Received: 23 April 2021 | Revised: 19 December 2021 | Accepted: 18 March 2022

DOI: 10.1111/meca.12391

METROECONOMICA
INTERNATIONAL REVIEW OF ECONOMICS

WILEY

ORIGINAL ARTICLE

Tax evasion and social reputation: The role of influencers in a social network

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Funding information
Universita degli Studi di Roma La Sapienza Open Access Funding provided by Universita degli Studi di Roma La Sapienza within the CRUI-CARE Agreement.

Abstract

In this paper, we present an agent-based model in which taxpayers 'live' in a network and care about their social reputation. Individuals decide whether to pay or to evade taxes considering the expected economic net benefit and the reputational cost from tax evasion. Individuals differ in income and in the weight they attach to social reputation, which is updated by assessing the opinions shared in their reference group. The reference group contains individuals irrespective of their income (integrated society) or it is made up of peers belonging to the same income group (segregated society). We simulate the model in the two alternative settings to find the frequency distribution of taxpayers in a dataset of random networks. The results indicate that, in an integrated society, network conformity is reached and all individuals either evade or pay their taxes. Conversely, a segregated society might generate obstacles to the diffusion of opinions and, as a result, tax evasion and tax compliance might coexist. Lastly, we consider the effects of a social media campaign starring a celebrity financed by a fiscal authority to increase overall tax compliance by exploiting the diffusion dynamics in the network. We show that such a policy is more effective if the diffusion of opinions is not hindered by social segregation.

The authors wish to thank two anonymous referees and participants at the conference on "Tax compliance: new methodologies and empirical approaches" held online, October 2020.

In an integrated society, especially if income inequality is low, a celebrity's endorsement of tax compliance might nudge widespread socially responsible tax behaviour.

KEYWORDS
income differences, influencers, social networks, social norms, tax evasion

JEL CLASSIFICATION
H26, D85, K42

1 | INTRODUCTION

Tax evasion is a serious concern, also in advanced societies.[1] It reduces available resources for economic and social policy, thus affecting society at large; moreover, if tax evasion is not equally distributed across income groups and/or income types it has redistributive effects, potentially reducing progressivity.

Measuring tax evasion has been described as an attempt to obtain ‘evidence on the invisible’ (Slemrod & Weber, 2012). Several approaches have been followed to estimate tax evasion from a macroeconomic as well as from a microeconomic perspective focusing on specific tax-base.[2]

From a theoretical point of view, the literature has identified three main motivations for individual tax-paying decisions: the monetary trade-off, tax morale and social reputation. The monetary trade-off depends on the institutional features of the tax system, including the tax-burden, the audit system and the fine to be paid in case tax evasion is discovered. Tax morale refers to individuals' intrinsic motivation and value system. Social reputation relates to the penalty for deviating from—and the reward for compliance to—the accepted social norms. Adherence to the social norm, motivated by social reputation concerns, tends to produce behavioural conformity.

In this paper, we focus on the role of social reputation in affecting individuals' taxpaying behaviour. To this purpose, we present an agent-based model in which taxpayers ‘live’ in a network and care about their social reputation. Individuals decide whether to pay or to evade taxes considering the expected economic net benefit (balancing monetary costs and benefits from tax evasion) and the reputational cost from tax evasion, which depends on the share of individuals in the reference group who

[1] According to Murphy (2019), in 2015 the EU tax gap—expressed as a proportion of expected tax revenue—varies from 8% in Luxembourg to 29.5% in Romania. Similarly, for the year 2018, Śmietanka et al. (2020) have estimated the VAT gap to be €140 billion. The Report estimates that the median gap is 9.2%, varying from the low values of Sweden (0.7%), Croatia (3.5%), and Finland (3.6%) to the largest gaps in Romania (33.8%), Greece (30.1%), and Lithuania (25.9%).

[2] From a micro-perspective, Pissarides and Weber (1989) have estimated underreporting of British self-employed in 1982 to be approximately 35%. The same consumption-based approach has been applied to estimate misreporting in Finland (Johansson, 2000), in United States (Hurst et al., 2014), in North Cyprus (Ekici & Besim, 2016), in Sweden (Engström & Hagen, 2017), and in Italy (Albarea et al., 2020). These studies have provided consistent evidence of underreporting of self-employed compared to employed households in a range between 15% and 40%. Similarly, Feldman and Slemrod (2007), using a tax deduction-based measure as an indicator of tax evasion, have found that the evasion rate for self-employed income ranges between 30% and 40%. From a macroeconomic perspective, Medina and Schneider (2018), Schneider et al. (2010), and Alm and Embaye (2013)—just to name a few—have analysed the informal economy across countries in order to provide a proxy for tax evasion. A recent contribution for European member states (Bousquet et al., 2019) has estimated the international tax evasion to be around €46 billion (0.32% of GDP).

pay taxes. If tax evasion is widely spread then the social sanction for not complying with the social norm is low; on the contrary, in a group in which everybody conforms to the social norm and pay their due taxes, the reputation loss from tax evasion is high. In the model, we consider two income-groups whose monetary incentive for tax evasion differ; ceteris paribus, high-income individuals gain relatively more from tax evasion than low-income individuals do. However, we assume that individuals also differ in the weight given to social reputation relative to monetary considerations. We interpret this parameter as measuring the strength of the social norm for the individual. This is our main parameter of interest and we assume that it is updated looking at the beliefs about the importance of social reputation in the individual's reference group. We consider two settings: in the first, the reference group comprises individuals from both income groups; in the second setting, the reference group only contains peers belonging to the same income group. The former characterises a more integrated society, the latter a relatively segregated society. In the updating process, *influencers*—individuals with many followers—play a fundamental role in affecting the social norm for tax compliance.

We simulate the model and characterise the steady state under the two alternative settings in a dataset of random networks. The results indicate that, in an integrated society, network conformity is reached and all individuals either evade or pay their taxes. On the other hand, a segregated society might generate obstacles to diffusion of (influential) opinions around the network, generating sub-network social norms; as a result, tax evasion and tax compliance might coexist.

This paper contributes to the literature by emphasising the role of social networks on individuals' tax-paying behaviour and by investigating whether the knowledge of the network structure might support a tax authority in devising policies aiming at improving tax compliance.

To this purpose, we consider the effects of a social media campaign starring a celebrity, financed by a fiscal authority to increase overall tax compliance by exploiting the diffusion dynamics in the network. Our simulations suggest that the social media campaign has a stronger impact on tax compliance when opinions freely spread around the network—that is, in an integrated society. We then compare this strategy with a policy that increases the audit frequency and conclude that our suggested policy can be as effective and less expensive.

The rest of the paper is organised as follows: in the next section, we review the related literature; in Section 3, we present a simple dynamic model of tax behaviour; in Section 4, the simulation results are presented; in Section 5, we illustrate the effects of a social media campaign; Section 6 contains some final remarks and policy implications.

2 | RELATED LITERATURE

This paper relates to the literature on the role of social reputation in individual tax-paying decisions and to the works on diffusion processes in social and economic networks.

The literature has identified three main motivations for tax compliance: the monetary trade-off, tax morale and social reputation. Consideration of the first dates to the works of Allingham and Sandmo (1972) and Yitzhaki (1974). They suggest that individuals decide how much tax to pay balancing out the expected monetary cost and benefit of tax evasion, where the (expected) cost depends on the penalty to be paid if detected and the audit probability. If economic considerations were the only factor affecting tax-paying behaviour, there should be far less compliance than that observed (Alm, 2019).

Recognising that people abstain from tax evasion not only for its expected monetary cost but also for moral and social considerations, several papers have incorporated tax morale and social reputation into the standard models of tax evasion.[3] Gordon (1989), Bayer (2004), and Eisenhauer (2008) describe tax morale as an individual norm that encourages adherence to ethical behaviour and reveals itself in feelings of remorse and disutility when it is violated. Thus, tax evasion reduces the utility that individuals derive from unreported income, regardless of whether it is detected. The heterogeneity in individuals' tax morale might explain the coexistence of tax evasion and tax-compliance in a society.

Social reputation refers to the appreciation of tax compliance and stigmatisation of tax evasion within the community. In this respect, the literature has pointed to the share of taxpayers in the population as an important factor affecting social reputation in individual tax-paying decisions. Recognising that taxpayers may be willing to pay taxes conditionally, depending on the behaviour of other taxpayers, Myles and Naylor (1996) characterise the social equilibrium in a model that adds a social norm for tax compliance to Allingham and Sandmo (1972). The interdependence of individuals' evasion decisions typically results in a multiplicity of equilibria. Traxler (2010) characterises, analytically, the multiplicity of social equilibria in the share of evaders and shows that an economy can end up either in a state where most pay their due taxes or in a state where evasion is more widespread.[4] Ratto et al. (2013) consider another reason for social interactions to affect individual taxpaying decisions: the reputation loss for being investigated. Assuming the magnitude of this loss depends on the number of honest taxpayers, they show that an increase in the probability of detection causes the share of tax evaders to shrink, directly (due to the higher monetary cost of evasion) and indirectly (due to social concerns).

