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THE EFFECT OF APPLIED ZAKAT ON WEALTH DISTRIBUTION USING AGENT BASED MODELING

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ABSTRACT

Zakat is the third pillar of Islam, therefore a mandatory alms and one of the most important tools of Islamic finance that ensures wealth redistribution and is used to reduce poverty in Muslim societies. Infact, it is intended to provide for the immediate needs of the eight categories of eligible recipients as they are recognized in the Holy Quran in Surat Tawba verse 60. The capitalistic system automatically generates a serious disparity between the rich and the poor then try to reduce this gap indirectly through taxation whereas the Zakat directly reaches the neediest and diminished category. In fact, the goal of the Zakat is to transform the poor into Zakat givers by pulling them out of poverty. This will be examined through simulation with agent based modeling commonly known as ABM and will be applied using simulation tools NETLOGO Version 6.4p by introducing the Islamic concept that is Zakat to the model of Simple Economy previously developed by Wilensky and used by [1] and [2] to study the Impact of Zakat on a Social Wealth Distribution. Many cases are simulated with and without Zakat and by using the indicators like Gini index, Lorenz curve, we are able to conclude that a wealth distribution is more equal and the gap between the rich and the poor is less significant compared to when Zakat is not applied.
Keywords: *Zakat, Agent Based, Wealth Distribution, Netlogo, Islamic finance*

1. INTRODUCTION

The global asset of Islamic institutions was about fives trillions dollars of United States of America (USD) in 1985 [3]. The Islamic finance was slowly rising gradually in the world since 1963 when the first Islamic bank was implemented in Egypt by Dr Ahmed Al-Naggar [3]. Now, it became too big to be ignored in some countries [4] especially after the subprime crises in 2008 flowing by double impact from the pandemic and the decline of oil prices in 2019. This crisis has proved that the Islamic Finance provides a lower risk and more resilience than conventional financing [5]. Actually the global asset of Islamic institutions was about 5 trillion dollars in the United States of America (USD) in 1985 [3] and now according to IFSB the value of global Islamic finance service industry is around to USD 3.25 trillion in 2022 (IFSB, 2023), so a huge work was done to develop it.

One of the most useful tool of the Islamic finance that muslims started using from the 1st day of Hijra is called “Zakat” or “Zakah” which is the obligatory charity. The main idea of Zakat is to give a part of personal wealth to some specific categories called “Asnaf” and therefore aims to ensure wealth redistribution in order to reduce poverty in Muslim societies. In fact, it is intended to provide for the immediate needs of the eight categories of eligible recipients as they are recognized in the Holy Quran in Surat Tawba verse 60.

Nowadays, there is many states whose applied “Zakat” for financing a social sector tempting to reduce the gap between rich and poor, in this paper we suggest to simulate Zakat or Islamic tax using Agent Based Models in order to understand this complex area [6], by Netlogo software package developed by Prof. Uri Wilensky at Northwestern University [7] to construct the agent-based environment.

Hence, the artificial society constructed in this paper could be seen as an initial starting base to create an artificial society attempting a real-world simulation that allows users to track the complex interactions between various agents and assess the effect of introducing Zakat in a close economy system. In this context, the distribution will be evaluated by the following parameters: the Gini index, the Lorenz curve, etc.

Based on initial research hypotheses, this study demonstrate that introducing the Zakat has a positive impact on wealth redistribution. Actually, in an artificial world where only transactions are conducted on wealth without redistribution, it was found that the distribution of wealth tends to look similar to a Pareto repartition. However, when Zakat has been implemented, it has been proven that wealth redistribution has also become more equitable, thus, this paper finding can be used to prove that Zakat is one of the tools that can be used to decrease disparities.

The main goal of this study is to answer to the following question: How Zakat affect the distribution of wealth? To reach this target, this paper is divided into three main parts, the first one talking about the conceptual framework, the second part display the methodology and design of the model and the last part is a simulation and results.

2. LITERATURE REVIEW

Agent-based models are referred to by distinct names in different branches of science. in biology and ecology they're called individual-based, in economics it called agent-based computational economics models in computer science and logistics they're called a multi-agent systems [8]. In economy there are many studies using Agent-based Modeling although [9] considers that the first study using agent based environment on Islamic finance is a paper of [10] even if it does not included Zakat.

