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Zakat Charity and Wealth Distribution An Agent-Based Computational Model

Muhammad Asif Jaffer
Institute of Business Administration, Karachi, Pakistan

ABSTRACT

An established Agent Based Model (ABM) of wealth distribution that creates representative Pareto distribution of wealth is used to simulate the impact of Zakat on the wealth distribution in an artificial society. The standard model generates representative wealth distribution patterns found in empirical studies. The model is customized to introduce Zakat (a charity in Islamic Finance) to observe its impact on wealth distribution pattern. The impact of this small charity on the part of the rich changed the Pareto distribution of wealth in the model into a normal distribution over very small intervals of time. The reduction in wealth inequalities as a result of redistribution due to Zakat also increased the net wealth of the model as a whole, thereby stimulating economic growth. The results stress the importance of non-conventional handling of the issue of normalizing wealth distribution and highlights the significant role that Zakat charities can play in improving economic wellbeing in a society.

Key Words: Agent-Based Model, Wealth Distribution, Zakat, Islamic Finance

JEL Classification: C63, D31, D63, D64, Z12

INTRODUCTION

Complexity theory is paving its ways in mainstream economics. Under this theory, economic systems are viewed as complex adaptive systems (CAS). In its very basic definition, CAS are nonlinear systems where sum of individual entities or behaviors is not equal to the whole (Epstein & Axtell, 1996; Tesfatsion, 2002). It holds that macro level behavior is not the linear combination of its micro level constituents. Macro level phenomenon can emerge from complex interactions of heterogeneous agents. Uncertainty and novelty are therefore held as the inherent features of real world phenomena.

On the contrary, neoclassical economic theory holds that a representative individual can be taken to study the macro level behavior of the economic system. This theory is based on certain assumptions like fixed and a-priori knowledge of the choice set (indifference curves), convexity (choice of factor combinations are always linear) and absence of uncertainty (Debreu, 1987; Geoffrey Alexander Jehle, 2001). The emergence of complexity theory counters many of the assumptions of neoclassical economic theory.

Agent based modelling or simulation has emerged as a tool to simulate complex adaptive systems in sociology, economics, finance, political sciences, education and variety of other disciplines. Agent-based computational economics (ACE) is the computational study of economies modeled as evolving systems of autonomous interacting agents (Tesfatsion, 2002). Agent based models have been used for the study of economic behavior across variety of areas including evolution of behavioral norms, bottom-up modeling of market processes, formation of economic networks and alike (Tesfatsion, 2002).

Among several aspects of economic behavior, wealth distribution pattern is one major outcome of the economic activity in any society. Capitalist economies are criticized for creating unequitable distribution of wealth wherein wealth distribution tends to follow power law distribution with fewer people having large proportion of concentrated wealth and many people living on the lower end of the wealth concentration. This is what is also known as Pareto distribution. Rich have a propensity for getting richer and poor tend to suffer more as the capitalist economy grows.

Though capitalist system tends to address this issue by monetary and fiscal policies (especially direct taxation and public expenditure); divine teaching on the other hand tackles this problem by creating a sense of social and economic responsibility on the part of rich towards the poor. One of the financial policing measure in Islamic Finance is Zakat. Zakat is an annual charity (a personal obligation to charity) on net wealth of rich individuals whose net wealth exceeds a fixed threshold. Its magnitude is 2.5 percent of the net wealth to be computed annually and paid to one or more poor individuals (with wealth less than the threshold). Studies have shown the impact of Zakat on wealth distribution, and that Zakat reduces income and wealth distribution inequalities (Ahmad, 1984) (Geoffrey A Jehle, 1994). An unregulated Zakat culture in some countries like Pakistan has made it to be ranked as one of the most charity giving countries in the world (M. Amjad & Ali, 2018)

In the context of this paper, we have constructed an agent based model of wealth distribution to study the impact of Zakat (a small charity in Islamic Finance) on wealth distribution pattern. The remainder of this paper is organized as follows. Section 2 outlines the key literature relevant to the current study followed by section 3 that discusses the specifications of the model used to generate the wealth distribution data for analysis. Section 4 discusses the simulation scenarios and their results, i.e. the main findings of the simulation experiments. This is followed by the conclusion and recommendations in section 5 further followed by limitation and areas of future research in the last section.