To evaluate the relevance of social reputation on tax evasion, some recent papers have analysed the effectiveness of ‘naming-and-shaming’ policies that reveal the amount of tax paid and/or the identity of tax evaders. Dwenger and Treber (2018) find that the shaming policy introduced in 2012 in Slovenia singling out tax evaders reduced their tax debt by 8.5%, particularly in industries where reputational concerns are likely to be important. Using data for Pakistan, Slemrod et al. (2019) find that a disclosure policy that reveals the amount of the income tax paid increased individual reported income by 2–9 log points.[5] Analysing the effect of a similar policy for Norway, Bø et al. (2015) observe a 3% average increase in reported income among business owners, while Hasegawa et al. (2013), using data for Japan, find no evidence that income tax disclosure increases business reported taxable income.

Few papers have considered the three motivations for tax compliance simultaneously. Building on Bénabou and Tirole (2006, 2011), Besley et al. (2019) study the dynamics of tax evasion in a model in which individual tax compliance decision reflects extrinsic motivation (enforcement), intrinsic motivation (tax morale) and social reputation concern. They suggest that the desire to acquire a prosocial reputation creates social interactions among taxpayers, which might generate social norms for tax compliance. The comparative statics and dynamics of their model indicate that temporary shocks in individual intrinsic motivation and in tax enforcement factors might persistently change the social norm for compliance. Following Besley et al. (2019), although in a static setting, Di Gioacchino and Patriarca (2017) show that group specific social norms increase the negative effect of income inequality on tax evasion, having a further regressive effect on disposable incomes. They suggest that policies aimed at increasing tax compliance could exploit the social norm effects and would be more effective if they also reduce segregation among social groups.

Along the same lines, Di Gioacchino and Fichera (2020) add a network structure to Besley et al. (2019). They study the dynamics of tax compliance in a framework in which individuals differ in

[3] See Luttmer and Singhal (2014) for a survey on tax morale and the possible mechanisms through which it affects tax compliance.

[4] See also Mengel (2008) and Spichtig and Traxler (2011).

[5] The same policy applied to members of the national parliament increased reported income by 40 to 60 log points.

the initial value of their intrinsic motivation (*tax morale*), which is updated overtime according to an adaptive rule based on the intrinsic motivation of the individual's reference group. In their model, individuals also care about their reputation as taxpayers, which depends on the strength of the social norm in the reference group. They simulate the model and characterise the steady state share of taxpayers with reference to model parameters such as the probability to find like-minded peers in one's reference group (network integration) and the weight agents attribute to reputation. They also consider the possibility for a fiscal authority to increase tax compliance by exploiting the knowledge of the network structure and by targeting 'central' individuals.

Few other contributions have recently studied tax-paying decisions in a social network using an agent-based model. This allows to conduct a theoretical exercise and, using computer simulations, compare the outcome resulting from different initial conditions and parameters' value. Hashimzade et al. (2014, 2015, 2016) apply agent-based modelling to study the role of occupation in tax compliance in a setting in which taxpayers are heterogeneous in risk aversion, beliefs about the probability of audit, and attitude towards tax compliance.[6] They analyse the dynamics of attitudes and beliefs and show that it leads to compliance behaviour that differs across occupational groups. In this framework, the tax authority may wish to condition its audit strategy not only on reported income but also on occupation. To this purpose, Hashimzade et al. (2016) examine the extent to which predictive analytics on tax evasion can improve the outcome—in terms of tax revenues—compared with random audits.

On the empirical side, some recent contributions have investigated whether individual evasion decisions are affected by the compliance behaviour of close-by individuals pointing out the strong relationship between the environment in which agents 'live' and their fiscal behaviour.[7] Boning et al. (2020) study the direct and network effects in a large scale-field experiment conducted by the United States Internal Revenue Service, in which treated firms could receive a deterrence letter or an in-person visit by the tax authority. They found that the first strategy had no significant network effects but that the second strategy (in-person audit) increased the compliance rate by approximately 2% among those that shared a tax preparer with a visited firm.[8]

In this paper, we follow Di Gioacchino and Patriarca (2017) and consider two income groups whose monetary incentives for tax evasion are different. As in Di Gioacchino and Fichera (2020), and similarly to Hashimzade et al. (2014, 2015, 2016), we focus on non-pecuniary costs and consider the pressure from neighbours (local peer effect) as the main driver of tax compliance. Specifically, we focus on the dynamics of social reputation and allow individuals' connections to be unidirectional and/or reciprocal. We stress the role model of influencers—defined as individuals with many followers—and the value to a tax authority of using their influence to increase social concern for prosocial behaviour. Gamannossi degl'Innocenti and Rablen (2020) have recently proposed the same idea.[9] They investigate the value to a tax authority—in terms of additional revenues raised—of knowing the structure of the social network and of targeting 'celebrity' taxpayers.

Our contribution to the existing literature is three-fold. First, using an agent-based model, we investigate the mechanisms by which local interactions affect the weight given by individuals to social reputation and, as a result, their fiscal behaviour. Second, based on the diffusion dynamics in the

[6] This is achieved by extending the model of Allingham and Sandmo (1972) and Yitzhaki (1974) to allow for individuals to choose their occupation first and then take an evasion decision based on realised income.

[7] See Frimmel et al. (2019), Alstadsæter et al. (2019), Paetzold and Winner (2016), and Bohne and Nimczik (2018).

[8] The indirect effect of a deterrence letter has been confirmed by Pomeranz (2015), using data for Chile, and by Drago et al. (2020) in a field experiment in Austria based on a geographical network.

[9] In their model, individuals care about relative consumption and, for this reason, taxpayers that are more central (influencers) have higher incentive for tax evasion.

network, we suggest a policy intervention—social media campaign starring a 'celebrity'—designed to enhance the concern for social reputation and increase overall tax compliance. The agent-based approach allows us to analyse the effectiveness of such policy in societies characterised by different levels of income inequality. Third, we compare this strategy with a policy that increases the audit frequency suggesting that behavioural strategies could be a valid complement to more traditional policies.

3 | THE MODEL

Our theoretical framework describes a scenario in which individual tax behaviour depends on the expected monetary net benefit from tax evasion and on social reputation for tax compliance. We assume that individuals have a desire for conformity: they are more likely to pay if the people around do the same and they tend to believe that tax evasion is socially not justified if this is the belief of the people they trust and to whom they look at for an opinion—that is, their reference group. Our setting is based on Besley et al. (2019) model of social norms and tax compliance, to which we add a network structure to describe individuals' reference group. A network is a list of links between individuals and an individual's reference group (neighbourhood) is the set of individuals to whom s/he is connected.[10] To reflect one crucial characteristic of real social networks (Instagram, Facebook and so on), where a content shared by a 'celebrity' reaches thousands of followers affecting their behaviour (consumption habits, attitudes, beliefs), we allow some individuals to be more influential than others because they are followed by more people.

Each period, individuals in the network must decide whether to pay or to evade taxes: $e_t \in \{0, 1\}$, where $e_t = 1$ denotes tax evasion at time t. Individuals trade off the benefits of tax evasion (lower tax payments) with the costs. These are given by the (expected) monetary cost of being caught and punished plus the social reputation loss. We assume a proportional income tax (τ) and a network population equally divided between two-income types: y^H and y^L, with $y^H > y^L$.[11] The expected monetary cost of tax evasion is computed by multiplying the probability of being caught (p) by the fine to be paid if discovered, which is equal to f times ($f > 1$) the evaded tax (τy^R, $R = H, L$). Accordingly, the expected monetary cost of tax evasion is equal to $pf\tau y^R$.

Individuals also differ in the importance they assign to social reputation. An individual obtains a reputation benefit (honour) from tax-compliance and pays a reputation cost (stigma) if s/he evades. We assume that: (i) each individual knows the fiscal behaviour of neighbours; (ii) individual i's reputation costs $c(\alpha_{i,t})$, and benefits $b(\alpha_{i,t})$, depend on the current share of taxpayers in the reference group ($\alpha_{i,t}$).

Summarising, at time t individual i decides whether to pay or to evade by comparing the payoff from paying the due taxes ($e_t = 0$) with the payoff from tax evasion ($e_t = 1$), respectively,

$$(1-\tau)y_i^R + \mu_{i,t} b(\alpha_{i,t}) \text{ and } (1-\tau f p)y_i^R - \mu_{i,t} c(\alpha_{i,t}) \tag{1}$$

The parameter $\mu_{i,t}$ is the weight given by the individual to social reputation relative to monetary gains and losses. At time $t = 0$, the reputation weight is randomly drawn from a uniform distribution defined over the interval [0, 1]. We assume that the individual updates $\mu_{i,t}$, assessing the opinions

[10] See Appendix A for some basic notions on networks, used in this paper.