On the other hand a few scientific papers study the effect of Zakat on wealth distribution or economic growth using agent based simulation with Netlogo software, these papers are [11]; [12]; [13] ; [14] ; [1] ; [15] ; [9] ; [2].

The most papers used two scenarios (with or without Zakat), they simulated the economy using agent based modeling for the purpose of observing how economic inequality emerges and explaining the reasons for inequality.

The paper of [11] Zakat is called Sadaqah and is based on a starting hypotheses to scenarios. They then simulated a closed economy for the purpose of observing how economic inequality emerges in a system and explaining the reasons for inequality. The result of simulation without Zakat distribution of wealth is in the form of the power law (Pareto).

The work of [12] aims to investigate how Zakah can reduce the level of the Gini index and simulated Zakat for its impact on economic growth through wealth redistribution. In fact, two scenarios have been used (with or without Zakat) with conception of Zakat as decentralized distribution, the result of simulation show Clearly that the Gini index remains stable when Zakat is applied and it could be used as one of the tools to minimize the negative impact of interest-bearing loans.

The studies of [14] and [9] are about the same concept : the first is a communication on 4th International Conference of Zakat (ICONZ), the second is an article on International Journal of Zakat, the author choose a model that does not restrict total wealth in the simulation Zakat as a decentralized distribution via two scenarios (ordered and random distribution). The simulation confirmed that applied Zakat can decrease in the poor category and increase in the size of the middle category and also restructuring of the distribution from a power distribution (Pareto) to a normal distribution.

[1] Aims to study the taxes and subsidies on social wealth distribution by expanding a simple economic program of Wilensy. This study concluded that taxes help to reduce a gap between the rich and the poor. then [15] studied the impact of Zakat system using a centralized treasury by simulation with Netlogo based on Agent based Modeling.

[2] This paper explores the simulation through agent-based modeling (ABM) to study economic inequality and in the same time observe the Islamic charity (sadaqah) or Zakat can help attenuate it. Based on the obtained results, the authors confirmed that the taxation and zakat are both enable to help getting more equitable redistribution of wealth and equality.

Before exposing the conceptual framework, we should answer this question, why is this model is different?

In the fact, the answer is the program calculate Zakat for each agent with wealth over Nissab value and in the same time observe the agent who keeps more than Nissab value for a period of time (One year), then the program push the agent to give Zakat to the poor agents whose haves less than a fixed wealth whitch is considerate as poverty

threshold, by using Netlogo 6.4 as a simulation tool. As far as the authors knows, this never done before.

3. CONCEPTUAL FRAMEWORK

The Islamic economy is based on Shariah (Principles of Islamic religion), and the last of the five goals of Islam is to conserve protection money, it come just after the goal of conserving one's life, religion, mind and dignity. It's different of taxes because the idea behind zakat is not only economic but also spiritual, while the objective of taxation is only materialistic and according to holy Quran, Zakat makes the wealth pure [16] [17].

3.1 Islamic Finance

Islamic economy has a broader meaning than Islamic finance; Islamic finance is often confused with Islamic (or participatory) banking, since Islamic banking is only one component of Islamic finance, which in turn is an element of the Islamic economy ecosystem.

Islamic finance refers to the provision of financial services in accordance with Islamic jurisprudence (called Shariah). It is based on Islamic principles and God's instructions, respectively the Holy Quran (words of God), Sunna (words, habits and behaviors of the Prophet Mohamed), Al Ijmaa (simply the doctrine, concepts or practices on which the scholars rule as to whether or not they are lawful) and Al Qiyass (the tool of studying new issues that have not already arisen and are not already resolved by the Quran). The sunna and Al Ijmaa, then the scholars have a recourse to give an opinion or a solution, to the application of analogies of already existing solutions) [18].

