Modelling of Wealth Distribution using *Agent Based Modelling*

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Abstract—Wealth distribution is an active topic that still discussed until today [2-5]. The simulations done in this paper are based on ideal-gas in a closed system. In this paper, we add another factor to select a pair of agents that will transact their wealth using probability based on their current wealth. We also study the effect of taxes payment to the system. From the simulation we got that the distribution of wealth will be more distributed evenly if every agent has higher saving propensity factor. We also found that taxes payment can only make the distribution better on a short period of time.

Index Terms—*Wealth Distribution, Agent Based Modelling*

1 INTRODUCTION

WEALTH distribution can be modelled in some ways. One of them is using Agent Based Modelling (ABM) based on ideal-gas in closed system [1]. In this model, money M represents Kinetic Energy stored on a particle and collision between particle represent transaction between two person exchanging some amount of money.

In this paper, we will evaluate some factors to be implemented to the model. Those factors are using probability to select agents who will transact each others based on their wealth and evaluate the factor of tax. transaksi antara individu.

After the model run for some period of time, the gini index of the populations will be evaluated as a parameter to indicates the wealth distribution.

This paper organized as follows. In section 2 we introduce model used here. In section 3 we evaluate the simulation result. In section 4 we give the conclusion.

2 MODEL DESCRIPTION

2.1 Agent's Attributes

Every agent will have 2 attributes, wealth (w) and saving propensity factor (λ). Initially, wealth for every agents will be randomized between [0 - 100]. Saving propensity factor is a factor that determine the tendency of every agent to spend money on a transaction. Saving propensity factor varies between 0.1 to 0.9. The bigger the saving propensity factor, the less that agent will spend money on the transaction.

In this paper, we will try both the simulation with equal and the simulation with various saving propensity factor.

2.2 Transaction

In every transaction, the simulation will select two agents to do transaction. The selection is based on their current wealth. The higher an agent's wealth, more often this agent to be selected. This action done to simulate that rich people can do more transaction than poor people.

The selected agents, agent A and agent B will spend some money of their wealth to be transacted (Eq. 1 and Eq. 2).

$$W_A = (1 - \lambda_A) \cdot w_A \quad \textbf{(1)}$$

$$W_B = (1 - \lambda_B) \cdot w_B \quad \textbf{(2)}$$

Value λ_A and λ_B are the saving factor of agent A and agent B respectively. While W_A and W_B are the amount of money taken from them. So, the total amount is formulated in Eq. 3.

$$W_{tr} = W_A + W_B \quad \textbf{(3)}$$

After the transaction, wealth value of agent A and agent B will be updated based on Eq. 4 and Eq. 5.

$$w'_A = w_A - W_A + \mu W_{tr} \quad \textbf{(4)}$$

$$w'_B = w_B - W_B + (1 - \mu) \cdot W_{tr} \quad \textbf{(5)}$$

Value μ is a random value between [0.1 - 0.9].

This transaction can simulate any kind of selling and buying activity, such as paying school, buying food, or investment.

2.3 Payment of Taxes

Payment of taxes is an action of paying some percent of wealth to be distributed evenly to other agents periodically. Total tax paid by all agents formulated in Eq. 6.

$$T_{sum} = \sum_{i=1}^{N} \alpha \cdot w_i \quad \textbf{(6)}$$

Then, wealth of every agents will be updated based on Eq. 7.

$$w_i = w_i - \alpha \cdot w_i + \frac{T_{sum}}{N} \quad \textbf{(7)}$$

Coefficient α is the tax factor, a percentage to determine how much money to be paid by agent in every period of time. Value N is number of agent in that simulation.

2.4 Wealth Classes

Every agent will be divided into three class, High Class, Middle Class, and Low Class. This classification done based on their current wealth. If w_{max} is the wealth of the richest agent, then Eq. 8 show the rule for the classification.

$$class_i = \begin{cases} high, if\ w_i > \frac{2}{3} \cdot w_{max} \\ mid, if\ w_i > \frac{1}{3} \cdot w_{max}\ and\ w_i \le \frac{2}{3} \cdot w_{max} \\ low, if\ w_i \le \frac{1}{3} \cdot w_{max} \end{cases} \quad \textbf{(8)}$$

3 SIMULATION RESULT

2.1 Simulation of Random Saving Propensity Factor (λ)

The first simulation is the simulation using random saving propensity factor (λ). In this simulation, every agent has a random value between [0.1-0.9]. This value assumes that at least every agent has 10% wealth that resides in his pocket. And also, at maximum, he can only save money up to 90%, because in the real world, he have to spend some money to stay alive.

The simulation run for 1000 cycles. In every cycle, there will be N/2 transactions done. N is the number of agents in the simulation.