[11] Changing the share of the two groups does not change qualitative results (see Appendix B).

shared by people in the reference group (the set of neighbours s/he follows), according to the following rule:

$$\mu_{i,t} = (1 - \lambda)\mu_{i,t-1} + \lambda \mu^{g}_{i,t-1} \tag{2}$$

where $\mu^{g}_{i,t-1}$ is the average weight given to social reputation in individual i's reference group and $\lambda \epsilon (0, 1]$ measures the (relative) importance of the group for the individual (peer effect).

Individuals with many followers—*influencers*—are more likely to enter in $\mu^{g}_{i,t}$ and thus more likely to influence the weight others give to social reputation.

From (1), the threshold value that determines individual i's taxpaying behaviour at time t is:

$$\mu^{*}_{i,t} = \frac{\tau(1 - fp)y^{R}_{i}}{h(\alpha_{i,t})}$$

where $\tau(1 - pf)y^{R}_{i}$ is the expected monetary net benefit from tax evasion and $h(\alpha_{i,t}) = b(\alpha_{i,t}) + c(\alpha_{i,t})$ is the reputation gain from tax compliance (the earned honour plus the avoided stigma) which is inversely related to the share of tax evaders. If $\mu_{i,t} > \mu^{*}_{i,t}$ then individual i pays at time t.

Given the institutional setting, summarised by $k = \tau(1 - pf)$, an individual is more likely to evade the higher is the share of tax-evaders in his/her reference group, if his/her income is high and if s/he believes that social reputation is not so important.

The condition for tax compliance can be written as $\mu_{i,t} h(\alpha_{i,t}) > k y^{R}_{i}$. Namely, individual i complies if the overall reputation gain from tax compliance—$\mu_{i,t} h(\alpha_{i,t})$—is higher than the expected monetary net benefit from tax evasion—$k y^{R}_{i}$. Note that there are two parts to social reputation. The first, $h(.)$, is a social norm for tax compliance; namely, everyone agrees that reputation costs and benefits from tax behaviour depend on the behaviour of the own reference group. The second, $\mu_{i,t}$, is a subjective component that measures how much the individual cares about social reputation; this is the key element of our dynamics: the weight given to social reputation changes with social interactions.

Allowing for individuals' interactions in a social network makes the dynamics of our system extremely complex being the result of two interacting dynamics: the change in behaviour (α) and the change in opinions (μ). In this setting, it is very difficult, if not impossible, to find (the conditions for) a stable equilibrium. For this reason, we use an agent-based approach and computer simulations to find the steady state.

As explained in detail in Appendix A, to generate our (random) network, we use the algorithm in Azzimonti and Fernandes (2018)—hereafter AF. This setting allows for two important characteristics of social networks: (i) connections can be unidirectional (directed) or bidirectional (reciprocal), namely, individuals can follow and/or be followed by others in the neighbourhood; (ii) some individuals are more influential than others because they have more followers (differential influence). The number of followers is thus a measure of an individual's influence and the reference group is the set of neighbours the individual follows and whom s/he looks at for an opinion.[12]

In the simulations, we consider two different reference groups: *both-income* and *same-income*. In the first, the reference group contains individuals from both income groups; in the second, an

[12] In a directed network, an individual might have two kinds of neighbours: *in-neighbours* and *out-neighbours*. The first indicates the individual's followers; the second includes the individuals whom s/he follows. Thus, in our framework, an individual's reference group is the set of *out-neighbours*.

individual only looks at peers in the same income group.[13] The first describes a more integrated society, the second a rather segregated society.

4 | SIMULATIONS

To conduct the simulations, we have generated a dataset containing 5,000 distinct networks each populated by one hundred individuals ($N = 100$). Each network is obtained by randomly drawing the parameters of AF's algorithm, within specified intervals.[14] In choosing these intervals, our aim was to generate networks with enough reciprocal connections and such that some individuals are more influential than others. For each run, we set the exogenous parameters (τ, p and f) and then simulate the model for a time horizon of 100 periods. We compute the steady state compliance share in each of the 5,000 random networks and characterise its frequency distribution.

In the simulations, we set $h(\alpha_{i,t}) = \frac{1}{1-\alpha_{i,t}}$.[15] It follows,

$$\mu^{*}_{i,t} = k\,(1 - \alpha_{i,t})\,y^{R}_{i} \tag{3}$$

Summarising, the simulation's protocol is the following:

1. The economic characteristics are chosen. Unless otherwise specified, we set $\tau = 0.35$, $f = 1.5$ and $p = 0.05$, which implies $k = 0.3237$.[16]
2. At time zero, individual weights on social reputation ($\mu_{i,0}$) and the share of taxpayers in the reference group $\alpha_{i,0}$, are randomly drawn from a uniform distribution with support [0, 1].
3. Individuals assess the opinions shared by people in their reference group and update $\mu_{i,t}$ as in Equation (2).
4. The threshold values ($\mu^{*}_{i,t}$) are computed as in Equation (3).
5. Individuals decide whether to comply or not, looking at their payoff as in Equation (1).

In what follows, we first discuss the dynamics of the reputation weight μ and then characterise the frequency distribution of the steady state compliance share.

4.1 | The dynamics of the reputation weight (μ)

As discussed above, at time 0 individuals differ in the weight they assign to reputation ($\mu_{i,0}$). This is updated over time looking at the own reference group. We consider two alternative reference groups: *both-income* and *same-income*.

[13] Obviously if all individuals have the same income, the two reference groups coincide, and the relative updating procedures produce the same results.

[14] As discussed in Appendix A, to generate a network using AF's algorithm, two parameters have to be specified: the probability that an individual is connected to another (ϕ) and the expected number of influential individuals ($\overline{\gamma}$).

[15] This is a simple (monotone) increasing and convex function, which implies a linear $\mu^{*}_{i,t}$. Moreover, given $\alpha_{i,t} \in [0, 1]$, it follows that $\mu^{*}_{i,t} \in \left[0,\ k y^{R}_{i}\right]$. The function $h(\alpha_{i,t}) = \frac{1}{1-\alpha_{i,t}}$ can be thought of as the sum of $b(\alpha_{i,t}) = \frac{z\alpha_{i,t}}{1-\alpha_{i,t}}$ and $c(\alpha_{i,t}) = \frac{1-z\alpha_{i,t}}{1-\alpha_{i,t}}$, both increasing with the number of taxpayers.

[16] The chosen value for the tax burden ($\tau = 0.35$) is close to the average tax burden among OECD countries in 2018, which is 34.3% (https://data.oecd.org/tax/tax-revenue.htm). We have tried other parameters values and results are qualitatively the same.

In the first, the individual's reference group contains individuals from both income groups. In this case, if the network is (i) strongly connected and (ii) aperiodic, then individuals' reputation weights converge to a common value μ^N (Jackson, 2010).[17] The first condition ensures that opinions freely spread around the network and, therefore, everyone receives, through the neighbours, all the opinions shared in the network. The second condition ensures that $\mu_{i,t}$ does not cycle indefinitely. The limit value μ^N is a weighted average of the initial values $\mu_{i,0}$ with weights correlated to individuals' influence (see Golub & Jackson, 2010). Thus, if all individuals in the network have the same influence, the expected value of μ^N is equal to the expected value of $\mu_{i,0}$, that is, $\frac{1}{2}$. By contrast, if there is one or more *influencers* the expected value of μ^N will be biased towards their initial evaluation of social reputation.[18] However, since we have assumed $\mu_{i,0}$ to be uniformly distributed in [0,1], the expected value of an influencer's initial evaluation of social reputation is $\frac{1}{2}$ and the limit distribution of μ^N is symmetric around its mean $\left(\frac{1}{2}\right)$. Figure 1 shows the limit distribution of μ^N in our simulations, where convergence is obtained in 99% of the 5,000 networks.

When the reference group only contains individuals with the *same income*, the original structure of the network splits into (two or more) sub-networks. In this case, if each sub-network is strongly connected and aperiodic, the above result applies to each sub-network and $\mu_{i,t}$ converges to a unique value in each sub-network.

