Question 1

a. In the experiments below, the minimum and maximum sugar endowment are set to be 0 and 100 respectively. No matter what the initial population are, the final wealth distribution reflects the fact that only a minority of the population have above average wealth, while most agents have wealth near the same level as the initial endowment. When the initial population is increasing, it takes fewer ticks for the skewed distribution to emerge.

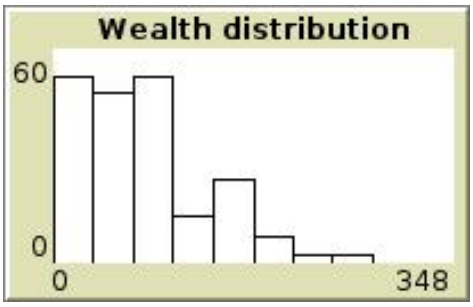

Figure 1: Initial population = 200

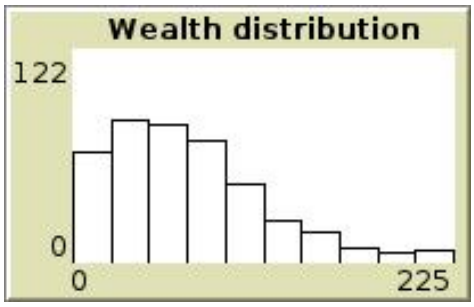

Figure 2: Initial population = 400

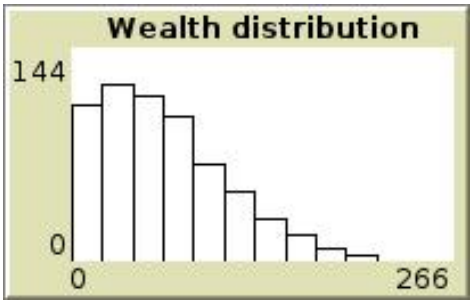

Figure 3: Initial population = 600

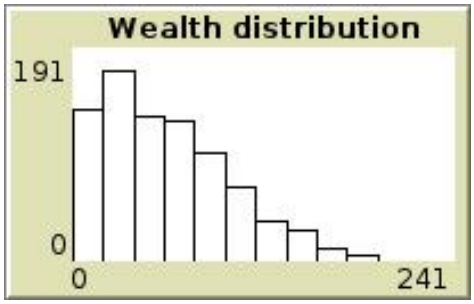

Figure 4: Initial population = 800

b. Increasing minimum sugar endowment has no effect on the vision of agents. The vision of agents is a random number in the range of 1 to 6 and turtles can look horizontally and vertically up to vision patches but cannot look diagonally at all.

c. In the experiments below, the maximum sugar endowment is fixed at

100 and the minimum sugar endowment is adjusted from 0 to 90 in steps of 30. As the minimum sugar endowment increases, the median of the skewed wealth distribution also increases because most of the agents have wealth near the same level as their initial endowment, which is a random number between minimum-sugar-endowment and maximum-sugar-endowment. Also, the Gini index of the population decreases as the minimum sugar endowment is increased, meaning that the wealth are more equally distributed.