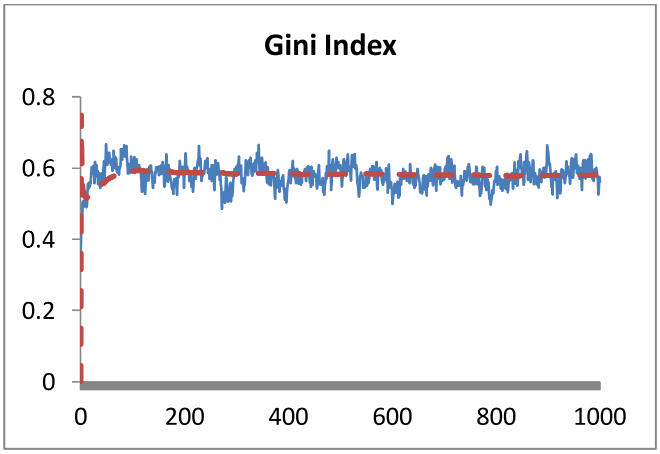

Figure 1. Gini Index of random saving propensity factor simulation

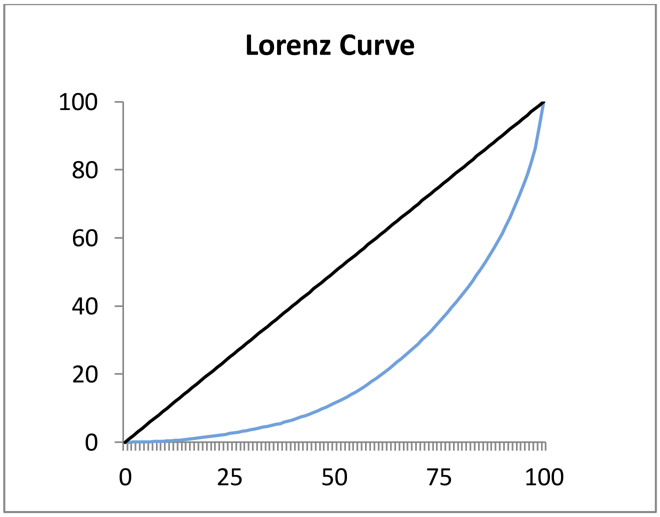

Figure 2. Lorenz curve of random saving propensity factor simulation

Figure 1 show the gini index in the simulation. Average gini index value is 0.58. And the lorenz curve shown in Figure 2.

Figure 3 show the class distribution of every agents. On the final result, 88% agents are on the Low Class, 9 % are on the Middle Class, and 3% are on the High Class.

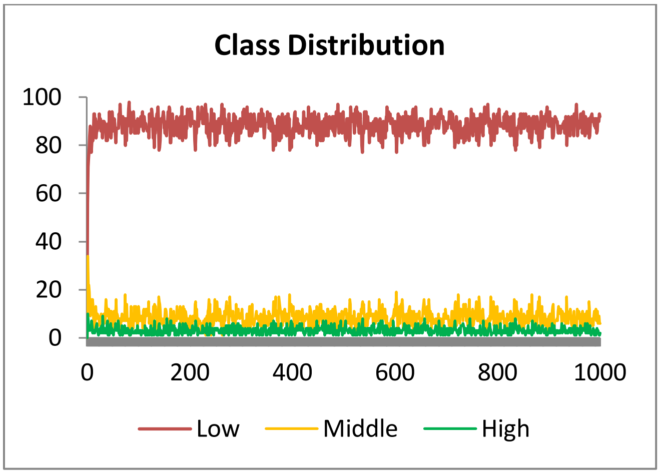

Figure 3. Class distribution of random saving propensity factor simulation

This simulation is represent the condition of the real world where all individu has various tendetion to saving money. Some of them are very strict when spending money, while the others are extravagant. The lorenz curve also show the power tail curve which shows that most wealth are controlled by rich people.

2.2 Simulation of Equal Saving Propensity Factor (λ)

In this simulation, every agent has the same saving propensity factor. The relation between saving propensity factor and final gini index value shown in Figure 4.

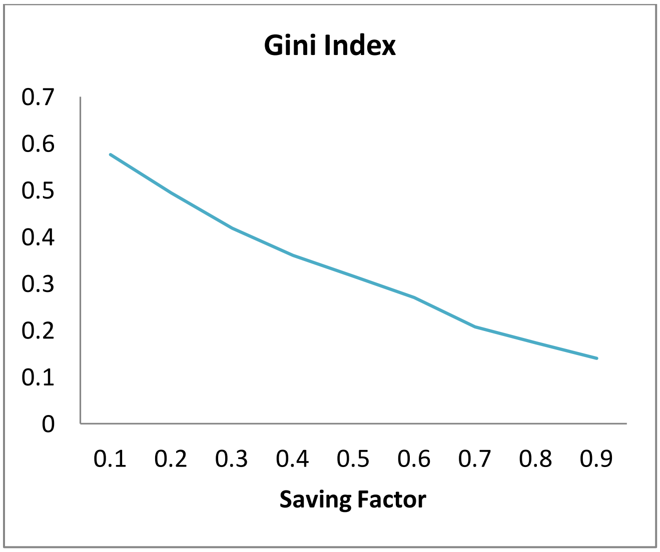

Figure 4. Relation between global saving propensity factor and final gini index

Diagram in Figure 4 shown that the higher the saving propensity value, wealth is more distributed between agents indicated by the lower gini index value.