As for the speed of convergence, DeMarzo et al. (2003) have shown that if the sufficient conditions for convergence are verified, the updating process in (2) leads to convergence for any positive value of λ. The weight that individuals place on the average opinion in the reference group only affects the speed of convergence: the higher is λ the quicker is the convergence process.[19]

4.2 | Tax compliance

To find the steady state share of taxpayers (C), we first consider the benchmark case in which all individuals have the same income. To this purpose, we set $y^H = y^L = \frac{1}{k}$. This ensures that $\mu^*_{i,t}$ and $\mu_{i,t}$ are both defined in the interval [0, 1].[20] By contrast, if individuals have different income levels, there is no way to ensure that $\mu^*_{i,t}$ and $\mu_{i,t}$ vary in the same interval. This fact might generate a bias in individuals' decisions: an *evasion bias* if the maximum value of the threshold $\mu^*_{i,t}$ is higher than the maximum value of the reputation weight, and a *compliance bias* if the threshold $\mu^*_{i,t}$ never reaches the maximum value of the reputation weight. The size of the *evasion bias* can be measured by the value $\overline{\alpha}_{i,t}$ such that $\mu^*_{i,t}$ reaches 1, namely $k\left(1-\overline{\alpha}_{i,t}\right)y_i^R = 1$. The higher this value, the smaller is the share of tax-evaders required in the reference group to induce tax evasion.[21] Note that the evasion bias is higher for high-income individuals. To measure the *compliance bias*, note that, when all in the reference group evade ($\alpha_{i,t} = 0$), the expected monetary net benefit of tax evasion falls short of the reputation

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[17] The first condition (strong connectedness) requires that there exists a path between every pair of nodes i and j. This is more likely the higher is the parameter ϕ. The second condition (aperiodicity) means that the length of the greatest common divisor of all directed cycle is 1 (see Jackson, 2010).

[18] If influencers have divergent evaluations of social reputation, their influence on the value of μ^N might balance and even cancel out. Recall that the number of influencers in the network is affected by the value of the parameter γ.

[19] See Figure B3 in Appendix B. Without loss of generality, in our simulations we have set $\lambda = 0.5$.

[20] In fact, with $ky = 1$ in (3) $\mu^*_{i,t}$ varies in the interval [0, 1], which is the support of $\mu_{i,t}$.

[21] If $\overline{\alpha}_{i,t} = 0$, there is no evasion bias. This happens if $y_i^R = \frac{1}{k}$. Note that $\overline{\alpha}_{i,t} = 1 - \frac{1}{ky_i^R} > 0$ implies $y_i^R > \frac{1}{k}$. This means that when all neighbours evade ($\alpha_{i,t} = 0$) the monetary net benefit of tax evasion overcomes the reputation gain from tax compliance, which induces the individual to evade. By contrast, if all neighbours comply ($\alpha_{i,t} = 1$) then $\mu^*_{i,t} = 0$ and all individuals pay their taxes, no matter their income.

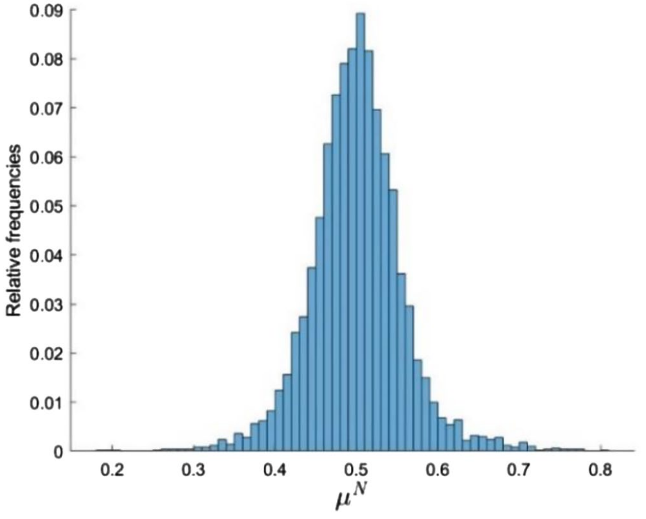

FIGURE 1 Distribution of μ^N, both-income reference group

gain from tax compliance if $\mu^*_{i,t} = ky^R_i < 1$. In this case, an individual might decide to comply even if all in the reference group evade. Differently from the evasion bias, the compliance bias—measured by $\left(1 - ky^R_i\right)$—is higher for low-income individuals. This suggests that if $y^H > \frac{1}{k} > y^L$ there is an evasion bias for high-income individuals and a compliance bias for low-income individuals. In what follows, we focus on this case and, to balance the evasion bias of high-income individuals and the compliance bias of low-income individuals, we assume $y^H y^L = \frac{1}{k^2}$.[22]

To set the stage, let us first consider the benchmark case in which there are no income differences. In this case, the two reference groups in the updating process coincide and, if the conditions for convergence are satisfied, all individuals end up sharing a common value of the reputation weight (μ^N). Moreover, since they all have the same income, their (expected) monetary cost of tax evasion is the same. It follows that, in equilibrium, they all take the same tax-paying decision: either they all pay (if $\mu^N > \mu^*_{i,t}$) or they all evade (if $\mu^N < \mu^*_{i,t}$).

Next, consider the model with income differences. In case of an integrated society in which individuals follow others no matter their income, if the convergence conditions are satisfied, individuals end up sharing a common value of the reputation weight (μ^N) and it is possible to reach network conformity, either complete compliance ($C = 1$) or complete tax evasion ($C = 0$). However, with income differences, this is not always the case. In fact, although individuals reach a consensus on the weight to place on social reputation, the heterogeneity in the (expected) monetary cost of tax evasion might lead them to undertake different decisions: to evade if the gain from evasion is not enough to balance the reputation loss $\left(\mu^N < \mu^*_{i,t}\right)$ and to comply otherwise (if $\mu^N > \mu^*_{i,t}$). When tax compliance and tax evasion coexist, due to differences in the expected net benefit from tax evasion, it is more likely that low-income individuals pay than high-income do. Figure 2 shows the distribution of C over 5,000 runs (networks) assuming two different sets of income values.[23] In panel *(a)* $y^H = 3.5$ and $y^L = 2.7$; in panel *(b)* $y^H = 7.4$ and $y^L = 1.3$.[24]

[22] This is obtained by setting the evasion bias equal to the compliance bias: $1 - \frac{1}{ky^H} = 1 - ky^L$.
[23] The figure reports only the cases in which the reputation weights converge.
[24] Both satisfy the no-bias condition: $y^H y^L = \frac{1}{k^2}$.

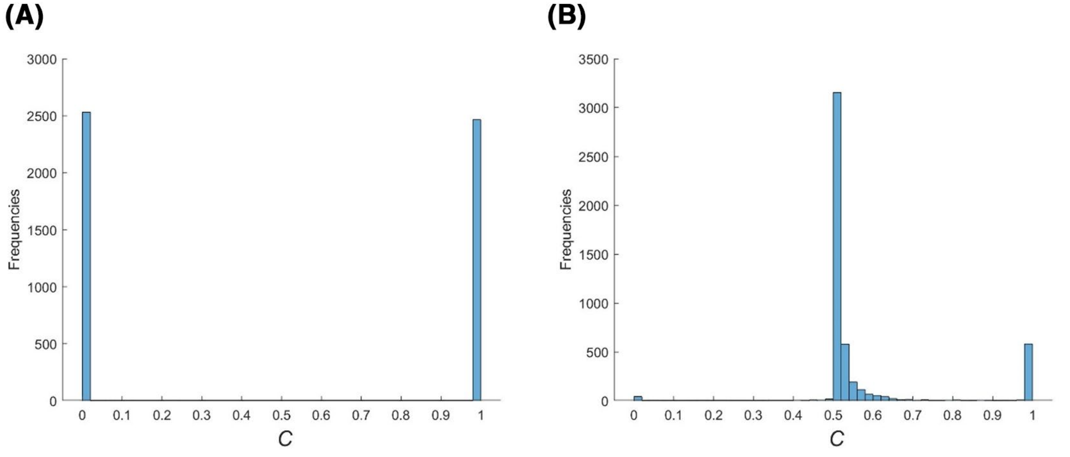

FIGURE 2 The frequency distribution of C, both-income reference group. (A) Share of taxpayers—$y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers—$y^H = 7.4$ and $y^L = 1.3$

In the first case ($y^H = 3.5$ and $y^L = 2.7$), we observe almost always network conformity: complete compliance ($C = 1$) or complete tax evasion ($C = 0$). Having assumed an equal share of low and high-income individuals, C is (almost) equally distributed between $C = 1$ and $C = 0$. In the second case ($y^H = 7.4$ and $y^L = 1.3$), although in many networks tax compliance and tax evasion coexist in equilibrium, in most simulations the steady state share of taxpayers is higher than 50%. This is due to having set y^L so low that even when all in the reference group evade, the expected monetary net benefit of tax evasion for low-income individuals is not enough to balance the expected reputation loss $\left(\text{i.e., } y^L k < \frac{1}{2}\right)$.[25]

In this setting, the role of influencers is fundamental: the network is more likely to end up with a prevalence of taxpayers (tax-evaders) the higher (lower) is the weight placed on reputation by influencers and if their income is low (high).[26]

Figure 3 shows the steady state of a network with 30 individuals, setting $y^H = 7.4$ and $y^L = 1.3$. It shows that, due to the divergence of the expected monetary cost of tax evasion implied by income differences, low-income individuals (circles) might comply (in green) even if they only follow (high-income) tax-evaders (in blue). This is, for instance, the case of individual 11, who, despite only following tax-evaders (8, 15, 28), does not evade. In this example, individuals 1, 2, and 3 are the most influential with, respectively, 17, 10 and 15 followers.

