Tax Compliance Behaviours- Agent Based Approach

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1 ABSTRACT

Tax compliance rates by small business owners is modeled in an agent-based framework. It is modeled as a repeated game between government who operates through tax collectors and tax payers. The taxpayers (business owners) display 3 major types of behaviours Honest, Strategic, Defiant; defined by the amount of income they reveal. The model is used to simulate changes in a static population of 10,000 taxpayers. A simulation using realistic parameters for the probability of audit and penalty rate finds that after seventy five time periods, the initial number of Honest business owners declines and the number of Defiant business owners emerges as a majority.

2 INTRODUCTION

For over decades Tax Evasion has been a great liability on the country's economy. It disturbs all the Revenue collection targets of the government and affects budget allocation Governments have tried repeatedly(without success) to hinder Tax Evasion or at least determine correct revenue generation taking in account such behaviour from a part of total population. Through this paper, we try to address both the issues using an agent based model of the situation.

In this project we aim to build an agent based model to predict and analyse the the tax compliance rate in a population comprising of different classes of taxpayers. It will be modeled

as repeated game between taxpayers and tax collectors where both try to maximise their payoffs. The results will give an insight as to how we can improve tax collection and compliance in tax behaviours.It will also help to determine better predictions for tax revenue generation in future.

3 MODEL

Taxpayers are modeled as agents who display 3 main behaviours -

- Compliant - Taxpayers which report 90-100% of their income.
- Defiant - Taxpayers which report 0-10% of their income.
- Strategic - The class of remaining taxpayers.

Furthermore taxpayers are divided into 3 income categories. Based on these income classes the taxpayers are placed in groups. Groups are essential for factoring in the 'neighbourhood effect'.

NEIGHBOURHOOD EFFECT In real life scenarios, when people hear of a person getting caught in an audit, it affects their level compliance. Hence we factor this effect in by creating groups of five members. The groups are formed of taxpayers of the same income level. If any person of the group is caught in an audit, all the members of the group increase their compliance ,i.e. increase the portion of income reported and their perceived tax rates also goes up. If neighbourhood effects are turned off, each taxpayers level of compliance is independent of others. It only increases if the individual himself is caught.

The net income of each taxpayer is

- When the tax collector is honest

$$\text{netI} = (1 - p_i a_j)(1 - r s_i) I_i + p_i a_j (1 - r(1 + f(1 - s_i)) I_i$$

- When the tax colector is corrupt

$$\text{netI} = (1 - p_i a_j)(1 - r s_i) I_i + p_i a_j (1 - r(s_i + b(1 - s_i)) I_i$$

Here a_j is the audit rate of j'th tax collector, p_i is the factor to incorporate perceived audit rate by the individual. s_i is the fraction of income revealed by tax payer i, r is the tax rate(.3 for simulation), I is the Income, f(=2) is the fine in case a person gets caught, b(=.8) is the fraction of tax saved taken as bribe by tax collector.

The payoff is calculated relative to a taxpayer who reveals his full income.

$$\pi_i = \text{netI} - (1 - r) I_i$$

Tax collectors are modeled as agents for check for fraudulent taxpayers and conduct audits to catch them. They display 2 types of behaviours -

- Honest - These tax collectors collect the fine as set by the government laws. 20% of this is given as reward to the tax collectors for their work.
- Corrupt - These tax collectors collect a bribe from the taxpayers which is 0.8 times the unreported amount. This is smaller that the fine set by the government which is 2 times the unreported amount. All of this bribe goes to tax collector.

Payoff of tax collectors(Their income is not included in payoff calculations)

- When the tax collector is honest

$$\pi_j = \sum_i^n a_j mr((1-s_i)I_i - c)$$

- When the tax collector is corrupt

$$\pi_j = \sum_i^n a_j br((1-s_i)I_i - c_2)$$

  Here m(=.2) is the margin of tax collector in a successful raid and b(=.8) is the fraction of tax taken as bribe. They payoff of the tax collectors decides whether their audit rate increases or decreases in the next round. Therefore under similar conditions payoff for corrupt tax collector would be more if the audit is successful.

Payoff for government will be the total tax revenue generated, after deducting the cost of revenue collection.

After each round of tax collection the constant parameters in the payoff functions are updated, and this change of parameters is observed over a number of iterations to judge the behaviour of players and to see whether the values(changes in values of s_i) converge or not.