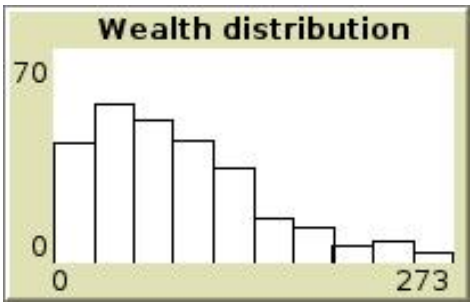

Figure 5: minimum sugar endowment = 0

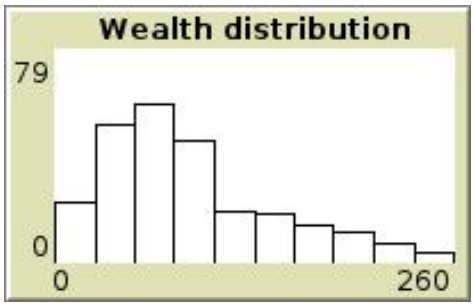

Figure 6: minimum sugar endowment = 30

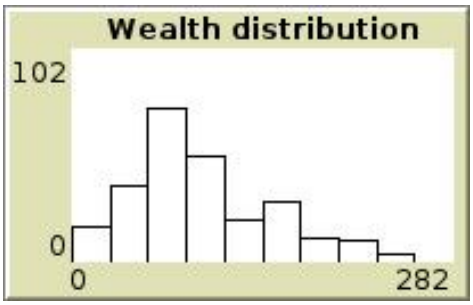

Figure 7: minimum sugar endowment = 60

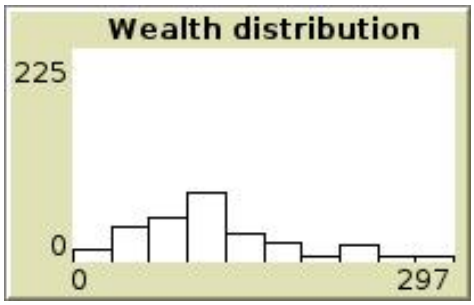

Figure 8: minimum sugar endowment = 90

d. The minimum sugar endowment is fixed at 20 and the maximum sugar endowment is adjusted from 40 to 160 in steps of 40. As the maximum sugar endowment increases, the median of the skewed wealth distribution also increases. Also, the Gini index of the population decreases as the maximum sugar endowment is increased, meaning that the wealth are more equally distributed.

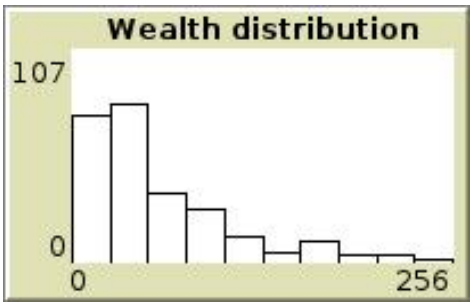

Figure 9: maximum sugar endowment = 40

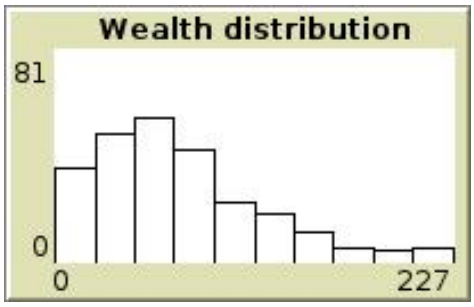

Figure 10: maximum sugar endowment = 80

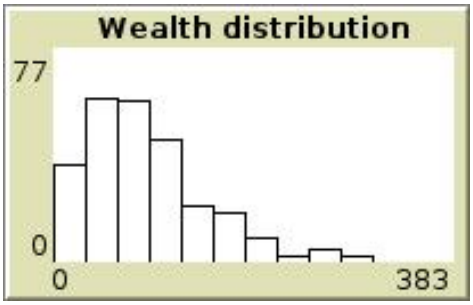

Figure 11: maximum sugar endowment = 120

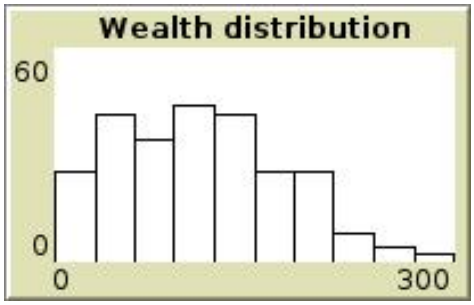

Figure 12: maximum sugar endowment = 160

Question 2

a. In the model, there are initially 250 agents with minimum-sugar-endowment 50 and maximum-sugar-endowment 100. After the modification, only the agents dying from old age will be able to reproduce. The wealth distribution still exhibits a screwed shape as the original model. However, the number of agents in the system decreases dramatically as time goes on. Also there is not too much change in the Gini index.