LITERATURE REVIEW

There are few studies in agent based simulation of wealth distribution (Al-Suwailem, 2008; Damaceanu, 2008; Goswami & Sen, 2014; Impullitti & Rebmann, 2002; Sabzian, Aliahmadi, Azar, & Mirzaee, 2018). Included among these is a model of wealth distribution as a function of resource growth interval stressing the importance of renewable resources (Damaceanu, 2008). Another model simulates the impact of agents' preferences in choosing other agents for interaction, on wealth distribution (Goswami & Sen, 2014). Another model yet studies agents' and environment's general attributes for their impact on wealth distribution patterns (Impullitti & Rebmann, 2002).

Though charity, especially Zakat has earlier been simulated through agent based simulations, the purpose and scope of our simulation is different. For example, Sabzian et al. (2018) have modeled Sadqah in an agent based simulation environment with an absolute charity of one unit of money to study its impact on wealth distribution, conserving the total wealth thereby do not allowing for any growth. More recently, Putriani, Ghani, & Kartiwi (2020) have simulated Zakat for its impact on economic growth through redistribution of wealth. A related simulation study is also conducted Younas, Hussain, Anam, & Jaffry (2021) modeling Islamic Finance interventions, including Zakat modeled as a centralized treasury. A rather earlier, and probably first study in Islamic Finance in agent based environment as by Al-Suwailem (2008) but that does not include charity (or more specifically Zakat).

Our work is different from these two earlier studies in its purpose and scope. First, Zakat has been modeled as a relative charity on rich as against fixed amount of charity as in Sabzian et al. (2018). Second, our model does not restrict the total wealth in the simulation thereby allowing for economic growth. Third, the simulations are run in too scenarios with an ordered (poorest first) Zakat distribution and another, random Zakat distribution, which none of the earliest studies modeled. Finally, our experiments do not model Zakat as a centralized treasury as in Younas et al. (2021), rather, we model Zakat as a decentralized individual level distribution which is a more realistic case in countries like Pakistan. These aspects distinguish our simulation experiments from others.

It should be noted that apart from agent based simulation models, there are models suggesting mathematical equations for Zakat (like (Namdar, Moradi, Mohmodian, Shahdani, & Hassanzadeh, 2021)), this is not our purpose in this paper. We therefore do not discuss mathematical models of Zakat or wealth distribution suggested by economists. We also do not review theories of wealth distribution. What we present is an agent based computational model that produces typical representative distributions evidenced in real world economics and show and analyze the impact of small specific charity (Zakat) on such distributions. Our findings are interesting as well as suggestive of a different viewpoint of addressing the problem of wealth inequalities.

THE MODEL

The simulation was modeled in NetLogo (Wilensky, 1999) and the model is adapted from Epstein & Axtell's "Sugarscape" model (Epstein & Axtell, 1996). This model is included in the standard library of models in NetLogo (Wilensky, 1998). The model simulates the distribution of wealth in a hunter-gatherer society and is representative of the wealth distribution in capitalist economics because it produces a Pareto (power law) distribution of wealth which is a real phenomenon in the capitalist economies. We customized the model to include the charity (Zakat) procedure.

The Environment

The environment consists of patches that grow grain with an assigned maximum capacity. There is some land (collection of patches) that grow maximum grain and as such is best land, whereas some other patches grow lesser grain. At each time tick, grains on the patches are refreshed. The environmental space has periodic patterns as to condensation of grain with higher and lower concertation of grain, as such giving it a spatial dimension.

The Agents

Agents (proxy for individuals in an artificial society) have certain attributes. For each agent a location on the grain space is specified. In the model, agents are initially randomly distributed in the grain space, meaning that some agents find more grain around them and some others do not. Each agent has an initial endowment as to grain metabolism (consumption of grain to survive), a level of vision (to look for grain in the proximity), and the agent's initial position in the landscape. The agents are as such heterogeneous. Agents also have life expectancy which again is a random number between 1 and maximum limit set in the model. Agents die when their lifespan runs out or they run out of grain.

An offspring is produced that has a random metabolism and a random amount of grain as the model does not consider the inheritance of wealth.

The Interactions

Agents collect grain from the patches, and eat the grain to survive. The model begins with a random wealth distribution. The agents then look for gathering more grain within their vision, by attempting to move in the direction where the most grain lies. Each time tick (modeled to be equivalent of a year), each person eats a certain amount of grain. How much grain each person accumulates over and above consumed, is the agent's wealth. Agents are divided in three classes based on their wealth as compared to the wealth of the richest agent at any given point in time. Agents are classified as poor (and colored red in the model) if they have less than a third the wealth of the richest agent. Agents that have more than two third of the richest agent's wealth are classified as rich (colored blue). Rest of the agents are classified as middle class (colored green).