Finally, consider the case of a segregated society in which the reference group only contains individuals from the *same-income* group. Segregation hinders the diffusion process because opinions do not freely spread around the network and individuals do not receive all the opinions shared. Therefore, it is unlikely that the first condition for convergence of $\mu_{i,t}$ be satisfied. Figure 4 shows the frequency distribution of the steady state compliance share for the same set of income values as before. In Figure 4A, where $y^H = 3.5$ and $y^L = 2.7$, the distribution is symmetric around its mean $\left(\overline{C} = \frac{1}{2}\right)$ and network conformity is quite rare (around 25%), with a similar frequency of 'all taxpayers' and 'no taxpayers'. Moreover, as expected, among taxpayers the share of low-income individuals (orange

[25] In few cases, the limit value μ^N is lower than $y^L k = 0.4208$ and the outcome is complete tax evasion.

[26] See Figure B4 in Appendix B.

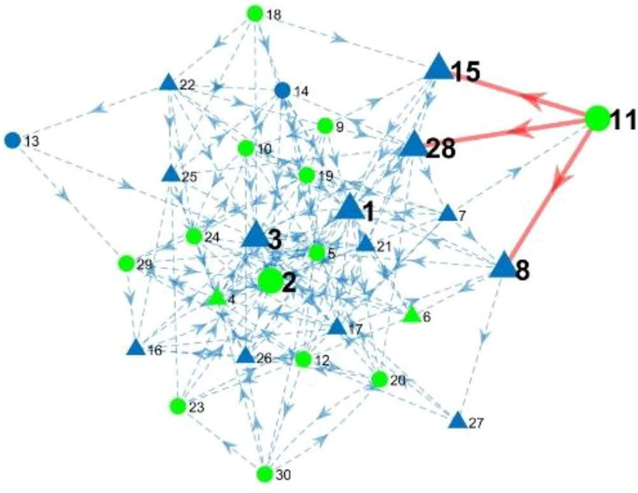

FIGURE 3 Triangles are for high-income and circles for low-income; green is for taxpayers and blue for tax-evaders

diamonds on the right scale) is much higher than the share of high-income individuals.[27] Differently, in Figure 4B, where $y^H = 7.4$ and $y^L = 1.3$, network conformity is almost never reached. What we observe is that no matter the compliance share, taxpayers are all low-income, while high-income individuals never pay.[28] The reason for non-compliance of high-income individuals is twofold: (i) their monetary incentive for tax evasion is high and (ii) they only look at people who have high incentive for tax evasion.

To compare the results obtained in an integrated society and in a segregated society, the graphs in Figure 5 illustrate the dynamics of tax-paying decisions in a network with 30 individuals and assuming $y^H = 3.5$ and $y^L = 2.7$. Figure 5A describes the directed edges, individuals' income, and their tax paying behaviour in the initial state of the network: triangles indicate high-income and circles low-income; green is for taxpayers and blue for tax-evaders. Figure 5B shows the final network configuration when the reference group only contains peers with the *same income*. Individual 5, who belongs to the high-income group, breaks the connection between (low-income) individuals 22 and 18. The latter are influencers in the red and in the black sub-network, respectively. In the final network configuration, individuals in the 'red' sub-network end up paying because of the influence of individual 22, a taxpayer 'celebrity'; in the 'black' sub-network all individuals end up evading, because of the influence of individual 18, a tax-evader 'celebrity'. By contrast, as shown in Figure 5C, when individuals follow *both-income* types, individual five acts as a bridge between the two low-income influencers (22 and 18) and opinions freely spread between the two sub-networks (and more generally around the network). This adds to the positive effect of the most influential individual (individual 1, a high-income taxpayer) and generates network conformity (in this specific case compliance).

[27] For example, when the compliance share is 50%, and this happens in 2.802 networks out of 5,000 (left scale), the orange diamond indicates that around 95% of taxpayers are low-income (right scale).

[28] The figure on the right exhibits also cases in which a small share of low-income individuals evades. See footnote 25 for the reason this might happen.

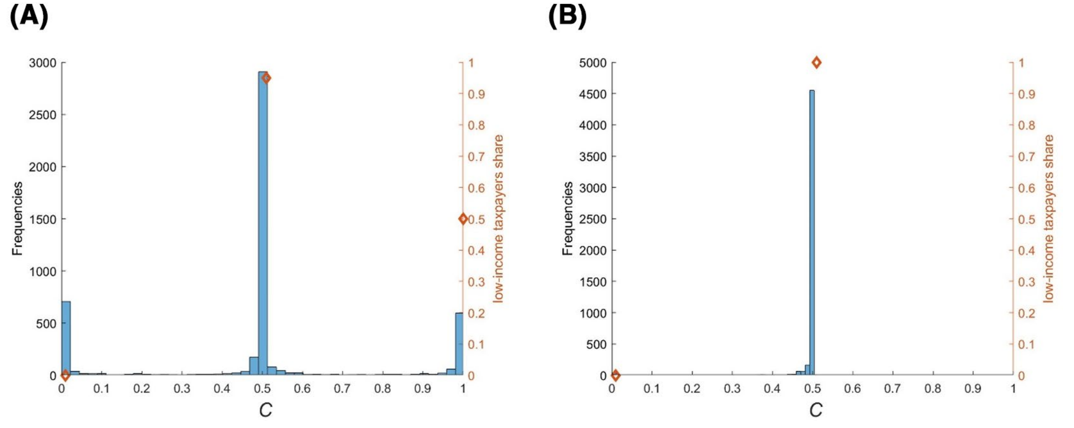

FIGURE 4 The frequency distribution of C, same-income reference group. (A) Share of taxpayers with $y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers with $y^H = 7.4$ and $y^L = 1.3$

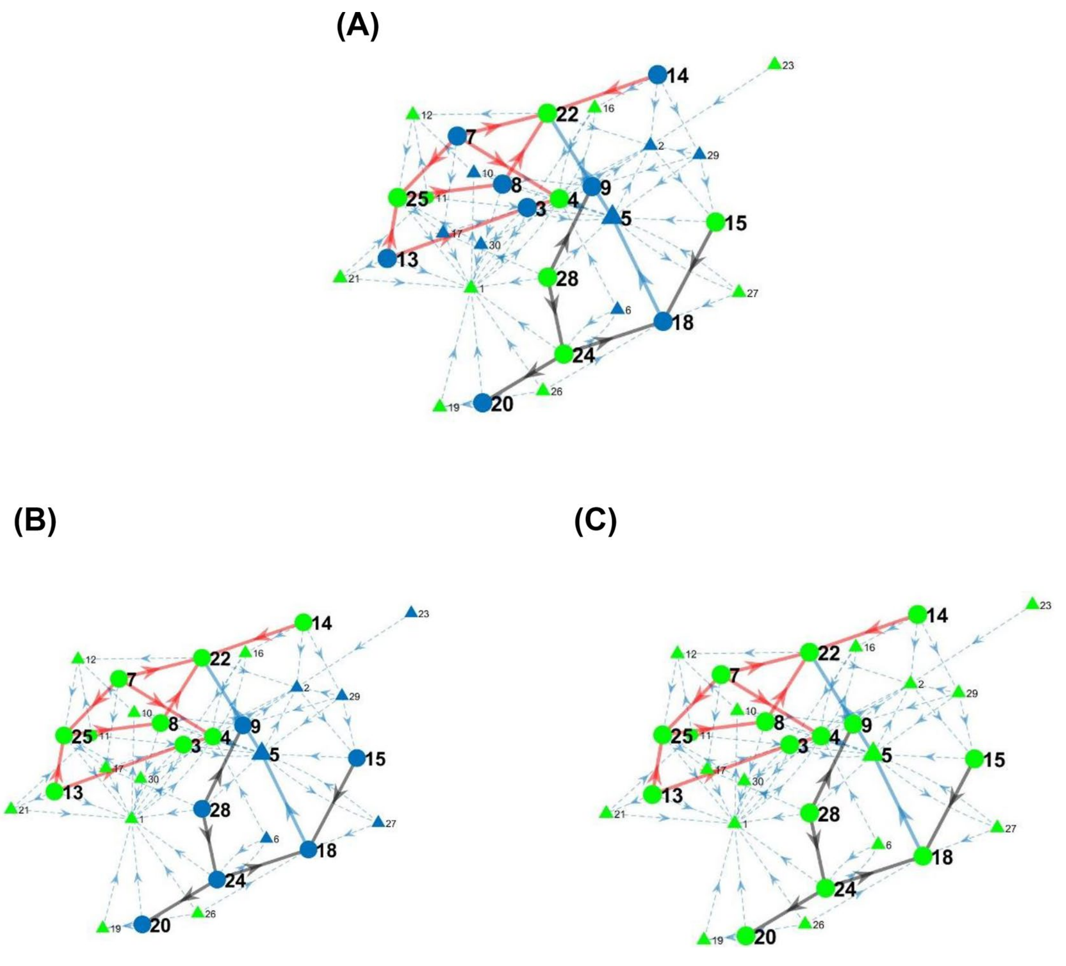

FIGURE 5 The dynamics of tax paying decisions. (A) $t = 0$. (B) Segregated society—end period. (C) Integrated society—end period