4 Simulation

Code for simulation: `https://github.com/ArpitJain20/Tax-Evasion-Behaviour`

Independent parameters for simulation-

- Simulation is performed with a tax rate(r) of 0.3.
- We assumed total 10,000 tax payers of which around 2000 are complaint, 1700 are defiant and rest are strategic. Income of each taxpayer in each category is a random number from a normal distribution with some fixed mean and standard deviation. The mean is 700000, 3000000, 10000000 for complaint, defiant and strategic respectively. Similarly the variance is 200000, 500000, 3000000 for compliant, defiant and strategic respectively.

- For the realistic case,audit rate for the tax collectors is assumed to be in the range 0.05 to 0.15 which is uniformly distributed. To get to the point where complaints become more than defiant, simulation has been done for audit rates up to .6. On the other hand the perceived audit rate factor for the tax payer is assumed between 0.5 to 1.5. The net audit rate for a particular combination of a tax collector and a tax payer is product of the two.
- The number of tax collectors is 50 of which around 70% are honest and 30% are corrupt. Simulation was run for 75 iterations.
- For Neighbourhood effect we divided tax payers in equal sized groups based on their income with 5 people in each group.

5 Results

We know from the actual data that only around 1 percent of total population, pays taxes. But due to the income categories and class of taxpayers selected for our model, it becomes a subset of total population who are eligible to pay taxes, whereas if you see the whole population, a majority of it is not even eligible to pay taxes due to very low income levels. For the subset we took, it has been observed that around 20-25 percent of them pay their taxes. our results from the simulation closely match this number when audit rates are kept realistic i.e. around .1. Figure - 5.1 shows the initial and final distribution of population where x axis is the fraction of income revealed in the intervals of .1. If the range is 0 to .1 then it means defiant behaviour, when it is .9 to 1, it is compliant behaviour and in between is strategic behaviour.

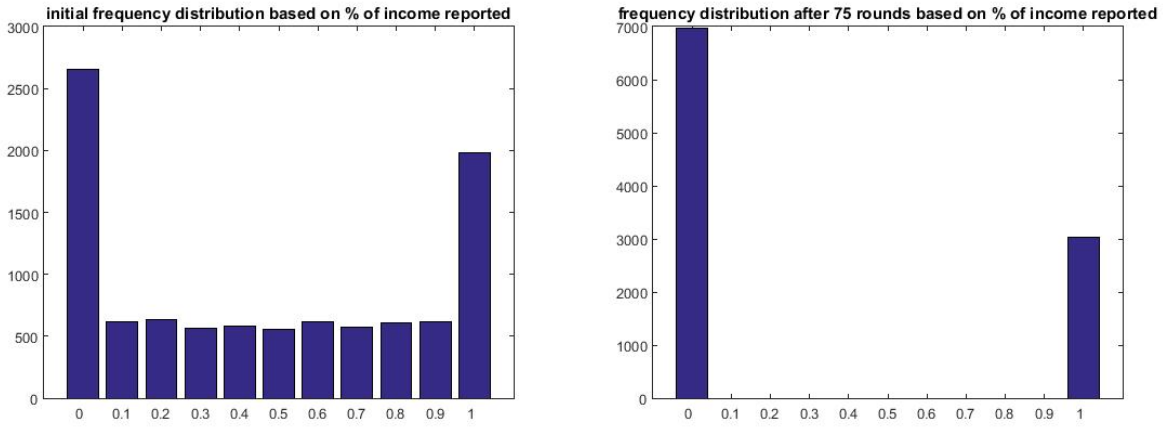

Figure 5.1: Results for before and after 75 iteration, when avg. audit rate is .1

In final results the number of strategic players becomes zero, this is because our payoff function is linear with respect to fraction of income, revealed. So their is no point of extrema in between, hence the nature drifts to either defiant or compliant to maximise payoff.

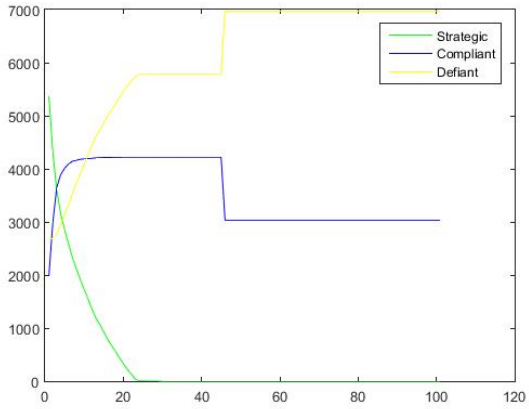

Figure 5.2: Plot showing the nature of taxpayers against the number of times the game is played.

From Figure 5.2 we can see that the number of strategic players becomes 0 after around 25 iterations. We can see that around 15 iterations, the number of compliant and defiant taxpayers become constant, but at around 50 iterations their is an abrupt change in their numbers which afterwards remains constant, irrespective of the number of iterations. This type of curve nature is consistent with many of the 2 player repeated games observed in theory.