Charity (Zakat Procedure)

To observe the impact of Zakat, a Zakat procedure was inserted in the model whereby in each cycle, each rich (blue) agent donates Zakat (2.5% of his unused wealth) to a poor agent. Two different variants of this charity were modeled. In one simulation, the recipients of charity (Zakat) were prioritized on the basis of amount of wealth, that is, the poorest agent gets the first charity and then the next one. In the second simulation, the distribution was made on random basis, that is, a rich agent gives charity to one of the random poor agent. The first charity variant is to observe the ideal scenario whereas the second variant is to consider the more realistic situation.

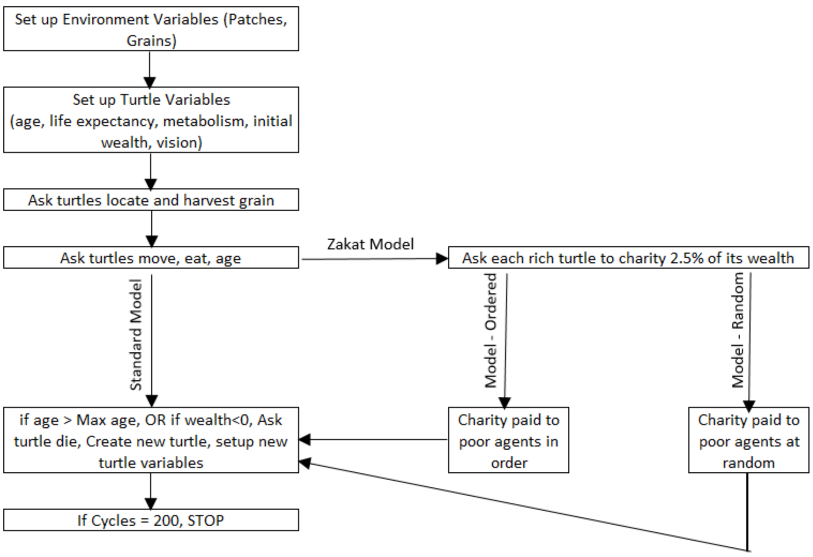

Figure 1. Steps in Computational Model

Model Output and Measures

The standard wealth distribution model in NetLogo is programmed to facilitate visibility of agent's movement, agents' wealth and grain in the environment. Size of each class (number of agents in each of the three classes i.e. poor, middle and rich) and average wealth of agents in each class are plotted. As a measure of wealth distribution, the model employs Lorenz curve and Gini Index. Gini Coefficient assumes a value between zero and one where a lesser value signifies a more equitable distribution of wealth.

Parameters of the environment and agents

Three independent simulations were run; one without charity (the standard wealth distribution model of NetLogo), one with charity paid to poor in the reverse order of their wealth (poorest get first), and one with the charity paid to random poor agents. The first charity scenario is labelled as ordered scenario whereas the second one is labelled as random scenario. Other parameters in these simulations were kept same. These parameters have been summarized below:

Number or agents = 100
Agent's vision = Random b/w 1 and 5
Agent's metabolism = Random b/w 1 and 15
Agent life expectancy = Random b/w 1 & 83
Best Land with maximum grain = 10%
Maximum grain a patch = 50

THE SIMULATION EXPERIMENT AND RESULTS

Three independent runs of the standard model were made (without any charity). In comparison, three independent runs were made with the Zakat procedure incorporated in the model, for both ordered scenario and random scenario. As mentioned earlier, this charity procedure requires rich agents to give charity (Zakat) at 2.5% of their wealth to the poor agent, in each cycle (tick). The order of recipients of this charity is different in ordered and random scenario (as mentioned).

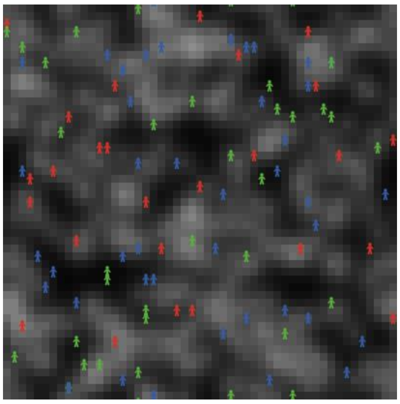

Figure 2. View of Model On Initialization Showing three economic classes

Table 1 is the summary of the outcomes of the three runs of each of the three simulations averaged over 200 cycles (ticks).

