Physica A 387 (2008) 5857–5861

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Controlling tax evasion fluctuations[☆]

Georg Zaklan [a,*], F.W.S. Lima [b], Frank Westerhoff [a]

[a] Department of Economics, University of Bamberg, Feldkirchenstrasse 21, D-96045 Bamberg, Germany

[b] Departamento de Física, Universidade Federal do Piauí, 64049-550 Teresina – PI, Brazil

ARTICLE INFO

Article history:
Received 1 April 2008
Received in revised form 31 May 2008
Available online 2 July 2008

Keywords:
Opinion dynamics
Sociophysics
Ising model

ABSTRACT

We incorporate the behaviour of tax evasion into the standard two-dimensional Ising model and augment it by providing policy-makers with the opportunity to curb tax evasion via an appropriate enforcement mechanism. We find that tax evasion may vary greatly over time if no measures of control are taken. Furthermore, we show that even minimal audit rates of a tax authority may help to alleviate this problem substantially. Similar results are observed for other network structures.

1. Introduction

In economics, the problem of tax evasion from a multi-agent-based perspective has received scant attention so far (see Ref. [3] for a recent overview). Realistic models of tax evasion appear to be necessary because tax evasion remains to be a major predicament facing governments (see Refs. [1,10,12]). The goal of our paper is to show that substantial fluctuations in tax evasion may be caused by local interactions (herding behaviour) among heterogeneous agents and that already minimal audit rates of a tax authority may suffice to alleviate this problem.

Experimental evidence provided by Gächter [7] indeed suggests that tax payers tend to condition their decision regarding whether to pay taxes or not on the tax evasion decision of the members of their group ("conditional cooperation"). So-called conditional cooperators are thus more likely to behave honestly, if they have the impression that many others pay their taxes. However, if most others evade taxes, an individual is more likely to cheat on her taxes. Frey and Torgler [6] also provide empirical evidence on the relevance of conditional cooperation for tax morale. They find a positive correlation between people's tax morale, which is measured by asking whether tax evasion is justified if the chance arises, and their perception regarding how many others evade paying tax. Conditional cooperation from the viewpoint of the standard economic theory may be explained by changes in risk aversion due to changes in equity [4].

In this paper, we use the Ising model to study the implications of conditional cooperation in a multi-agent-based framework. Our setup allows us to consider a large number of heterogeneous agents who interact locally with each other and base their decision whether to evade taxes or not on the behaviour of their neighbours (and thus they display some kind of imitation/herding behaviour). Note that the Ising model was first used in an economic context by Föllmer (see Ref. [5]).[1]

To be precise, we incorporate the behaviour of tax evasion into the standard two-dimensional square lattice Ising spin model and furthermore add a policy maker's tax enforcement mechanism. We aim to extend the study of Zaklan et al. [16], which illustrates how – in a world where agents are conditionally cooperative – different levels of enforcement affect

☆ We thank Dietrich Stauffer for his stimulating discussions and many constructive comments.

* Corresponding author.
E-mail address: georg.zaklan@gmail.com (G. Zaklan).

1 Our study may also be related to evolutionary games, where some agents try to cheat (for a short survey, see Ref. [14]).

0378-4371/$ – see front matter
doi:10.1016/j.physa.2008.06.036

aggregate tax evasion over time. Enforcement consists of two components: a probability of an audit each person is subject to in every period and a length of time detected tax evaders remain honest for. We also embed our tax evasion model in different network structures and find that substantial fluctuations in aggregate tax evasion behaviour may arise if no enforcement is used. For our simulations, we make use of the fact that a dominant strategy exists at temperatures below the critical level and that the states, which are predominant, may change over time if the temperature is chosen to be slightly below its critical value. This process has been used for two decades in the field of physics, and also by Hohnisch et al. [8] to replicate the evolution of the IFO business climate index. We also observe a second important and maybe less obvious effect of enforcement: numerical evidence suggests that even minimal levels of enforcement may help to reduce the presence of fluctuations in tax evasion. Such fluctuations may, for instance, be completely prevented in the considered networks by setting the audit rate to sufficiently high but still realistic levels. Everybody then remains compliant for most of the time.

