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Learning in experiments: Dynamic interaction of policy variables designed to deter tax evasion

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ABSTRACT

While neoclassical economic theory sheds insight into the way that audit rates and penalty rates interact when individuals decide to declare income for taxation, it predicts far lower levels of compliance than observed levels of compliance. This paper analyses experimental responses to explore a dynamic interaction between audit and penalty rates as individuals learn how to comply with taxation. It compares the responses of subjects in experiments with responses that are predicted when individuals rely on an adaptive learning process (that offers information feedback about decision payoffs). This comparison suggests that learning is an important consideration when explaining differences between predicted and observed levels of tax compliance.

1. Introduction

Neoclassical theory predicts that there is an interaction between audit and penalty rates when individuals decide how much income to declare for tax. When the audit rate increases, the increase in income declaration depends on the penalty. When the penalty increases, the increase in income declaration depends on the audit rate (Allingham & Sandmo, 1972; Myles, 1995). The influence of interaction between audit and penalty rates (e.g. as noted in Kirchler's 2010 literature survey) might be deduced from results presented in Alm, Sanchez, and DeJuan (1995). But how important are these interaction effects when individuals decide how much income to declare for taxation?

While neoclassical theory assumes that individuals behave *as if* they have solved an expected utility maximisation problem, in practice individuals, with limited cognitive ability, are more likely to acquire expertise in a repeated decision-making process. Learning is likely to be very important when analysing taxpayers' response to different audit and penalty rates, and when predicting levels of tax compliance. In this paper the objective is to assess the importance of learning and the importance of a dynamic interaction between audit and penalty rates in a learning process. If learning how to comply with taxation

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is acquired in a repeated decision-making process, will 'learning' be relevant when explaining differences between predicted and observed levels of compliance?

This paper begins by focusing on subjects' responses in two experiments. These experiments are designed to shed insight into the pattern of interaction between audit and penalty rates. A partial factorial design is used in these experiments. The impact of increased audit rates on declared income is assessed when the penalty is fixed. The impact of increased penalty rates on declared income is also assessed when the audit rate is fixed.

Later in the paper the focus is on the impact of an adaptive learning model (premised on a selection mechanism and based on optimisation principles). The questions are (i) whether the pattern of tax compliance depends on interaction between audit and penalty rates, and (ii) whether the tax compliance observed in experiments is consistent with the pattern of tax compliance predicted when taxpayers employ an adaptive learning process.

This methodology has been employed in other studies. Axelrod (1980), Axelrod (1990) employs this approach to examine effective strategies in the prisoner's dilemma game. Simulation results confirmed the robustness of the strategy (tit-for-tat) that proved so successful in computer tournaments. Andreoni and Miller (1991) employed this approach to explain observed patterns of response in the 'public goods' game. In the 'public goods' game, theoretical results and simulations based on the learning process are generally in agreement (although free riding often proves to be lower than anticipated in experiments). Gale, Binmore, and Samuelson (1995) employ this approach to analyse the ultimatum game. In the case of the ultimatum game, the learning process results in an outcome that exceeds theoretical predictions, but an outcome that is consistent with observations in experiments.[1] This paper sets out to apply the same methodology to analyse tax compliance. Can observations reported in individual decision-making experiments be explained with reference to simulations generated when there is an adaptive learning process? Will the pattern of tax compliance predicted by an adaptive learning process converge to the level of tax compliance that is predicted by neoclassical theory?

While a variety of dynamic simulation models have been adopted to examine different aspects of tax compliance (e.g. Bloomquist, 2006; Mittone & Patelli, 2000; Pommerehne, Hart, & Frey, 1994), this paper sets out to focus on 'learning'. The impact of 'learning' has yet to be examined *explicitly* in the tax compliance literature.

The adaptive learning model used in this study is based on optimisation principles; there is a greater likelihood of adoption of the most successful decisions. Will an adaptive learning process (that guides individuals towards decisions with the highest utility) lead individuals to fully rational decisions? Is learning relevant when explaining differences between levels of compliance predicted by the Allingham and Sandmo (1972) model and levels of compliance that are observed? To date, the literature has attempted to explain these differences by challenging the assumptions of the Allingham–Sandmo model, e.g. that taxpayers have full knowledge of audit rates and penalty rates; that taxpayers are as self-interested as *homo economicus*; that taxpayers ignore social norms (e.g. Alm, McClelland, & Schulze, 1992; Cullis & Jones, 2009; Torgler, 2002). In this paper, there is another, perhaps more natural, explanation. The difference between predicted and reported levels of compliance might also depend on the process by which individuals learn to comply. Differences between predicted and reported levels are likely to depend (in part) on the observation that individuals are continually engaged in a process of learning how to comply.

The next section of the paper describes the experiments designed to question the relevance of the interaction between audit and penalty rates. Section three presents a description of the adaptive learning algorithm and the simulation results that are used to predict behaviour. When focussing on the learning process, the intention is to rely on plausible utility functions. Later in the paper experimental results are compared with simulations drawn from an adaptive learning process. Are the experimental responses consistent with the proposition that citizens are learning how to comply with taxation? The final section of the paper considers the policy implications.

2. The experimental study

2.1. Theoretical background

To begin, consider the predictions of neoclassical theory. An individual with income, I, is asked to declare income, X, to be taxed at the marginal rate of tax τ. The individual may declare any amount between zero and actual income, I, with knowledge that there is a probability of audit by tax authorities, p, and a penalty (as a multiple of the unpaid taxes) that must be paid if there is evasion $\alpha\tau(I - Z)$, with $\alpha > 1$. Neoclassical theory predicts that individuals will evade tax if $p\alpha < 1$. The decision facing the individual is to determine the optimal level of income to declare, X^*. This condition is realized by maximising expected utility $E[U(X)]$:

$$E[U(X)] = (1 - p)U(I - \tau X) + pU(I - \tau X - \alpha\tau(I - X)) \quad (1)$$

For risk-averse individuals, increasing the audit rate or the penalty rate leads to higher compliance (see for example Cullis & Jones, 2009). While a change in optimal declared income is positively related to increases in the audit rate or penalty rate,

[1] Other adaptive learning models have also been used for comparison with, and interpretation of, experimental data. These include the use of a genetic algorithm to determine optimal output in a cobweb model (Afrovic, 1994) and comparison of reinforcement learning models to data sets associated with different experimental games (Roth & Erev, 1995).

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