Table 1. Average Frequencies and Wealth Distribution in the three classes over 200 Ticks

Model	*Runs*	*Poor Class*			*Middle Class*			*Rich Class*		
		Turtles	*Total Wealth*	*Avg. Wealth*	*Turtles*	*Total Wealth*	*Avg. Wealth*	*Turtles*	*Total Wealth*	*Avg. Wealth*
Standard Model	*Run 1**	67	15,339	228	24	16,236	666	8	8,771	1,060
	Run 2	68	14,109	209	25	15,492	612	7	7,282	1,017
	Run 3	66	15,449	235	26	18,635	721	8	10,098	1,199
Zakat Model - Perfect	*Run 1*	27	7,638	280	48	26,806	558	25	21,040	855
	Run 2	21	5,476	258	51	25,654	502	28	20,981	758
	*Run 3**	23	5,302	234	50	24,887	501	28	22,247	803
Zakat Model - Random	*Run 1*	22	3,472	159	50	23,550	474	29	20,579	721
	Run 2	28	4,339	156	48	20,889	437	24	16,387	691
	*Run 3**	20	3,510	172	52	26,335	503	27	21,151	777

* these instances are titled as representative runs in the discussion that follows

With a small charity (Zakat) as low as 2.5%, the change in pattern of wealth distribution is apparent. As for class size, the strength of poor class reduces from around 67% in the standard model to less than 30% in the Zakat models. Similarly, strength of rich and middle class increases, thus reducing the relative differences of the three classes. Standard models yield a power law distribution, whereas Zakat models gives a fairly normal distribution in terms of the relative frequencies of the three classes. Figure 3 illustrates this difference (one representative instance of each model).

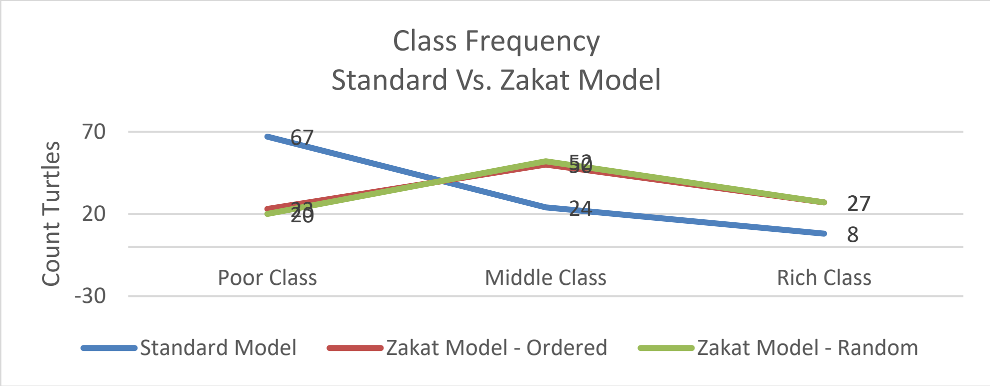

Figure 3. Class Frequency Distribution: Standard Model Vs. Zakat Model

Zakat model also reduced income inequalities in terms of per capita wealth of agents. Average net wealth of rich decreases with some decrease in middle class also, yet bringing the three classes closer in terms of wealth distribution. Though average wealth of poor class increases only marginally in ordered model and reduces in random model, this is substantiated by the fact that relative frequency of the agents in poor class is much lower in Zakat model than in the standard model (Figure 4).