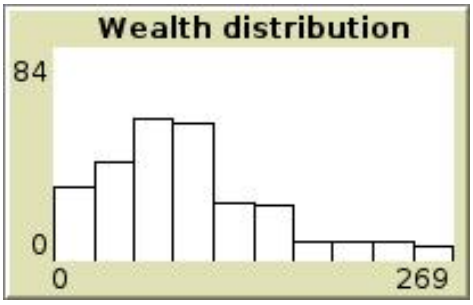

Figure 13: Original model

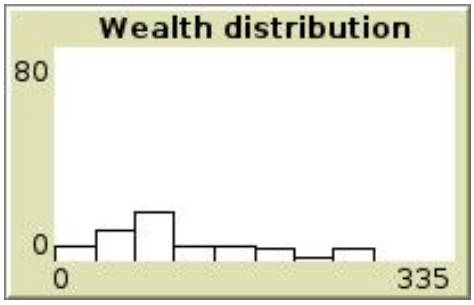

Figure 14: Modified model

b. We calculated the average visions and the standard deviation of visions of all the agents in the system after 500 ticks for both the original model and the modified model. After 10 runs of the experiments, the average and standard deviation of the original model are not significantly different from those of the modified model (although the average vision in the original model is higher most of the time). Therefore, there is no clear impact on the vision of agents in the system.

c. Similarly, we calculated the average metabolism and the standard deviation of metabolism of all the agents in the system after 500 ticks for both the original model and the modified model. After 10 runs of the experiments, the average and standard deviation of the original model are not significantly different from those of the modified model. Therefore, there is no clear impact on the metabolism of agents in the system.

Question 3

a. We implemented the tax-collection and tax-distribution process in the code (see attachment). In the experiment, we set the flat tax rate to be 40% and the total tax will be distributed among the poorest 50% agents. The other parameters are kept the same as previous experiments (initial population = 250, minimum-sugar-endowment = 50, maximum-sugar-endowment = 100). The wealth distribution, Lorentz curve and Gini index are shown below. After implementing the tax, the wealth distribution becomes a lot more equal and the Gini index is stabilized around the value 0.13.

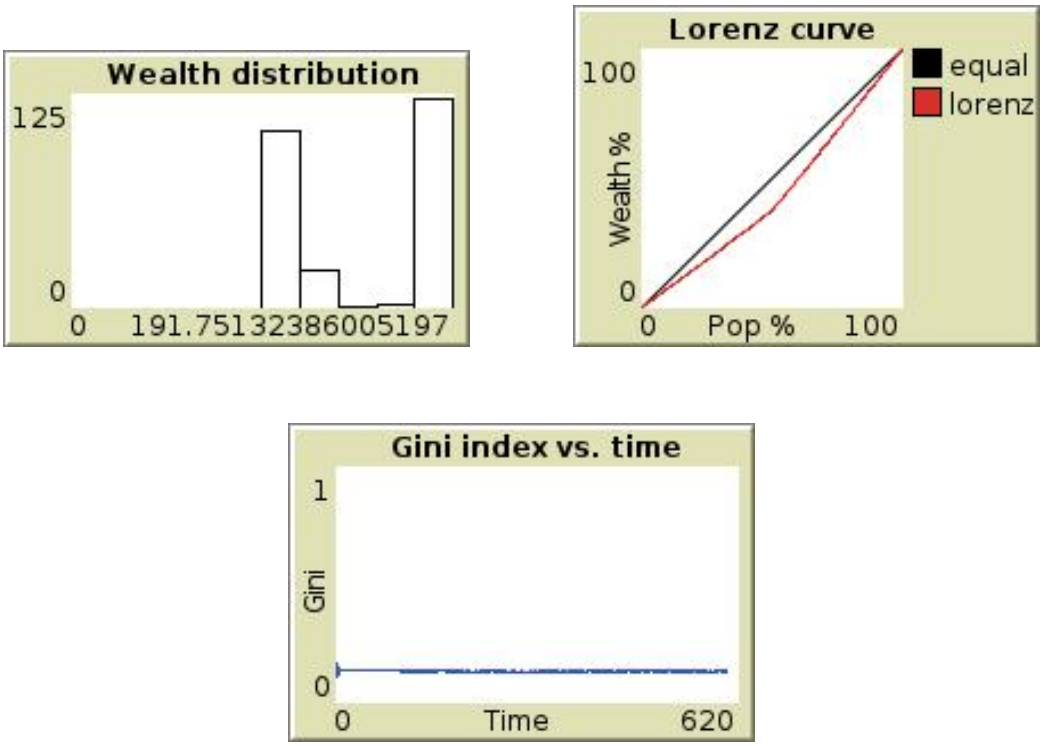

Figure 15: X = 40%, Y = 50%

b. After observing and comparing the mean and standard deviation of the agents' vision in the system, there is no clear impact on the vision after implementing the tax process.

c. We adjust the tax rate from 20% to 80% in steps of 20%. Y is kept at 50%. The wealth distribution and Gini index are plotted below. As we increase the tax rate, the wealth inequality becomes higher and the Gini index is also increased.