Indeed, the Islamic economic system is the fruit of a doctrine that has been put into practice for fourteen centuries in Islamic civilization [19]. Hereafter are the fundamental principles of Islamic finance:

- Prohibition of interest (Called also Riba)
- The principle of Profit and Loss Sharing (PPP/3P)
- Prohibition of uncertainty and speculation (called Gharar and Maysir)
- Tangibility of assets
- Illicit activities (activities that is prohibited by Holy Quran like sell wine)

3.2 Zakat

Zakat is the third pillar of Islam, therefore a mandatory alms and one of the most important tools of Islamic finance that ensures wealth redistribution and is used to reduce poverty in Muslim societies [20]. In fact, it is intended to provide for the immediate needs of the eight categories of eligible recipients as they are recognized in the Holy Quran: Surat Tawba verse 60 "Alms-tax is only for the poor and the needy, for those employed to administer it, for those whose hearts are attracted ˹to the faith˺, for ˹freeing˺ slaves, for those in debt, for Allah's cause, and for ˹needy˺ travellers. ˹This is˺ an obligation from Allah. And Allah is All-Knowing, All-Wise".

The two main categories of Zakat are Zakat Al-Fitr and Zakat Al-Mal. The former is expected to be paid by Muslims during the final days of the holy month of Ramadan up till the 1st day of the Hijri month "Chaouel". The latter, Zakat Al Mal, is a donation upon wealth that has been in one's possession during the previous hijri year and has exceeded the "Nissab": the equivalent value of 85g of gold or 612 g of silver. The due donation is calculated based on a rate of 2,5% of the existing wealth.

Zakat aims to create a global socio-economic system that generates revenue for the less fortunate by implementing a fair distribution of wealth. The system is then designed to make today's poor become tomorrow's Zakat payers [21].

3.3 Agent Based Modelling

The concept of Agent-based modeling was inspired from biology, in the last years many applications are used in Economic area like labor market, game behavior and financial market [1]. The Agent based modeling used to simulate or modeling a complex adapting systems, in fact the economic systems is consider as complex systems [6]. There are many computer simulation tools supported by agents based modelling in economic area as ANYLOGIC, CORMAS, DOMIS, JACK, JADE, JADEX, SWARM, MASON, REPAST, STARLOGO and NETLOGO [22]. The most prominent in economic simulation is Netlogo used to construct the agent-based environment, a software package developed by Prof. Uri Wilensky at Northwestern University [7].

4. METHODOLOGY

In this study, we are tempting to introduce the Islamic concept that is Zakat on the model of Simple Economy developed by Wilensky. The first

model is simple economy model without Zakat and the second with Zakat and the description model follows the ODD (Overview, Design concepts, Details) protocol made by [23] [24] [25].

The code can be download here: https://www.comses.net/codebase-release/09544386-dbbf-49b9-85ac-967b509fa37c/ ; and see also the program in Appendices 1 and 2.

4.1 Overview Section

4.1.1 Purpose

The purpose of our model is to illustrate the impact of Zakat given on wealth distribution. Our model is based on simple economy model developed by Welinsky, in the original model the economic activity involve simple transaction by a fixed amount with other agent randomly however the main idea of our model is to introduce the concept of Islamic tax which is Zakat, which is every agent give a little part of his wealth to a poor one. The objective is to examine the ability of Zakat as tool to reduce inequality and make an equitable wealth distribution.

4.1.2 Entities, State Variables, And Scales

Entities: Only one entities is adopted for our model is "Agents" representing populations.

Variable: The Agents are characterized by Wealth given on dollars USD in each time (Tick)

Scales: population number is 500 agents

4.1.3 Process Overview And Scheduling:

Initially, for the two scenarios 1 and 2, the agents receive a random amount of money in the range 0$ to 100$, and at each tick (discrete time), the scenario instructs agents to transact by giving a set value (1$) to any other agent chosen randomly, so that the wealth of this agent will be minus 1$ and will increase by 1$ wealth of the agent that received it.

Pseudo-code Model 1:

- For every time step "t"
- For each agent "i" look if $Wi_{(t-1)} > 1$ Then $Wi_t = Wi_{(t-1)} - 1$
- Give a dollar to another agent "i" then $Wi_t = Wi_{(t-1)} + 1$

In the model 2, we introduce to the model 1 the obligatory Islamic charity (alms) called Zakat or Zakah by imposing to the riches agents to give 2,5% of wealth to another "poor" agents. It's considered riches agents whose have a wealth more than wealth value called "Nissab" for more than one years, then the program calculate Zakat for each agent with wealth over Nissab value and in the same time keeps more than Nissab value for a period of time (One year = 100 ticks), then the program push this agents to give Zakat to the poor agents whose haves less than fixed wealth witch is considerate as poverty threshold, the following Pseudocode describe the process:

Pseudo-code Model 2:

- For every time step "t"
- For each agent "i" look if $Wi_{(t-1)} > 1$ Then $Wi_t = Wi_{(t-1)} - 1$
- Give a dollar to another agent "i" then $Wi_t = Wi_{(t-1)} + 1$
- For each agent "i" look if $Wi_{(t-1)} >$ Nissab and $Wi_{(t-1)} >$ Nissab for 100 ticks Then :
- Calculate $Zi = Wi_{(t-1)} * 2{,}5\%$ and $Wi_t = Wi_{(t-1)} - Zi$
- If agent "i" with $Wi_{(t-1)} < 40\$$ don't exist so :
- Let Storage-Wealth = storage-Wealth + Zi and $Wi_{(t-1)} = Wi_{(t-1)}$ + storage-Wealth / (number of agent)
- if agent "i" with $Wi_{(t-1)} < 40\$$ exist so : $Wi_{(t-1)} = Wi_{(t-1)} + Zi$

$Wi_{(t-1)}$: Wealth before ; $Wi_{(t)}$ Wealth now ; Z : Zakat ; Nissab : 90$

4.2 Design Concepts

4.2.1 Basic Principles

In the beginning for the both model 1 and 2, the population receive randomly a wealth between 0 and 100$, then every discrete time (ticks) the model ask agents to transact by given a fixed amount 1$ to another agent randomly so the wealth of this agent will be decreased by 1$ and increase the wealth of the agent who receive it by 1$.

In the model 2, we introduce to the model 1 the obligatory Islamic charity (alms) called Zakat or Zakah by imposing to the riches agents to give 2,5% of wealth to another "poor" agents. It's considered riches agents whose have a wealth more than wealth value called "Nissab" for more than one years, then the program calculate Zakat for each agent with wealth over Nissab value and in the same time keeps more than Nissab value for a period of time (One year = 100 ticks), then the program push this agents to give Zakat to the poor agents whose haves less than fixed wealth witch is considerate as poverty threshold.

4.2.2 Emergence

The interaction roles between agents (transact and given Zakat) let wealth move in a complexes area, we observe emergence of the wealth distribution.

4.2.3 Adaptation

The riche agents given to poor agent a small part of their wealth, and the poor agent don't give anything even the riches agents stopped to give Zakat if they not have any more Nissab for one year. If the wealth of the poor agents become less than 1 $ then the agent stop to transact.

4.2.4 Objectives

Flowing step by step the distribution of wealth and plot the curve of Gini index and the Lorenz cube.

4.2.5 Learning: not available for our models

4.2.6 Prediction: not available for our models

4.2.7 Sensing: not available for our models

4.2.8 Interaction

The agents interact by redistribution Zakat from the riches agents to the poor's one and transact randomly.

4.2.9 Stochasticity

The first thing is the initial wealth is given randomly, then a transaction and redistribution of Zakat are acted also randomly, so this is can be described like a stochastic process.

4.2.10 Collectives: not available for our models

4.2.11 Observation

Many indicators and plots are used to see what's happened

- Plot Gini index
- Plot Lorenz curve
- Plot of distribution wealth top 10% and bottom 50% population

4.3 Details

4.3.1 Initialization

Initialization parameter of simulations are:

- 500 agents
- Each agent gets a random amount of wealth between 0 and 100$
- Every agent with a wealth exceeds Nissab (90$) for a year (100 ticks) should give 2,5% of his wealth to a poor agent randomly
- A poor agents are agents who have a wealth less than 40$

For stabilization the model we let a model of simple economy work for 2000 ticks then we introduce Zakat model (The simulation work for 10 000 ticks)

4.3.2 Input Data : There is no input data

4.3.3 Submodels

4.3.3.1 Scenario 1

Scenario 1:

In this scenario the simulation is RUN without Zakat based only on model simple economy of Wilensky [26].