The remainder of our paper is organised as follows. In Section 2, we present our model, which is based on the standard two-dimensional Ising model on a square lattice. In Section 3, we describe the evolution of the aggregate tax evasion behaviour that our model generates under different enforcement regimes. In Section 4, we additionally embed our model into the Barabási–Albert network and the Voronoi–Delaunay random lattice and discuss the resulting tax evasion dynamics.

2. The model

We use the standard Glauber kinetics of the Ising model on a 20×20 square lattice. In every time period, each lattice site is occupied by an individual who can either be an honest tax payer ($S_i = +1$) or a tax evader ($S_i = -1$). The small number of agents may be imagined to represent the elite of a country, whose tax evasion/compliance behaviour may be interesting to look at. For our analysis we assume that everybody is honest initially. Each period individuals have the opportunity to become the opposite type of agent to what they were in the previous period. Each agent's social network, which is made up of four nearest neighbours, may either prefer tax evasion, reject it or be indifferent.

Tax evaders have the greatest influence to turn honest citizens into tax evaders if they constitute a majority in the given neighbourhood. If the majority evades, one is likely to also evade. On the other hand, if most people in the vicinity are honest, the respective individual is likely to become a decent citizen if she was a tax evader before. How strong the influence from the neighbourhood is can be controlled by adjusting the temperature, T. The total energy is given by the Hamiltonian $H = -\sum_{\langle i,j\rangle} J_{ij} S_i S_j - B \sum_i S_i$. We choose $J = 1$ and $B = 0$. For very low temperatures, the autonomous part of decision-making almost completely disappears.[2] Individuals then base their decisions solely on what most of their neighbours do. A rising temperature has the opposite effect. Individuals then decide more autonomously. It is well known that for $T > T_c$ ($\approx$2.269), half of the people are honest and the other half cheat, while for $T < T_c$ states coordinated on cheating or compliance prevail for most of the time. Because we set $T = 2.265$, the case where agents distribute in equal proportions onto the two alternatives is excluded.

As an enforcement measure, we introduce a probability of an efficient audit (p). If tax evasion is detected, the individual remains honest for a certain number of periods. We denote the period of time (in Monte Carlo steps per site) for which detected tax evaders are punished by the variable k. One time unit is one sweep through the entire lattice. Audits are stochastically independent from other agents and from the history any agent has.

3. Dynamics of the model

The top-left panel of Fig. 1 illustrates the baseline setting, i.e. no use of enforcement, for the square lattice. We depict the dynamics of tax evasion over 50,000 time steps. Although everybody is honest initially, it is not possible to predict which level of tax compliance will be reached at some time step in the future. Agents are usually either mostly compliant or mostly non-compliant, and the system typically remains in either state for a while. Switching from a mostly compliant to a mostly non-compliant society, or vice versa, is favoured by both the small number of agents and the temperature, which needs to be somewhere close to the critical level. If, by chance, more than 50% of agents start to prefer the opposite action of the currently dominating one, this strategy will then start to prevail for a while. As soon as there is a majority for the previously dominating strategy regarding tax evasion, aggregate behaviour is then likely to reverse again. If more agents or a temperature further below the critical level are picked, it would take longer for a switch in aggregate tax evasion behaviour to occur. Apparently, a suitable measure of control is needed to prevent agents from repeatedly falling into non-compliance.

Fig. 2 illustrates different simulation settings for the square lattice, where for each considered combination of degree of punishment ($k = 1$, 10 and 50) and audit rate ($p = 0.5\%$, 10% and 90%) the corresponding dynamics of tax evasion is depicted over 50,000 time steps. Surprisingly, even very small levels of enforcement (e.g. $p = 0.5\%$ and $k = 1$) suffice to almost completely prevent fluctuations in aggregate tax evasion behaviour and to establish mainly compliance. Only seldom does tax evasion then become the predominant aggregate choice of action. Both a rise in audit probability (greater p) and a higher penalty (greater k) work to flatten the time series of tax evasion and to shift the band of possible non-compliance

[2] The autonomous part of individual decision-making is responsible for the emergence of the tax evasion problem, because some initially honest tax payers decide to evade taxes and then exert influence on others to do so as well.