium solution (K^*, x^*) of the map represented by (21) and (28) needs to satisfy the following system of equations:

$$\begin{cases} K^* = \varphi(x^*) w(K^*, x^*), & \text{(A1)} \\ x^* = P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right), & \text{(A2)} \end{cases}$$

where $P : \mathbb{R} \to (0, 1) \subset \mathbb{R}$ is the cumulative distribution function in (27), assumed to be continuously differentiable with $P'(\cdot) > 0$ over its support.

Given (17) and (21)-(22), we can use (A1) to express K^* as a function of x^* and get:

$$K^* = \left[\big(1 - (\alpha + \beta)\big)\big(\varphi(x^*)\big)^{1-\beta}\big(\phi(x^*)\big)^{\beta}\right]^{\frac{1}{1-(\alpha+\beta)}}. \tag{A3}$$

Therefore, in order to demonstrate both the existence and the uniqueness of the long-run equilibrium solution (K^*, x^*), we need to show that there is a unique $x^* \in [0, 1] \subset \mathbb{R}$ which solves (A2).

Let us specify:

$$\psi(x) \equiv x - P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x)\big)\right), \tag{A4}$$

from which it follows that the condition in (A2) is satisfied if, and only if, $\psi(x^*) = 0$.

Considering that, by assumption, $0 < P(\cdot) < 1$ over its support, it is straightforward to see that $0 < P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right) < 1$ for all $x \in [0,1] \subset \mathbb{R}$. Thus, we can establish that:

$$\psi(0) = -P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(0)\big)\right) < 0 \quad \text{and} \quad \psi(1) = 1 - P\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(1)\big)\right) > 0. \tag{A5}$$

We can demonstrate that there is a unique $x^* \in (0,1) \subset \mathbb{R}$ such that $\psi(x^*) = 0$. Considering the inequalities in (A5), and that the function $\psi(x_t)$ in (A4) is continuous over the domain represented by $[0,1] \subset \mathbb{R}$, we can apply the intermediate value theorem to conclude that there is some $x^* \in (0,1) \subset \mathbb{R}$ such that $\psi(x^*) = 0$.

Moreover, since $P'(\cdot) > 0$ over its support and the function $\psi(x)$ in (A4) is continuously differentiable over the domain given by $[0,1] \subset \mathbb{R}$, it follows that:

$$\psi'(x) = 1 + \varepsilon P'\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x)\big)\right)\upsilon'\big(\varepsilon\gamma(x)\big)\gamma'(x) > 0, \tag{A6}$$

for all $x \in [0,1] \subset \mathbb{R}$. As a consequence, given that the function in (A4) is continuous on the closed interval $[0,1] \subset \mathbb{R}$, there exists a unique $x^* \in (0,1) \subset \mathbb{R}$ such that $\psi(x^*) = 0$, thereby characterizing a polymorphic long-run equilibrium. That is, there exists a unique steady-state configuration in which both compliant and non-compliant behaviors are persistently maintained in fixed proportions within the population of taxpayers.

Appendix B Stability properties of the long-run equilibrium with heterogeneity in tax compliance strategies across taxpayers

The Jacobian matrix evaluated around the long-run equilibrium (k^*, x^*) is given by:

$$J(K^*, x^*) = \left[\begin{array}{c|c} \frac{\alpha}{1-\beta} & \varphi'(x^*)w(K^*, x^*) + \varphi(x^*)\frac{\partial w(K^*, x^*)}{\partial x_t} \\ \hline 0 & -\varepsilon P'\left(\upsilon(\tau) - \upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*) \end{array}\right]. \tag{B7}$$

Let ξ be an eigenvalue of the Jacobian matrix in (B7). We can set the characteristic equation of the linearization around the long-run equilibrium as follows:

$$\begin{vmatrix} a-\xi & \varphi'(x^*)w(K^*,x^*)+\varphi(x^*)\frac{\partial w(K^*,x^*)}{\partial x_t} \\ 0 & c-\xi \end{vmatrix} = \xi^2-(a+c)\xi+ac=0, \tag{B8}$$

where $a \equiv \frac{\alpha}{1-\beta}$ and $c \equiv -\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)$.