Pseudo-code:

For every time step "t"
For each agent "i" look if $Wi_{(t-1)} > 1$ Then $Wi_t = Wi_{(t-1)} - 1$
Give a dollar to another agent "i" then
$Wi_t = Wi_{(t-1)} + 1$
After 10 000 Ticks we obtain:

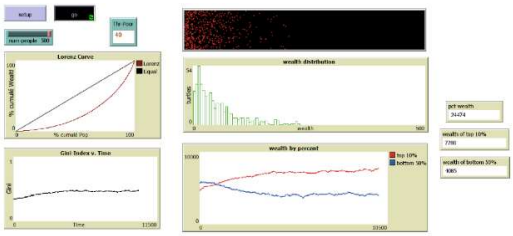

Figure 1: Simulation Results Of Simple Economy
Source: By Authors

4.3.3.2 Scenario 2:

In this simulation, we applied the concept of Zakat, expended before:

Pseudo-code:

For every time step "t"
For each agent "i" look if $Wi_{(t-1)} > 1$ Then $Wi_t = Wi_{(t-1)} - 1$
Give a dollar to another agent "i" then $W_{it} = Wi_{(t-1)} + 1$
For each agent "i" look if $Wi_{(t-1)}$ > Nissab and $Wi_{(t-1)}$ > Nissab for 100 ticks Then :

- Calculate $Z_i = Wi_{(t-1)} * 2,5\%$ and
- $Wi_t = Wi_{(t-1)} - Z_i$

if agent "i" with $W_{i(t-1)} < 40\$$ don't exist so :
let Storage-Wealth = storage-Wealth + Z_i and $Wi_{(t-1)} = Wi_{(t-1)}$ + storage-Wealth / (number of agent)
if agent "i" with $Wi_{(t-1)} < 40\$$ exist so : $Wi_{(t-1)} = Wi_{(t-1)} + Z_i$

After 10 000 Ticks we obtain:

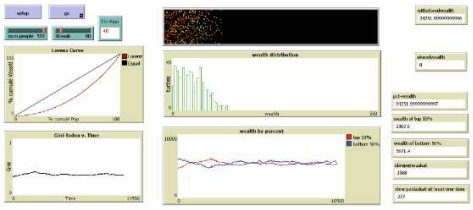

Figure 2: Simulation Results Of Simple Economy With Zakat
Source: By Authors

In order to analyze the results generated from the simulations in Figure 1 and Figure 2, and to interpret the findings in a more logical approach, we will mainly use three indicators: the Gini Index, the Lorenz Curve and the wealth concentration of the richest 10% and the bottom 50% of the population. On the basis of these assumptions we've already set out, these three indicators that are used to evaluate the degree of Zakat's influence on the redistribution of wealth in a closed economy.

Previous research has used these indicators: for example, the third criterion was used in study [2] to understand the distribution of wealth between different social categories, while the first and second criteria (the Gini index and the Lorenz curve) were combined with other indicators in study [15] to observe the performance of models based on a centralized or decentralized Zakat system. In study [13] the authors used those criterion to prove the ability of Zakat to decrease inequality and alleviate the negative impact of interest-rate loans. It was stated in [14] how wealth is distributed before and after the introduction of Zakat in an orderly and random manner. Finally, the study by [11] uses the Gini Index only, in addition to other metrics, to track the evolution of inequality in cases where the Sadaqah is applied or not.

5. RESULTS OF SIMULATION

Before reporting the simulation findings, and in the spirit of intellectual transparency and encouraging ongoing scientific dialogue, the knowledge in this field is constantly evolving, therefore the interpretation of the simulation results on Netlogo may require adjustment and refinement as new data emerges. Consequently, the current claims may be subject to reconsideration or refinement by additional research.

For the first simulation: In this situation, we can see:

- Total wealth is 24474$ (wealth of top 10% is 7780$ and Wealth of bottom 50% is 4085$)
- The distribution wealth respect the **Pareto Law**, when only 10% of the more rich population have 52% more than of total wealth of bottom 50% of population.
- The index Gini change between 0,47 et 0,48 so high income inequality

Evidently, wealth is tending to be concentrated into the possession of the very privileged minority, while the majority of people are sharing the rest. This is particularly well illustrated by the following figure 3:

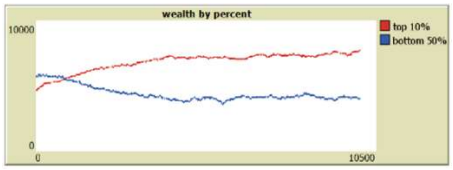

Figure 3: Wealth by percent (Scenario 1)
Source: By Authors

Figure 4 shows that the Gini index remains high (between 0.47 and 0.48) and Figure 5 reveals that the Lorenz curve is not close to the perfect curve, which implies significant inequality.