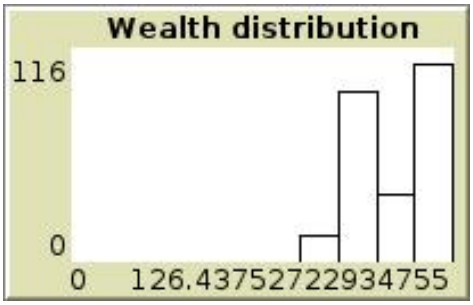

Figure 16: X = 20%, Y = 50%

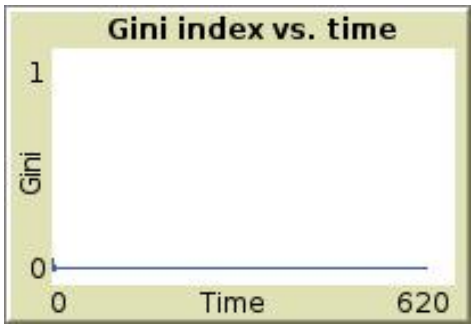

Figure 17: X = 20%, Y = 50%

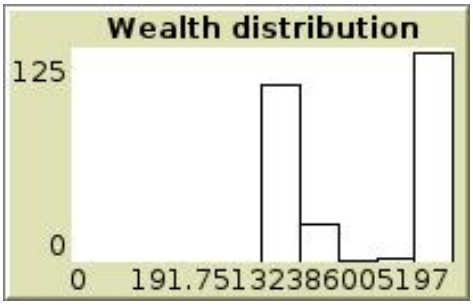

Figure 18: X = 40%, Y = 50%

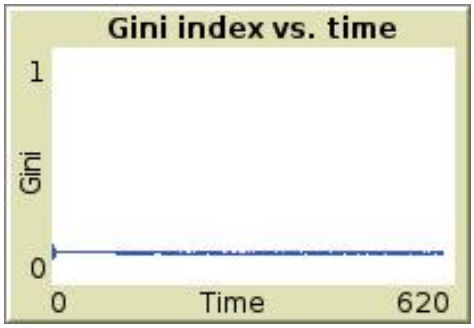

Figure 19: X = 40%, Y = 50%

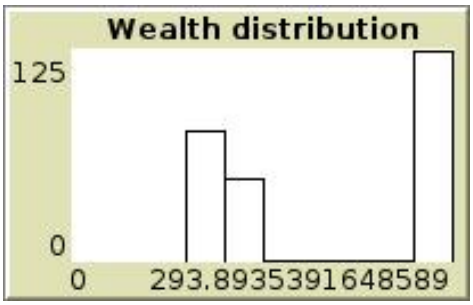

Figure 20: X = 60%, Y = 50%

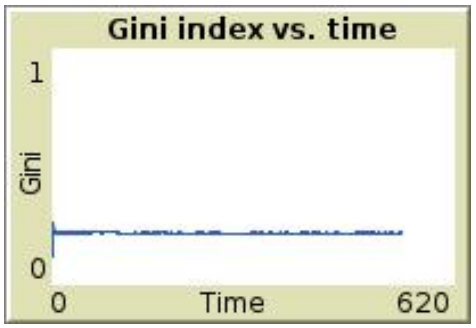

Figure 21: X = 60%, Y = 50%

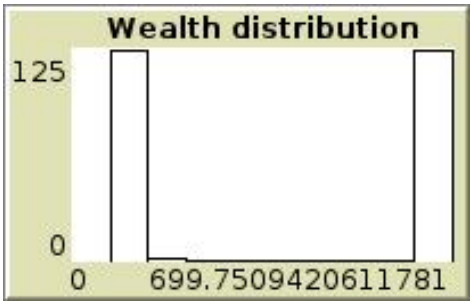

Figure 22: X = 80%, Y = 50%

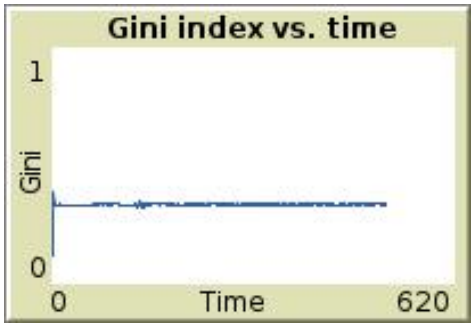

Figure 23: X = 80%, Y = 50%

d. Similarly, We adjust the Y from 10% to 90% in steps of 20%. X is kept at 40%. The wealth distribution and Gini index are plotted below. As we increase Y, the wealth are more equally distributed and the Gini index is also reduced.