The second-order characteristic equation in (B8) has two eigenvalues inside the unit circle if, and only if, the following conditions are satisfied (Medio & Lines, 2001, p. 52):

$$1+\mathrm{tr}J(K^*,x^*)+\det J(K^*,x^*) = \left(1+\frac{\alpha}{1-\beta}\right)\left[1-\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)\right]>0, \tag{B9}$$

$$1-\mathrm{tr}J(K^*,x^*)+\det J(K^*,x^*) = \left(\frac{1-(\alpha+\beta)}{1-\beta}\right)\left[1+\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)\right]>0, \tag{B10}$$

$$1-\det J(K^*,x^*) = 1+\left(\frac{\alpha}{1-\beta}\right)\left[\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)\right]>0. \tag{B11}$$

Since $\alpha \in (0,1) \subset \mathbb{R}$ and $\beta \in (0,1) \subset \mathbb{R}$, we know that $1+\frac{\alpha}{1-\beta}>0$, so that the condition in (B9) holds if:

$$\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)<1 \tag{B12}$$

Under the assumptions that $\alpha \in (0,1) \subset \mathbb{R}$, $\beta \in (0,1) \subset \mathbb{R}$, and $(\alpha+\beta) \in (0,1) \subset \mathbb{R}$, we can infer that $0<\frac{\alpha}{1-\beta}<1$ and $\frac{1-(\alpha+\beta)}{1-\beta}>0$. Considering this latter inequality, we know that the condition in (B10) is satisfied, since $1+\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)>0$. Finally, as $0<\frac{\alpha}{1-\beta}<1$ and $1+\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)>0$, the condition in (B11) is also satisfied. This completes the demonstration that the long-run equilibrium (K^*,x^*) is a local attractor if the condition in (B12) holds.

As seen above, the stability conditions in (B10) and (B11) are both satisfied irrespective of whether or not the condition in (B12) is satisfied. Therefore, only the stability condition in (B9) can be violated. In fact, when $\varepsilon P'\left(\upsilon(\tau)-\upsilon\big(\varepsilon\gamma(x^*)\big)\right)\upsilon'\big(\varepsilon\gamma(x^*)\big)\gamma'(x^*)=1$, the condition in (B9) is violated, which results in $1+\mathrm{tr}J(K^*,x^*)+\det J(K^*,x^*)=0$, where $\mathrm{tr}J(K^*,x^*)\in(-1,0)\subset\mathbb{R}$ and $\det J(K^*,x^*)\in(-1,0)\subset\mathbb{R}$. In this case, one of the eigenvalues of the Jacobian matrix in (B7) is equal to -1, which yields a flip (or period-doubling) bifurcation, as demonstrated in Medio and Lines (2001, p. 160).

Appendix C Fully expanded algebraic expressions of the Gini coefficients G_1 and G_2

We can obtain a fully expanded algebraic expression for the common within-stage Gini coefficient for the subpopulations of young and old individuals by substituting the algebraic expressions presented in Table 2 into (34), which yields:

$$G_1 = \frac{[\tau(1-2\varepsilon)(1-x^*) + \varepsilon(1-\varepsilon x^*)\gamma(x^*)]\, x^*}{1-\tau+[\tau-\varepsilon\gamma(x^*)]\, x^*}. \tag{C13}$$