5 | A SOCIAL MEDIA CAMPAIGN

We now consider the possibility that, exploiting the diffusion process in the network to promote tax compliance, a tax authority aims at increasing individuals' concern for social reputation. To this purpose, imagine that the tax authority organises a social media campaign in which a celebrity illustrates the social harm caused by tax evasion, emphasising the social stigma associated with it. Due to the social media campaign, the celebrity's stance on tax compliance has a stronger influence on the followers. We formalise this effect as an increase in the value of the reputation weight of the most influential individual—a 'celebrity'—and simulate the diffusion process in the two 'societies' considered in this paper.[29]

The results are graphically illustrated in Figures 6 (for an integrated society) and 7 (for a segregated society). As compared with Figures 2 and 4, in both cases we observe an increase in the average compliance share, more pronounced when opinions freely spread around the network (integrated society). When the reference group contains both income types, the celebrity's message about the importance of social reputation in tax behaviour increases the average value of C by 20% (from 0.5 to 0.6) when income differences are relatively low (Figure 6A) and by 7% (from 0.56 to 0.6) when income inequality is more pronounced (Figure 6B).[30] If the reference group is only made of same-income peers, the policy increases the average value of C by 10% (from 0.5 to 0.55), when income differences are relatively low (Figure 7A) and it has no effect on compliance when income inequality is relatively high (Figure 7B).

These results suggest that a policy intervention that exploits a celebrity's influence in a social network to boost tax compliance is more effective in situations in which opinions diffusion is not hindered by social segregation. In a more integrated society, and especially if income inequality is low, an influencer's endorsement of tax compliance might nudge a widespread socially responsible tax behaviour.

We now compare the social media campaign policy, aimed at convincing, with a more conventional punishment strategy that permanently increases the audit probability (or equivalently, the fine to be paid in case of detection). Note that in our framework increasing the value of the audit probability (or equivalently, the fine to be paid in case of detection) produces two effects. On the one hand, it reduces the expected monetary net benefit from tax evasion[31]; on the other hand, it simultaneously increases the compliance bias and decreases the evasion bias.[32] Both these effects encourage tax compliance.

To replicate the results obtained with the social media campaign in the case of an integrated society the tax authority would have to increase the audit probability from 5% (in basic set-up) up to around 9%.

If the two income groups are segregated, the same increase in the audit probability would rise the average value of C by 10% when income differences are relatively low, and it would have no effect on

[29] The success of the proposed social media campaign is higher the earlier it is implemented. The reason is that the celebrity's influence is more likely to positively affect tax compliance when individual reputation weights are heterogeneous, that is, before a consensus is reached. Therefore, if the social media campaign is launched 'too late', it might turn out to be ineffective. Recall that convergence is slower—and thus the campaign is more likely to be successful—the lower is the parameter λ (see Section 4.1). In our simulation, where $\lambda = 0.5$, we implement the social media campaign at the end of the second period.

[30] Note that, although the average is the same, the two distributions strongly differ.

[31] In fact, an increase in p or f reduces the value of k.

[32] Recall that the evasion bias is measured by $1 - \frac{1}{ky^H}$ and the compliance bias by $1 - ky^L$. Thus, lowering k reduces the evasion bias and increases the compliance bias.

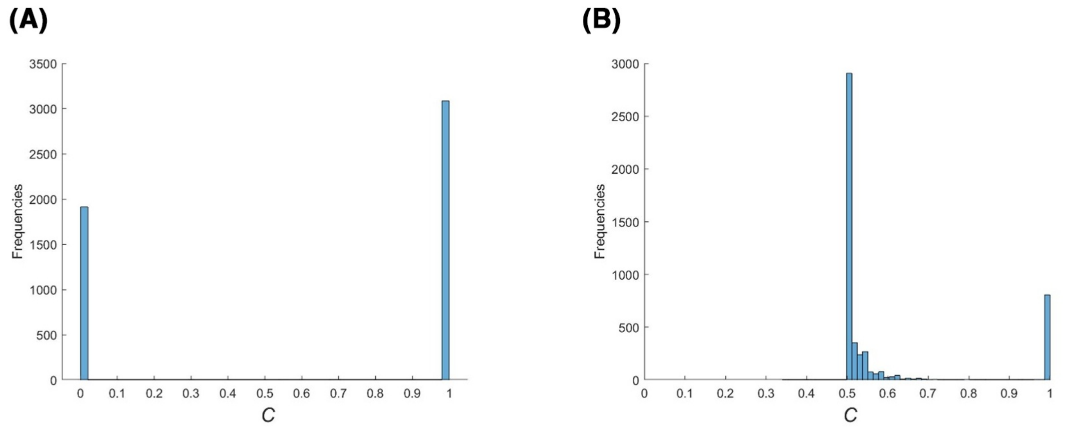

FIGURE 6 Social media campaign, both-income reference group. (A) Share of taxpayers with $y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers with $y^H = 7.4$ and $y^L = 1.3$

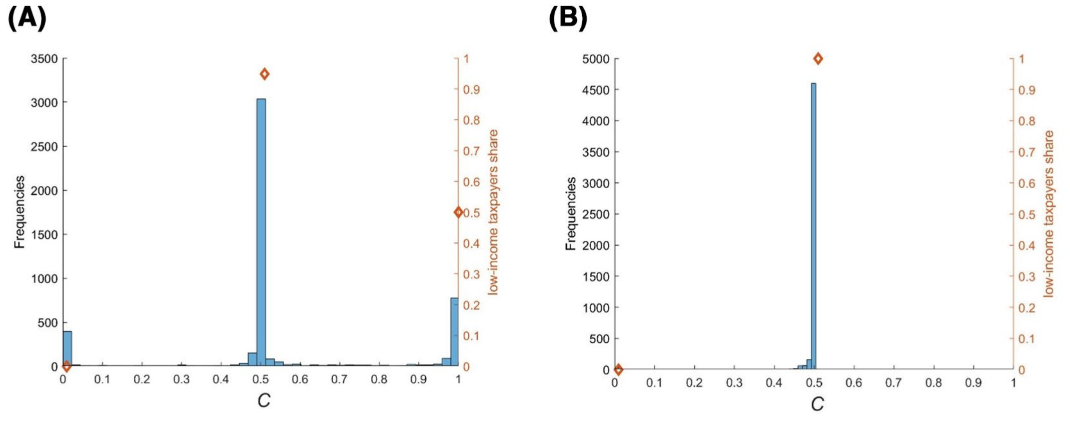

FIGURE 7 Social media campaign, same-income reference group. (A) Share of taxpayers with $y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers with $y^H = 7.4$ and $y^L = 1.3$

compliance when income inequality is relatively high: the same effect obtained with the celebrity's endorsement.[33]

This is not an indication that social media campaigns starring celebrities should be a substitute for audits; it rather suggests that behavioural strategies could be an effective complement to more traditional policies.

6 | CONCLUDING REMARKS

In this paper, we study tax evasion in a social network where individuals differ in income and concern for social reputation. *Ceteris paribus*, richer individuals have a higher incentive to evade because their net monetary benefit from tax evasion is higher. In this respect, to reduce this 'evasion bias' the tax

[33] As shown in Appendix B (Figures B1 and B2), the effects of the proposed social media campaign also hold changing the share of high-income individuals in the social network.

authority should condition the audit probability to individual characteristics such as income and occupation (see Hashimzade et al., 2014, 2015). In our model, income differences affect tax evasion also through network effects if individuals' reference group only contains *same-income* peers (a segregated society). In this setting, changing the monetary incentives of tax evasion for few rich individuals might have a relevant effect on tax evasion. We instead consider a social media campaign that, to reduce tax evasion, exploits the social network effect of celebrities' influence. We show that this strategy is potentially effective and could be a valid complement to more traditional policies. As a follow up, it would be interesting to design a field experiment and empirically investigate the effectiveness of an influencer's communication on the fiscal behaviour of his/her audience, relative to a control group. This assessment is left to future research.