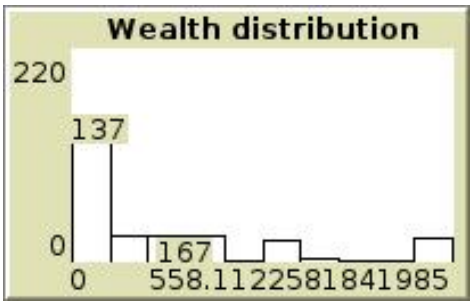

Figure 24: X = 40%, Y = 10%

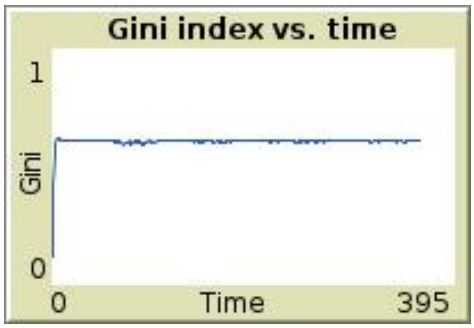

Figure 25: X = 40%, Y = 10%

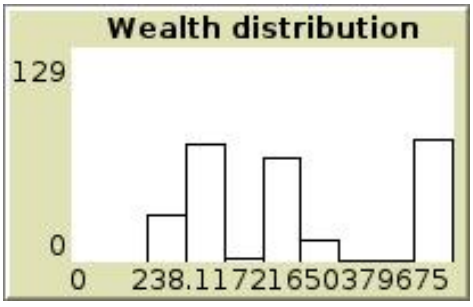

Figure 26: X = 40%, Y = 30%

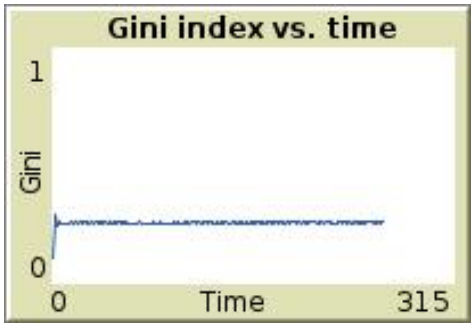

Figure 27: X = 40%, Y = 30%

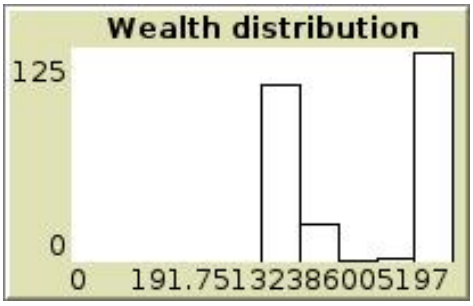

Figure 28: X = 40%, Y = 50%

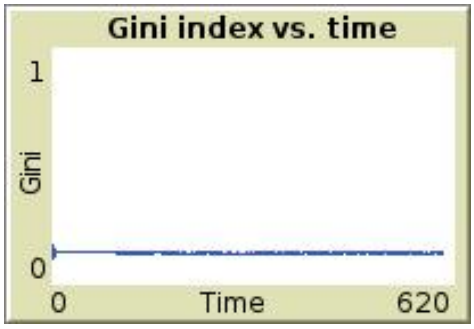

Figure 29: X = 40%, Y = 50%

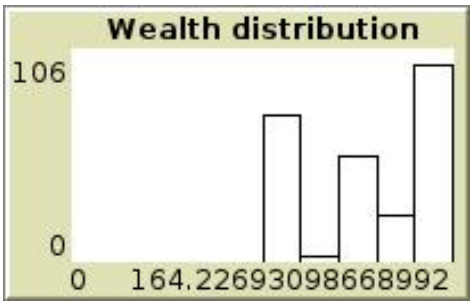

Figure 30: X = 40%, Y = 70%

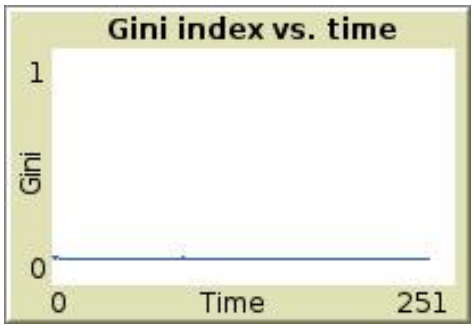

Figure 31: X = 40%, Y = 70%

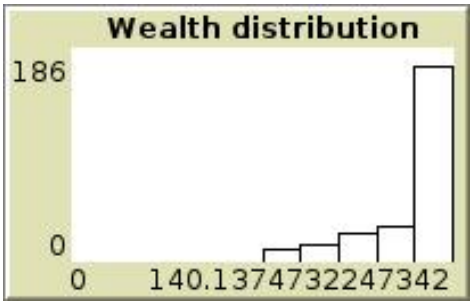

Figure 32: X = 40%, Y = 90%

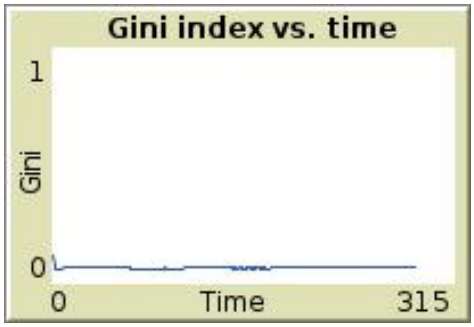

Figure 33: X = 40%, Y = 90%