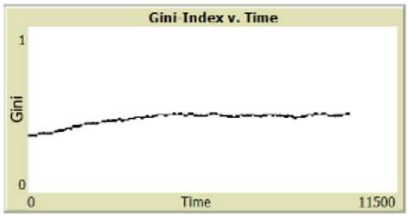

Figure 4: Gini index evolution (Scenario 1)
Source: By Authors

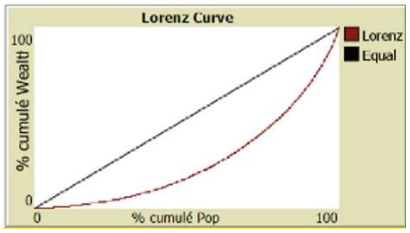

Figure 5: Lorenz Curve evolution (Scenario 1)
Source: By Authors

According to these results, in the first scenario Zakat is not involved, which simply shows that the distribution of wealth follows Pareto's law. Indeed, simple transactions between the agents, without any instruments for wealth redistribution, only result in the wealth being placed in hands of the richest. This is supported by the fact that, by the end of our simulation, over 52% of the wealth is held by 10% of the population.

For the second simulation: The Gini index and Lorenz curve shows that wealth distribution is more equal. By giving Zakat, our simulation look more interesting, and we can see:

- Total wealth is 24251$ (wealth of top 10% is 5362$ and Wealth of bottom 50% is 5671$)
- A total of top 10% wealthy turtles become less or at less equal than 50% bottom wealthy turtles (Disrespect the Pareto law).
- The index Gini change between 0,36 et 0,37 so low income inequality
- The Lorenz curve is very close to the line of perfect equality, this indicates a more equitable distribution.
- The Zakat was been given in this simulation 3568 time

In this case we have introduced Zakat to the system. Wealth distribution has become more equal, as wealth no longer remains in the possession of the top 10% of the population. Figure 6 here reveals a considerable improvement compared to figure 3 in scenario 1.

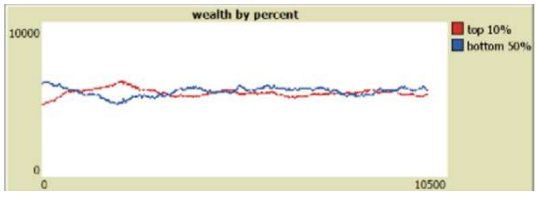

Figure 6: Wealth by percent (Scenario 2)
Source: By Authors

By reducing the value of the Gini Index (between 0.36 and 0.37) in figure 7, inequality in scenario 1 has also been reduced, while in figure 8, the Lorenz curve has moved closer to the perfect line.

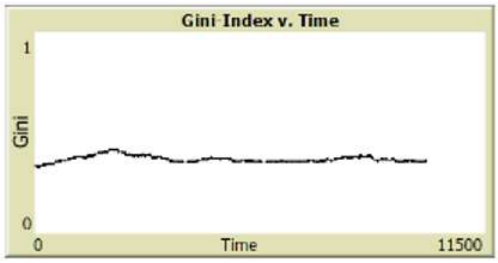

Figure 7: Gini index evolution (Scenario 2)
Source: By Authors

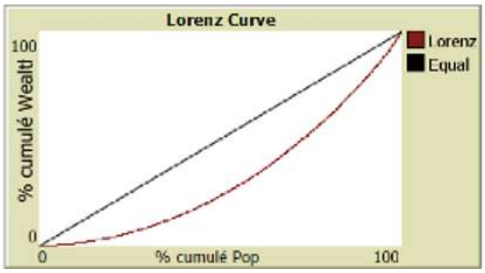

Figure 8: Lorenz Curve evolution (Scenario 2)
Source: By Authors

Although the approach is not the similar, the Simulation in this article confirms the results obtained by [11] regarding the Pareto distribution in the case where Zakat (or Sadaqah) is not applied, and that its application reduces inequalities. The key distinction of this paper compared to other studies using ABM to simulate Zakat is the underlying set assumptions, and code developed by the authors. Indeed, that study [11] provides the setting up of entities that act via preset strategies to support poor people, whereas our study requires wealthier agents to allocate Zakat to poor people in a systematic mode once the necessary conditions have been fulfilled.