The net aggregate income or overlapping-generations Gini coefficient defined in (35) can be decomposed into three components—the scaled within-stage component, defined as one-half of the corresponding within-stage Gini coefficient, G_1, the compounding component, and the overlapping-generational cross-strategies component. Using (35), we define the scaled within-stage component as:

$$G_2^{WS} \equiv \frac{\sum_{i\in\mathcal{S}}\sum_{i'\in\mathcal{S}}\sum_{\iota=1,2}\sigma_i\sigma_{i'}\left|y_\iota^i - y_\iota^{i'}\right|}{2\sum_{i\in\mathcal{S}}\sum_{\iota=1,2}\sigma_i y_\iota^i}; \qquad \mathcal{S}=\{C,UN,DN\} \tag{C14}$$

the compounding component as:

$$G_2^{C} \equiv \frac{\sum_{i\in\mathcal{S}}\sigma_i^2\left|y_1^i - y_2^i\right|}{2\sum_{i\in\mathcal{S}}\sum_{\iota=1,2}\sigma_i y_\iota^i}; \qquad \mathcal{S}=\{C,UN,DN\} \tag{C15}$$

and the overlapping-generational cross-strategies component as:

$$G_2^{OLG} \equiv \frac{\sum_{i\in\mathcal{S}}\sum_{i'\in\mathcal{S}\setminus\{i\}}\sigma_i\sigma_{i'}\left(\left|y_1^i - y_2^{i'}\right| + \left|y_2^i - y_1^{i'}\right|\right)}{2\sum_{i\in\mathcal{S}}\sum_{\iota=1,2}\sigma_i y_\iota^i}. \qquad \mathcal{S}=\{C,UN,DN\} \tag{C16}$$

Substituting the algebraic expressions presented in Table 2 into (C14)-(C16) to obtain a fully expanded algebraic expression for the scaled within-stage component, which is given by:

$$G_2^{WS} = \frac{\left[\tau(1-2\varepsilon)(1-x^*) + \varepsilon(1-\varepsilon x^*)\gamma(x^*)\right] x^*}{2\left\{1-\tau+[\tau-\varepsilon\gamma(x^*)]\, x^*\right\}} = \frac{G_1}{2}; \tag{C17}$$

for the compounding component, which is given by:

$$
\begin{aligned}
G_2^C =& \frac{1+\theta-r(K^*,x^*)}{2\,[3+\theta+r(K^*,x^*)]\,\{1-\tau+[\tau-\varepsilon\gamma(x^*)]\,x^*\}} \times \\
& \left\{\left[(1-\tau)(1-x^*)^2+(1-\varepsilon)^2 x^{*2}+\varepsilon^2\big[1-\gamma(x^*)\big]x^{*2}\right]\right\};
\end{aligned}
\tag{C18}
$$

and for the overlapping-generational cross-strategies component, which is given by:

$$
\begin{aligned}
G_2^{OLG} =& \frac{1}{2\,[3+\theta+r(K^*,x^*)]\,\{1-\tau+[\tau-\varepsilon\gamma(x^*)]\,x^*\}} \times \\
& \Bigg\{(1-\varepsilon)\Big[\Big|1+\theta-\tau(2+\theta)-r(K^*,x^*)\Big| + \Big|1+\theta+\tau\big[1+r(K^*,x^*)\big]-r(K^*,x^*)\Big|\Big](1-x^*)x^* \\
& + \varepsilon\Big[\Big|1+\theta-\tau(2+\theta)+\gamma(x^*)\big[1+r(K^*,x^*)\big]-r(K^*,x^*)\Big| \\
& \qquad + \Big|1+\theta+\tau\big[1+r(K^*,x^*)\big]-(2+\theta)\gamma(x^*)-r(K^*,x^*)\Big|\Big](1-x^*)x^* \\
& + (1-\varepsilon)\varepsilon\Big[\Big|1+\theta+\gamma(x^*)\big[1+r(K^*,x^*)\big]-r(K^*,x^*)\Big| + \Big|1+\theta-(2+\theta)\gamma(x^*)-r(K^*,x^*)\Big|\Big]x^{*2}\Bigg\}.
\end{aligned}
\tag{C19}
$$

To obtain a fully expanded algebraic expression for the overlapping-generations Gini coefficient, it is necessary only to sum the three components defined in (C17)–(C19):

$$
G_2 = G_2^{WS} + G_2^C + G_2^{OLG}. \tag{C20}
$$

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