e. To eliminate inequality and create the most equal society, we can set $X = 100\%$ and $Y = 100\%$. In this case, all the sugar will be equally distributed among all agents, which results in almost 0 Gini index.

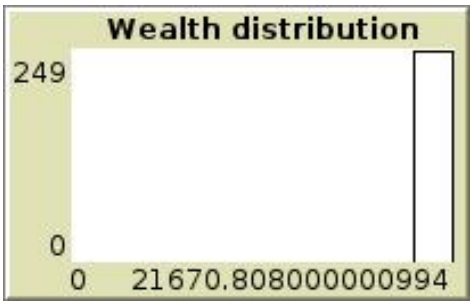

Figure 34: X = 100%, Y = 100%

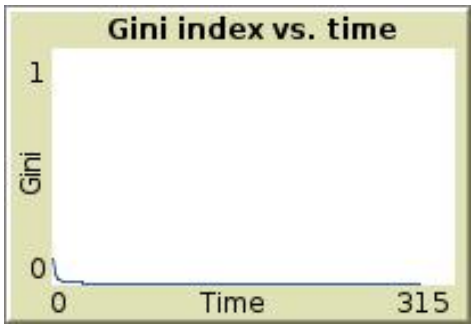

Figure 35: X = 100%, Y = 100%

Or we can set a relatively low tax rate and distribute the collected tax the majority of the agents. In this case, the society will not be perfectly equal but still exhibits good structure.

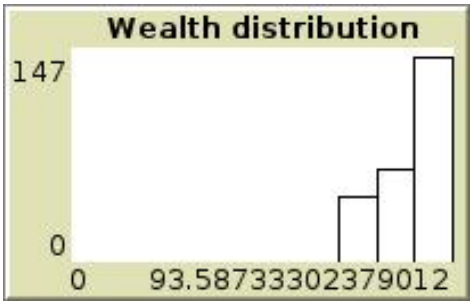

Figure 36: X = 20%, Y = 80%

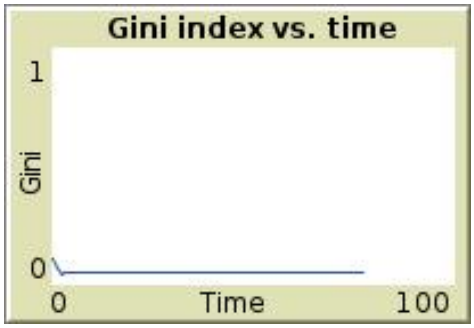

Figure 37: X = 20%, Y = 80%