Studies [12], [13] used the empirical study of [27] to confirm it through a simulation on Netlogo based on ABM. The result of study [12] showed that when Zakat is applied for local consumption, it can promote global production, and therefore boost economic growth. Moreover, the study [13] confirms that Zakat can be considered as one of the tools used to minimize the negative impacts of interest-rate loans, enabling a reduction in the Gini Index, and thus reducing inequalities in society. This again supports the findings of the present article, even though the starting hypotheses

are not the same, implying that Zakat has a positive effect on reducing inequality, and can be considered as an effective instrument for redistributing wealth.

The study [14] and [15] adopt a model that does not limit total wealth in the Zakat simulation as a decentralized distribution with two scenarios (ordered distribution and random distribution). As a results, reducing the class of the poor and increase the size of the middle class that transforms the distribution from a power distribution (Pareto) to a normal distribution, which is similar to our results.

In the same context, the study [2] built an artificial economic society, with two scenarios with and without Zakat. Also the result show that Zakat plays a great role to reduce inequality wealth distribution and social justice.

6. CONCLUSION

The simulation highlighted the value of using multi-agent technique, as a powerful tool for better comprehension of the complex and dynamic systems such as the economy. By using the "Simple Ecommoy" simulation model, we have been tracking the evolution of wealth within the closed economy, with Gini indexes and Lorenz curves as main indicators. However, the Netlogo model remains an approximation of reality, exempting scientists from the obligation to conduct surveys in real life. Which opens up the opportunity for serious discussions on social and fiscal policies.

In the simulation "Simple economy" only the distribution wealth we have only 10% of the more rich population have 52% of total wealth, this respects the Pareto Law, and looks as high income inequality but when we introduce Zakat or the Islamic tax, the simulation shows a more equitable wealth distribution, a total of top 10% wealthy population become less or at less equal than 50% bottom wealthy population. Thus all previous indexes show that using Zakat helps to get a more equitable distribution and the gap between the rich and the poor is less significant compared to when Zakat is not applied, in fact, the Zakat can transform the poor into Zakat givers by pulling them out of poverty.

Hence, Zakat can affect in the positive manner the distribution of wealth by taking a small part of the rich's wealth and transfer it to the poorest people. This small part of wealth does not affect too much the richest people but it has a huge effect on the poor people lives. In an artificial area, this part of wealth allows the poorest agent to transact, that means in real world the poor people can afford fundamental needs. Moreover, reduce the gap between the rich people and poorest ones.

However, the primitive nature of the model limits the generalization of the findings, requiring a deeper approach. But despite these limitations, this study provides a solid basis for exploring the relationship between Zakat, taxes and wealth redistribution.

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Appendix n° 1: Code for model 1

```
globals
 [
 gini-index-reserve
 lorenz-points
 ]
turtles-own [ wealth ]
to setup
 clear-all
 create-turtles num-people
 [
  set wealth random 100
  set shape "circle"
  set color red
  set size 2
  setxy wealth random-ycor
 ]
 update-lorenz-and-gini
 reset-ticks
end
to go
 if ticks < 10000
 [
  ask turtles with [ wealth > 1 ] [ transact ]
  ask turtles [ if wealth <= max-pxcor and wealth > 0 [ set xcor wealth ] ]
 update-lorenz-and-gini
 tick
 ]
end
to transact
 if wealth > 1 [ set wealth wealth - 1]
 ask one-of other turtles [ set wealth wealth + 1 ]
end
to-report top-10-pct-wealth
 report sum [ wealth ] of max-n-of (count turtles * 0.10) turtles [ wealth ]
end
to-report pct-wealth
 report sum [ wealth ] of turtles
end
to-report bottom-50-pct-wealth
 report sum [ wealth ] of min-n-of (count turtles * 0.50) turtles [ wealth ]
end
to update-lorenz-and-gini
 let sorted-wealths sort [wealth] of turtles
 let total-wealth sum sorted-wealths
 let wealth-sum-so-far 0
 let index 0
 set gini-index-reserve 0
 set lorenz-points []
 repeat num-people
 [
  set wealth-sum-so-far (wealth-sum-so-far + item index sorted-wealths)
  set lorenz-points lput ((wealth-sum-so-far / total-wealth) * 100) lorenz-points
  set index (index + 1)
  set gini-index-reserve gini-index-reserve + (index / num-people) - (wealth-sum-so-far / total-wealth)
 ]
end
```