ACKNOWLEDGEMENT

Open Access Funding provided by Universita degli Studi di Roma La Sapienza within the CRUI-CARE Agreement.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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How to cite this article: Di Gioacchino, D., & Fichera, D. (2022). Tax evasion and social reputation: The role of influencers in a social network. *Metroeconomica*, 1–22. https://doi.org/10.1111/meca.12391

APPENDIX A

In this appendix, we present the basic definitions on directed network used in this paper. A network is a pair (N, A) where N is the number of individuals (*nodes*) and A is a $n \times n$ adjacent matrix on the set of individuals. The elements of the matrix $a_{ij} \in \{0, 1\}$ indicate the relationship between individuals i and j. A directed relationship exists if $a_{ij} = 1$, namely if individuals i and j are connected, and it does not if $a_{ij} = 0$. Individual i's *out-neighbourhood* is the set of individuals to whom s/he is connected—$N_i^{\text{out}} = \left\{ j \in N \ s.t. \ a_{ij} = 1 \right\}$. Individual i's *in-neighbourhood* is the set of individuals connected with him/her—$N_i^{\text{in}} = \left\{ j \in N \ s.t. \ a_{ji} = 1 \right\}$. The *degrees* d_i^{out} and d_i^{in} are, respectively, the cardinality of the set N_i^{out} and N_i^{in}. A (directed) *walk* in a network refers to a sequence of nodes i_1, i_2, …, i_h, …, i_H such that $a_{i_h, i_{h+1}} = 1$, for $h = 1 \ldots H$. A (directed) *path* is a walk such that all nodes are distinct. A (directed) *cycle* in a network is a path in which the first and the last nodes of the sequence are the same. A network is *strongly connected* if there exists a path between every pair of nodes i and j.[34] The distance between two nodes in a strongly connected network is the length of the shortest path between them.

To perform our simulations, we have generated a dataset of distinct random networks using the three steps procedure in Azzimonti and Fernandes (2018). In the first step, a Barabási and Albert's (1999) random graph is generated, which is a directed network with few popular individuals (Figure A1A). Starting from a small random network (*seed*) of γ individuals, the algorithm iteratively adds new nodes which are connected to a fixed number γ_0 of existing node—where $\gamma_0 \le \gamma$[35]; γ thus, in each iterations the procedure expands the N_i^{in} of the existing nodes. To enhance the randomness of the network, we have randomly (and conventionally) drawn γ in the range [2, 5].[36] The probability of connection

[34] Note that in a directed network the existence of a path between two individuals, i and j, does not imply that also individual j can reach individual i.

[35] For each network, we randomly drawn γ0 in the range [2, γ].

[36] In Barabasi and Albert's (1999) algorithm the *seed* network can be any random networks with no isolated nodes (a node i is isolated if N_i^{out} and N_i^{in} are empty set). To generate the *seed*, we use the algorithm in Erdős and Rényi's (1960). This algorithm ensures, almost surely, the absence of isolated nodes when the probability of connection is greater than the

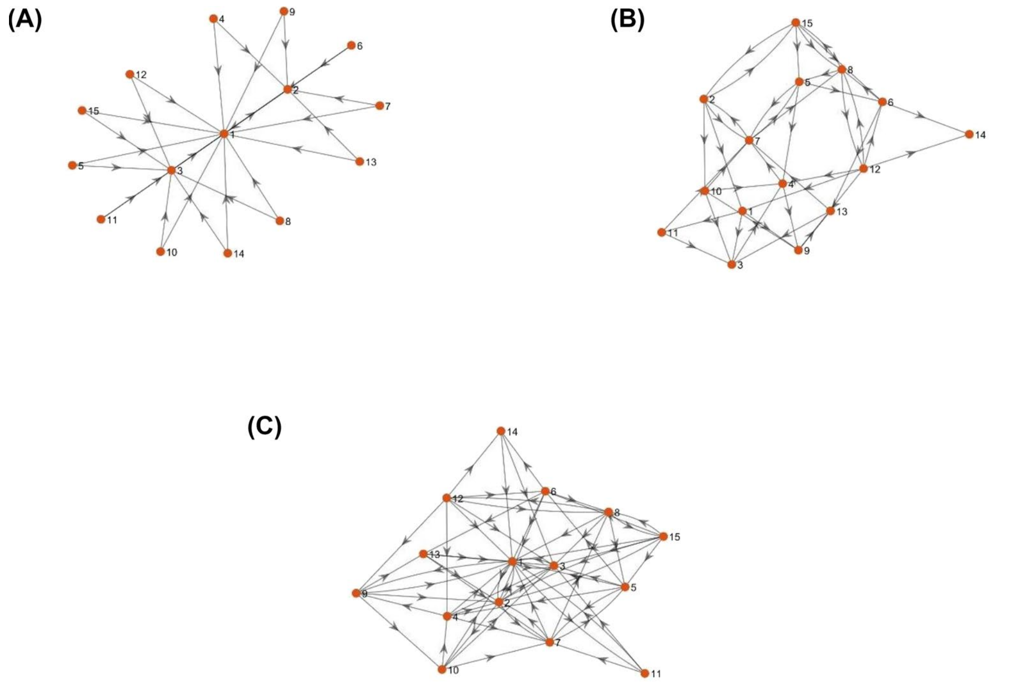

FIGURE A1 The three steps in Azzimonti and Fernandes's algorithm ($N = 15$, $\phi = 0.11$, $\gamma = 3$, $\gamma_0 = 2$). (A) 1° step—Barabasi and Albert's network ($\gamma = 3$, $\gamma_0 = 2$). (B) 2°step—Erdős and Rényi's network ($\phi = 0.11$). (C) 3° step—Azzimonti and Fernandes's random network

between a new and an existing node is endogenously determined. It is proportional to the number of connections that the existing nodes already have. Formally, the probability that an existing node i is chosen (among the other j existing nodes) as neighbour of a new node is: $pr_i = \frac{d_i^{in}}{\sum_j d_j^{in}}$. This process ensures that, the 'older' individuals are more likely to have many followers than the 'youngers' (this property is known as *preferential attachment*). As a consequence, individuals in the *seed* are more likely to be the network's influencers.

In the second step an Erdős and Rényi's (1960) random network is generated, according to which individuals have the same probability, ϕ, to be linked with any other individual in the network (Figure A1B). The value of ϕ is directly related with the reciprocity of connections. A value of $\phi = 1$ implies that all connections are reciprocal, whereas a value $0 < \phi < 1$ implies that only a fraction of them might be reciprocal. To generate the set of networks used in the simulations, for every network we have randomly drawn the probability ϕ in the interval [0, 0.18]. This condition, combined with the assumption on the *seed*, ensures a reciprocity rate around 6%, close to the one estimated in Azzimonti and Fernandes (2018).[37]

Finally, in the third step the two previous networks are combined (Figure A1C).

threshold value log(N)/N. However, this is a limit condition, more likely satisfied for network populated by a large number of individuals. For this reason, we have randomly drawn the connection probability between log(γ)/γ and 1, and checked for isolated nodes in the *seed*. If this last condition were not satisfied, we discarded the *seed* and repeated the procedure. This is done only for the *seed* network.

[37] In their network, the reciprocity rate is around 4%.

APPENDIX B

Figure B1 and Figure B2 illustrate the average compliance share ($\overline{C}$) as a function of the share of high-income individuals in the network (β), with and without the social media campaign (orange and blue lines respectively).[38] As expected, due to the income related monetary cost of tax evasion, the share of taxpayers is higher when the number of high-income individuals is lower. Comparing panel (a) and (b) in the two graphs, we see that when income differences are more pronounced (panel b), due to the effects of the compliance and evasion biases discussed in Section 4.2, the relationship is steeper.[39]

Finally, Figure B2B confirms that the social media campaign has no effect when the reference group only contains same-income peers and income inequality is relatively high.

Figure B3 plots the updating dynamics of 10 representative individuals. It shows that when the conditions for convergence are satisfied the reputation weight converges to a common value, faster for higher values of λ.