We limit the maximum saving propensity factor value in 0.9 because in the real world, people have to spend money to survive, at least to buy some food.

2.3 Simulation and Effect of Taxes Payment

Tax is some amount of money paid by every agent which then distributed evenly to all agents. The effect of tax to gini index shown in Figure 5.

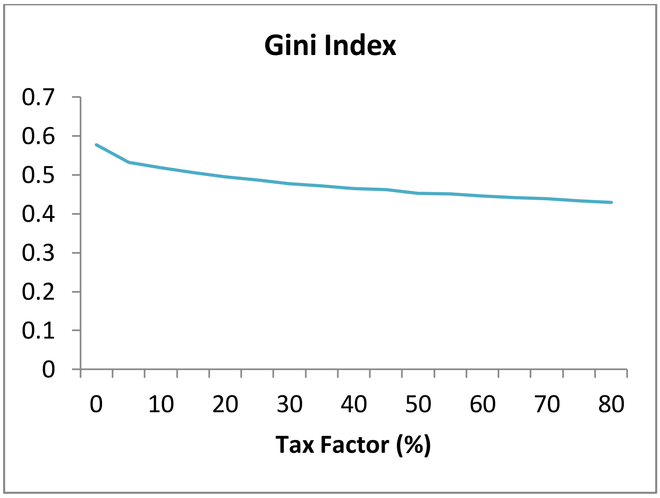

Figure 5. Effect of taxes payment to gini index

Simulation in Figure 5 was done with random saving propensity for each agent. Figure 6 shows the change of gini index when tax factor is 50%. Figure 7 shows zoomed in version of Figure 6 in ticks 500 - 550.

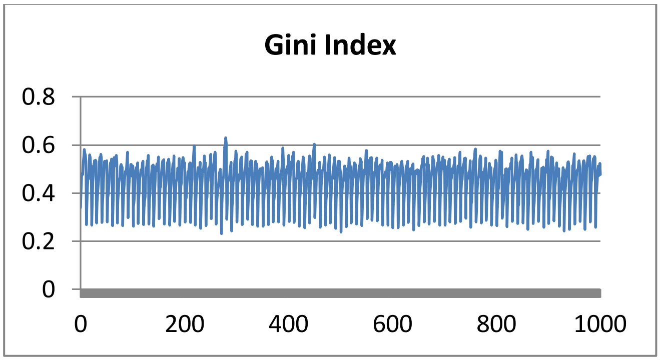

Figure 6. Gini index in taxes payment simulation

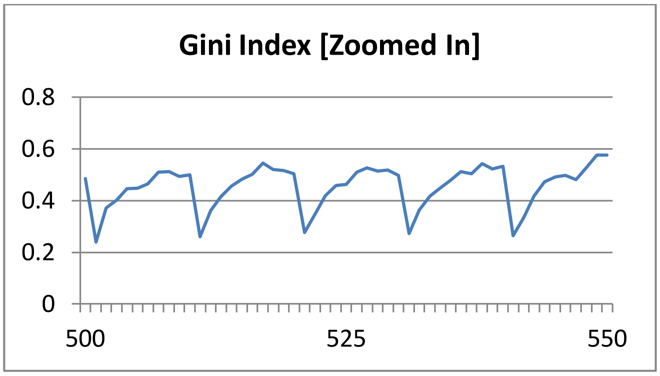

Figure 7. Gini index in taxes payment simulation

The diagram in Figure 5 shows that the increasing percentage of tax doesnt really affect gini index compared to variation of saving propensity factor shown in Figure 4. This phenomenon can be explained if we see the zoomed in version of gini index change during simulation in Figure 7. Diagram in Figure 7 shows that gini index value will decrease instantaneously when the taxes distributed to every agents. But after some period of time, gini index value will rise again to a fixed position untill next period of taxes.'

This simulation shows that distribution of taxes to individuals can only make the wealth distributed more evenly on a short period of time.

4 Conclusion

In this paper, we show that modelling wealth distribution based on ideal-gas in a closed system can be extended with the agent selection using probability based on their current wealth.

We also show that wealth distribution is better when every agent has higher saving propensity factor value, indicated by lower gini index value.

In the last simulation, we show that taxes payment doesnt really make wealth distributed more evenly along with the increasing of taxes factor. Distribution of taxes only make the distribution of wealth more evenly on a short period of times.

Acknowledgment

We wish to thank the lecturer of Model and Simulation Subject, Nugraha P. Utama and colleagues of this class. This paper is a project under that subject on 2nd Semester in 2019

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