Appendix n° 2: Code for model 2

```
globals
 [
 stored-wealth modx ids-over-Nissab
 ids-over-Nissab-no-repeat
 max-consecutive
 gini-index-reserve
 lorenz-points
 ]
turtles-own [ wealth consecutive-count has-satisfied-condition ]
to setup
 clear-all
 create-turtles num-people
 [
  set wealth random 100
  set shape "circle"
  set color red
  set size 2
  set stored-wealth 0
  setxy wealth random-ycor
  set consecutive-count 0
  set has-satisfied-condition false
 ]
 set ids-over-Nissab []
 set ids-over-Nissab-no-repeat []
 set max-consecutive 100
 update-lorenz-and-gini
 reset-ticks
end
to go
 if ticks < 10000
 [
  ask turtles with [ wealth > 1 ] [ transact ]
 if ticks > 2000
  [
  ask turtles [
  ifelse wealth > Nissab
  [
   set consecutive-count consecutive-count + 1
   if consecutive-count > max-consecutive
   [
    set consecutive-count 0
    set has-satisfied-condition true
```

```
        set ids-over-Nissab lput who ids-over-Nissab
        Give-Zakat
        if not member? who ids-over-Nissab-no-
repeat
        [
        set ids-over-Nissab-no-repeat lput who ids-
over-Nissab-no-repeat
        ]
      ]
    ]
    [
      set consecutive-count 0
    ]
  ]
  ask turtles [ if wealth <= max-pxcor and wealth >
0 [ set xcor wealth ] ]
  dist-stored-wealth
  ]
update-lorenz-and-gini
  tick
  ]
end
to transact
  if wealth > 1 [ set wealth wealth - 1]
  ask one-of other turtles [ set wealth wealth + 1 ]
end
to Give-Zakat
  let Zakat 0.025 * wealth
  set wealth 0.975 * wealth
  set color yellow
  if wealth < Nissab [set color green]
  let low-wealth-turtle1 one-of other turtles with
[wealth < Thr-Poor]
  ifelse low-wealth-turtle1 != nobody
  [
    let id-low-wealth-turtle1 [who] of one-of other
turtles with [wealth < Thr-Poor]
    ask turtle id-low-wealth-turtle1 [set wealth
wealth + Zakat]
  ]
  [
    set stored-wealth (Zakat + stored-wealth)
  ]
end
  to dist-stored-wealth
    if stored-wealth > 0
      [
        ask turtles [ set wealth wealth + (stored-wealth
/ num-people)]
        set stored-wealth 0
      ]
  end
to-report nbre-paidzakat-at-least-one-time
report length ids-over-Nissab-no-repeat
end
to-report nbrepayerzakat
report length ids-over-Nissab
end
to-report storedwealth
  report stored-wealth
end
to-report withstoredwealth
  report stored-wealth + sum [ wealth ] of turtles
end
to-report top-10-pct-wealth
  report sum [ wealth ] of max-n-of (count turtles *
0.10) turtles [ wealth ]
end
to-report pct-wealth
  report sum [ wealth ] of turtles
end
to-report bottom-50-pct-wealth
  report sum [ wealth ] of min-n-of (count turtles *
0.50) turtles [ wealth ]
end
to-report all-100-pct-wealth
  report sum [ wealth ] of max-n-of (count turtles *
1) turtles [ wealth ]
end
to update-lorenz-and-gini
  let sorted-wealths sort [wealth] of turtles
  let total-wealth sum sorted-wealths
  let wealth-sum-so-far 0
  let index 0
  set gini-index-reserve 0
  set lorenz-points []
  repeat num-people
  [
    set wealth-sum-so-far (wealth-sum-so-far + item
index sorted-wealths)
    set lorenz-points lput ((wealth-sum-so-far / total-
wealth) * 100) lorenz-points
    set index (index + 1)
    set gini-index-reserve gini-index-reserve + (index
/ num-people) - (wealth-sum-so-far / total-wealth)
  ]
end
```