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An agent-based model of network effects on tax compliance and evasion

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ABSTRACT

Agent-based models are flexible analytical tools suitable for exploring and understanding complex systems such as tax compliance and evasion. The agent-based model created in this research builds upon two other agent-based models of tax evasion, the Korobow, Johnson, and Axtell (2007) and Hokamp and Pickhardt (2010) models. The model utilizes their rules for taxpayer behavior and apprehension of tax evaders in order to test the effects of network topologies in the propagation of evasive behavior. Findings include that network structures have a significant impact on the dynamics of tax compliance, demonstrating that taxpayers are more likely to declare all their income in networks with higher levels of centrality across the agents, especially when faced with large penalties proportional to their incomes. These results suggest that network structures should be chosen selectively when modeling tax compliance, as different topologies yield different results. Additionally, this research analyzed the special case of a power law distribution and found that targeting highly interconnected individuals resulted in a lower mean gross tax rate than targeting disconnected individuals, due to the penalties inflating the mean gross tax rate in the latter case.

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1. Introduction

Neoclassical mathematical models of tax behavior conclude that to maximize their incomes, taxpayers will avoid declaring their actual incomes (Allingham & Sandmo, 1972; Yitzhaki, 1974), a result that overpredicts what is observed in the real world. This is due to some of the underlying assumptions of the neoclassical models, such as perfectly rational actors and infinite computing capacity (Axtell, 2007; Kirman, 1992). As an alternative, agent-based models provide more flexibility for analyzing complex systems and collective behavior arising from individual interactions. This research focuses on building an agent-based model in order to examine the impact of social network structures on aggregate tax compliance so that future models may incorporate appropriate networks, thereby resulting in more accurate estimates of individual and collective taxpaying behavior (Albin & Foley, 1992; Epstein, 2006; Axtell, 2000).

Section 2 provides a background on the problem of tax evasion, complexity theory, agent-based models of tax evasion, and social networks. The next section describes the environmental features, agent characteristics, and rules of the model. Within the results section, the dynamics between different networks are discussed, as well as a special “Big Fish” case, which

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focuses on the impact of power law networks on taxpayers' compliance. The discussion section includes commentary on findings, broader implications, and potential work for the future.

It should be noted that the authors are not presenting a realistic taxing regime that is then evaluated, as such "actual" rates of tax evasion are not provided for comparison. The authors do note, however, that the results of the model are plausible given a 2008 United States Internal Revenue Service estimate of an 84 percent voluntary tax compliance (US Department of the Treasury, 2009). Rather, the authors present a highly stylized taxing regime in order to highlight one main feature: the effect of changing the information flow among taxpaying entities. This being the case, readers should bear in mind several particularly strong assumptions contained in the model, namely, (1) a perfectly flat tax rate and (2) a penalty function used when taxpayers are caught not paying taxes, which can grow without bounds as a taxpayer's income increases.

2. Background

2.1. The problem of tax evasion

Andreoni, Erard, and Feinstein (1998) provide a comprehensive review of literature on tax compliance, most of which focuses on a taxpayer who chooses to declare income, and the reactions of tax authorities and law enforcement to the taxpayers' reports. There also exists research on non-filers, such as the finding of Erard and Ho (2001) that non-filers often hold occupations which make income that is less visible to tax agencies.

Psychological factors such as notions of guilt and shame (Erard & Feinstein, 1994), tax morale (Frey & Torgler, 2007; Alm & Torgler, 2006), social factors such as knowledge of successful evasion (Vogel, 1974), social norms (Alm, Sanchez, & de Juan, 1995), and business ethics (Molero & Pujol, 2012) may also influence taxpayer decisions to comply with tax laws. Additional information on the economic psychology aspects of tax behavior is compiled by Kirchler (2007). This work suggests that the movement of information among a set of social agents is critically important to tax compliance, as well as economic decisions in general (see generally: Easley & Kleinberg, 2010; Jackson, 2008). The underlying network, or how the social agents are connected, therefore is important as it has an impact on the way information can propagate (Dodds & Watts, 2004; Centola, 2010).

2.2. Complexity theory and agent-based models

For the purposes of this research the system of taxpaying behavior is treated as a complex adaptive system, a perspective selected for the following reasons. First, the taxpaying system is comprised of heterogeneous actors such as taxpayers, tax preparers, and tax enforcers. Moreover, each individual within these broad categories is unique, maintaining different values for income, tax rates, risk aversion, etc. The idea of a representative agent in this context is not meaningful (Epstein, 2006). Second, the actors change their behaviors over time. The actors are boundedly rational (Simon, 1991), leading agents to act rationally on the basis of their perception of their environment, rather than according to the objectively best response. Third, the system displays near-decomposability, meaning that although the system is made up of subcomponents, their individual behavior in isolation does not represent the behavior of the overall system when fully interconnected. Finally, as a consequence of the aforementioned characteristics, the system displays emergence ((Crutchfield, 1994)). Although many definitions of emergence exist, for the purposes of this work a definition consistent with Holland (1995) is used: emergence is taken to mean that the behavior of the system is difficult to infer from the behavior of individual components in isolation.

The above characteristics make closed form analysis difficult; therefore, simulation was chosen as an approach to reach a quantitative understanding of this phenomenon. Specifically, the analytic technique of agent-based modeling was chosen (Epstein & Axtell, 1996; Axtell, 2000; Epstein, 2006). Agent-based models are typically made up of three basic components: agents, interaction rules, and space (this could be geo-space or some other abstract space) (Cioffi-Revilla, 2010; Epstein, 2006). As the simulation progresses, agents interact with each other, update their internal states, and may interact with their environment. This creates a coupling among the agents that produces an aggregated dynamic from the micro-level interactions (Axtell, 2005). Given the heterogeneity of the system, adaptation of the agents, agents that would commonly be classified as outliers and excluded from analysis may actually drive the system to particular states otherwise not realized, which may be highly important from a policy standpoint (Schelling, 1978). Within this framework, modelers have interpreted tax compliance factors into a variety of agent characteristics and behaviors, functions and heuristics, and virtual landscapes and networks (see *infra*).

2.3. Agent-based models of tax evasion

Several key models paved the way for computational social scientists and researchers to study tax compliance. The model of Mittone and Patelli (2000) examines how different initial instantiations of heterogeneous types of agents cause variation on collective tax evasion. The model defines three types of agents, each with a unique utility function which defines them as honest, imitative, or free riding. The authors find that the absence of audits causes aggregate non-compliance even among initially honest taxpayers, as public goods begin to diminish and taxpayers withdraw their support for those resources.

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