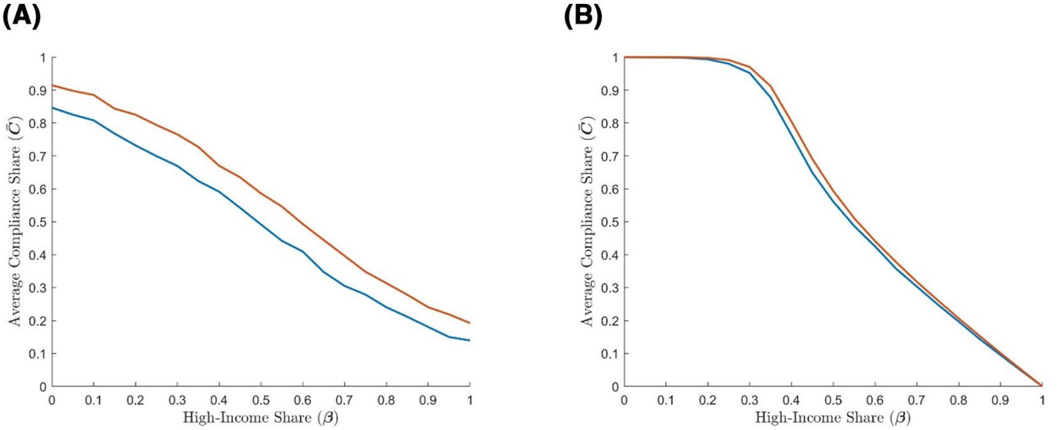

FIGURE B1 Average compliance share and share of high-income individuals with the social media campaign (orange line) and without intervention (blue line), both-income reference group. (A) Share of taxpayers with $y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers with $y^H = 7.4$ and $y^L = 1.3$

[38] Each point in the graph represents the average compliance share $\overline{C}$—computed over 5,000 networks—for a given share of *high-income* individuals in the population and following the simulation protocol in Section 4.

[39] In fact, in panel (b) $\overline{C} = 1$ for $\beta = 0$ and $\overline{C} = 0$ for $\beta = 1$ while in panel (a) $\overline{C} < 1$ for $\beta = 0$ and $\overline{C} > 0$ for $\beta = 1$. The reason is that, unlike the case of equal income considered in Section 4—in which there is no bias having set $y^H = y^L = \frac{1}{k}$—here when $\beta \to 0$ the compliance bias overcomes the evasion bias. Similarly, when $\beta \to 1$ the evasion bias overcomes the compliance bias. As discussed in Section 4, this effect is amplified when income differences are more pronounced (panel b). In this case, when $\beta = 0$ and all have the same income ($y = 1.3$), the compliance bias is so strong that in all networks we observe 100% compliance. Similarly, when $\beta = 1$ and all individuals have income $y = 7.4$, the evasion bias is so strong that in all networks we observe complete tax evasion.

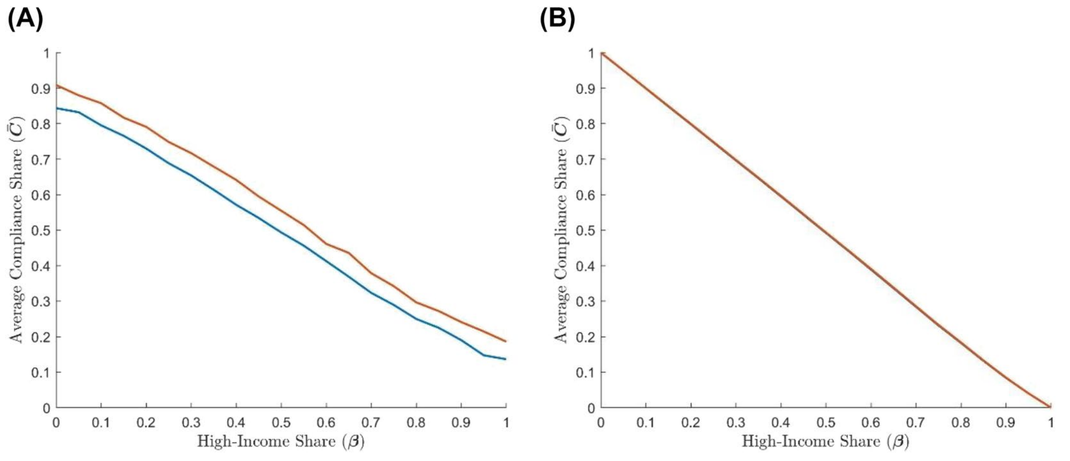

FIGURE B2 Average compliance share and share of high-income individuals with the social media campaign (orange line) and without intervention (blue line), same-income reference group. (A) Share of taxpayers with $y^H = 3.5$ and $y^L = 2.7$. (B) Share of taxpayers with $y^H = 7.4$ and $y^L = 1.3$

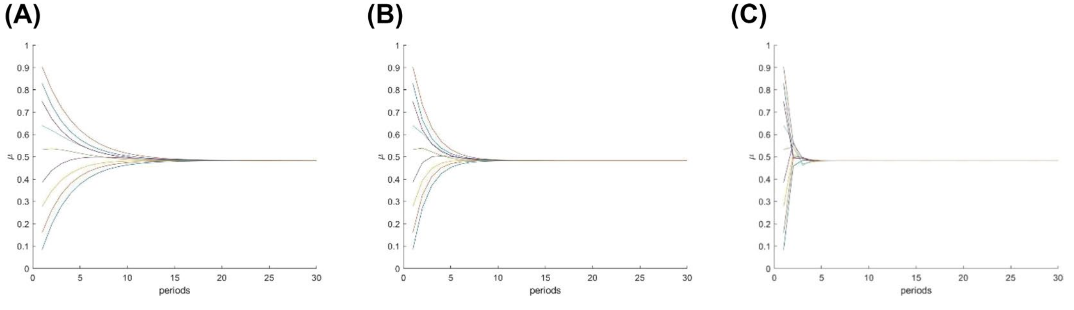

FIGURE B3 Reputation weight—Speed of convergence. (A) $\lambda = 0.3$, (B) $\lambda = 0.5$, (C) $\lambda = 1$

The graphs in Figure B4 show the average compliance share ($\overline{C}$) as a function of the celebrity's reputation weight at time zero (μ_{I_0}), in case of a low-income (blue line) and a high-income (orange line) influencer. As expected, the share of taxpayers increases with the influencer's initial reputation weight and it is higher when the influencer belongs to the low-income group (blue line). Comparing Figure B4A and Figure B4B, we see that when income differences are less pronounced (Figure B4A), the relationship is steeper. In this case the monetary incentive to comply or to evade are relatively low and, for this reason, individuals' fiscal decision is more exposed to reputational stimuli. On the other hand, when income inequality is higher (Figure B4B), the monetary incentive is stronger and, as a consequence, the reputation factor is relatively less important in the individuals' taxpaying decision.[40]

[40] Note that in this set of simulations μ_{I_0} is fixed at time 0. Thus, the simulations for $\mu_{I_0} = 1$ are different from the simulations for the social media campaign, in which the policy (an increase in the value of reputation weight of the celebrity) is applied at the end of the second period.

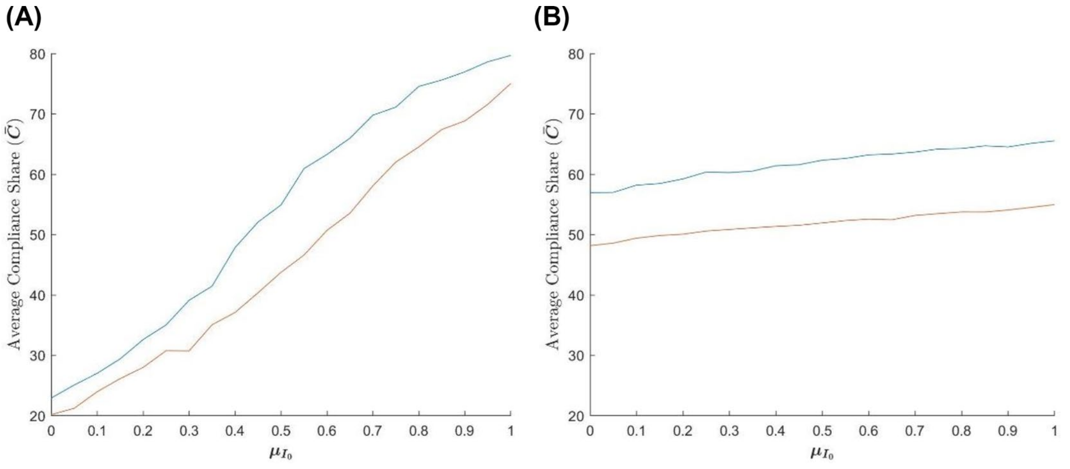

FIGURE B4 Average compliance share and reputation weight of low-income influencer (blue line) and high-income influencer (orange line), both-income reference group. (A) Share of taxpayers with $y_I^H = 3.5$ and $y_I^L = 2.7$. (B) Share of taxpayers with $y_I^H = 7.4$ and $y_I^L = 1.3$