Although the above simulation was for realistic audit rates, we wanted to find out the audit rate at which the number of compliant taxpayers exceed the number of defiant taxpayers. Because in future due to digitization and more transparency in transactions, the audit costs may significantly drop down. Hence it would be possible to increase audit rates to a much higher level.

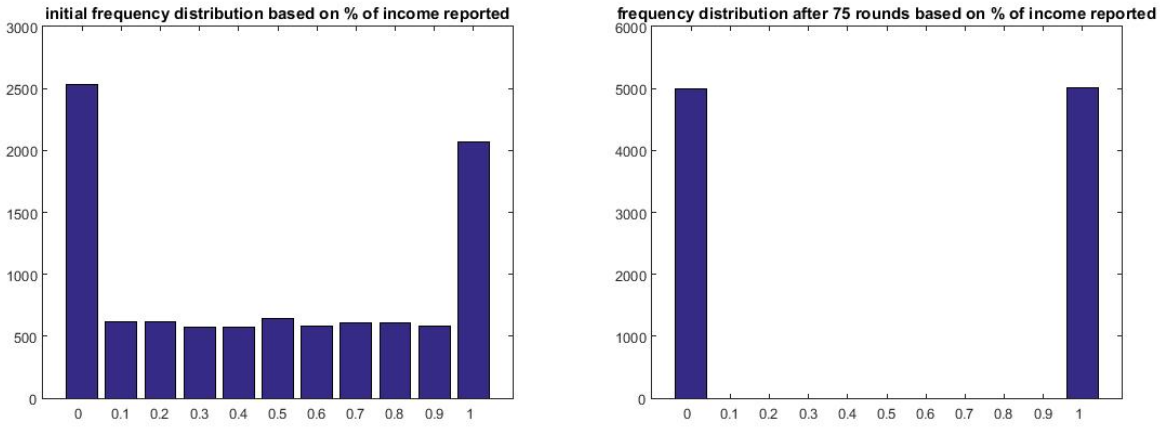

Figure 5.3: Results for before and after 75 iteration, when avg. audit rate is .55

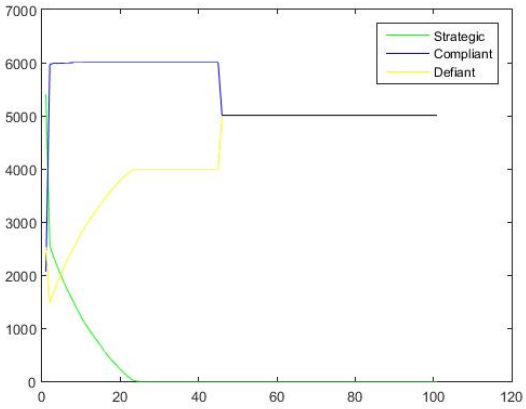

Figure 5.4: Plot showing the nature of taxpayers against the number of times the game is played. Audit rate = .55

At audit rate =.55 the number of defiant and compliant tax payers becomes almost equal, and below this audit rate number of defiant tax payers is always more. Although theoretically we get audit rate =.33 at which compliant behaviour becomes dominant but due to the factor of perceived audit rates the actual rate becomes much more.

6 Discussion

The results closely depict the actual scenario i.e. the increase in defiance in the population at lower audit rates. This is especially true for the case when neighbourhood effects are turned off which results in around 90% of all taxpayers to turn defiant.

The model can be further expanded to a three player game such that the players are the government, the tax collectors and the tax payers. The government would control factors like the audit rate, the tax rate, salary of tax collectors etc.

An important factor to include would be the cost the audits to the government. The cost of audits is different for different scenarios and also depends upon the taxpayer whose is being audited. It could also be that high earning taxpayers challenge the audits imposed on them in a court of law. This further increases the cost for the government.

If the cost of audits becomes drastically high for any given year, the government may take certain measures next time to overcome the losses. This may include decreasing salary for tax collectors or reducing the number of tax collectors. This step would largely change the dynamics between tax payer - tax collector interactions. A likely scenario to emerge would be decline in the audit rates. Hence this would further decrease the compliance rates which can be seen from the model.

The government can also change the tax rates according to the income levels of the tax payers. A low tax rate would naturally increase compliance for risk averse agents.

We see today the shift towards cashless economy. This policy would lead to paper trails for all the sources of income for an individual. This would largely bring down the cost of audits incurred and make it easier for the tax collectors to detect defiant tax payers. Hence the audit rates would rise. It can be shown by the model that this would increase compliance by a large amount.

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