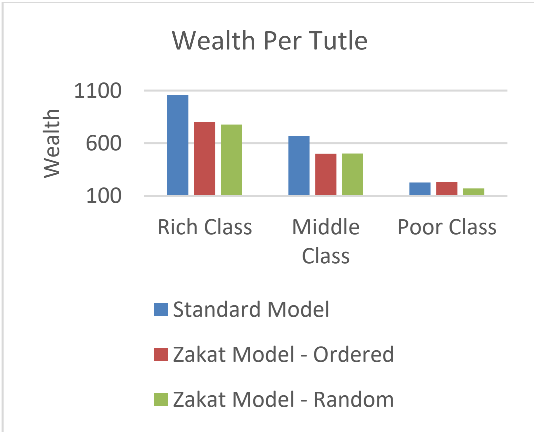

Figure 4. Per Capita Wealth

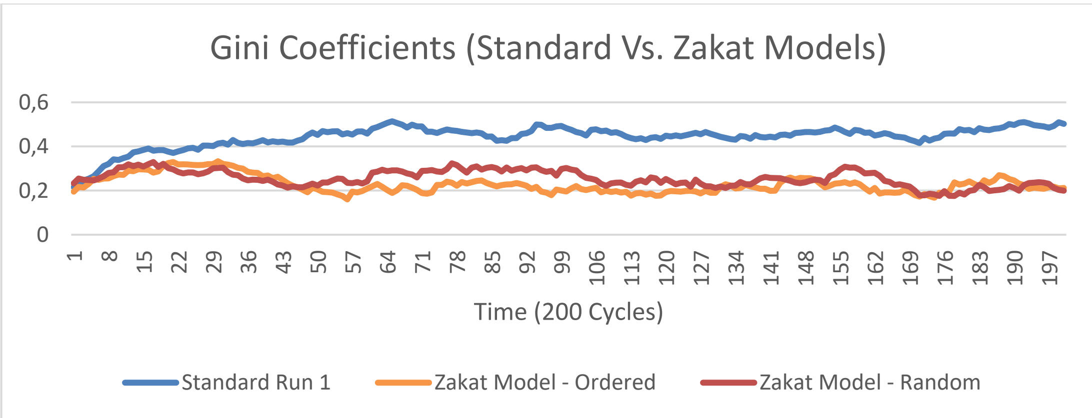

Figure 5. Gini Coefficients: Standard Model Vs. Zakat Model

A more precise measure of the inequality (or equality) in wealth distribution is Gini Coefficient. The value of Gini coefficient ranges from 0 to 1, with 0 representing perfect equality and 1 representing perfect inequality. The Gini coefficients of the representative runs of the three simulations are plotted in Figure 5.

Since initial wealth endowments are random, all the three models start with almost the same Gini Coefficient of around 0.2 and 0.25. However, the standard model approaches 0.4 within first 30 to 40 cycles in all the three runs, whereas both Zakat models revolve around 0.15 and 0.35. Average, highest and lowest Gini Coefficient values have been shown in Table 2.

Table 2. Gini Coefficients

Model	*Runs*	*Average*	*Maximum*	*Minimum*	*Model Initialized*
Standard Model	Run 1	0.4430	0.5014	0.2161	0.2161
	Run 2	0.4423	0.5141	0.2368	0.2368
	Run 3	0.4475	0.5443	0.2296	0.2296
Zakat Model – Ordered	Run 1	0.2331	0.2928	0.1737	0.1896
	Run 2	0.2158	0.2772	0.1626	0.2080
	Run 3	0.2276	0.3329	0.1601	0.1950
Zakat Model - Random	Run 1	0.2549	0.3294	0.1759	0.2081
	Run 2	0.2823	0.3505	0.2081	0.2460
	Run 3	0.2492	0.3163	0.1885	0.2330

Table 3. True Gini Coefficients (beyond 40 cycles)

Model	*Runs*	*Average (beyond Cycle 40)*	*Model Average*
Standard Model	Run 1	0.4621	0.4655
	Run 2	0.4667	
	Run 3	0.4677	
Zakat Model – Ordered	Run 1	0.2305	0.2206
	Run 2	0.2174	
	Run 3	0.2127	
Zakat Model - Random	Run 1	0.2784	0.2574
	Run 2	0.2454	
	Run 3	0.2484	

It is noted that minimum values across all the runs of standard model are initialized values, which means that the standard model never falls back to this value again. On the other hand, both the Zakat models assumes much lower values than the initialized ones. This reflects the potential of Zakat models of correcting imbalances in wealth distribution at the start of an economy.

However, these trends and averages are not the true reflection of the two models because it takes time for the model to get stable pattern once it starts from its initialized value. The pattern gets stable after the first 30 to 40 cycles. Average Gini values across all the six runs beyond first 40 cycles are produced below.

We conducted an independent sample t-test for comparison of these Gini averages across representative runs of the simulations. There was a significant difference in the averages

- for standard model (M=.4430, SD=.0502) and Zakat model – ordered, (M=.2276, SD=.0392); t=40.70, p <.001,
- for standard model (M=.4430, SD=.0502) and Zakat model – random, (M=.2550, SD=.0367); t=40.01, p <.001,

which confirms that the Average Gini coefficients of Zakat model are significantly different from that of Standard Model, further implying that the samples are representing two different populations.

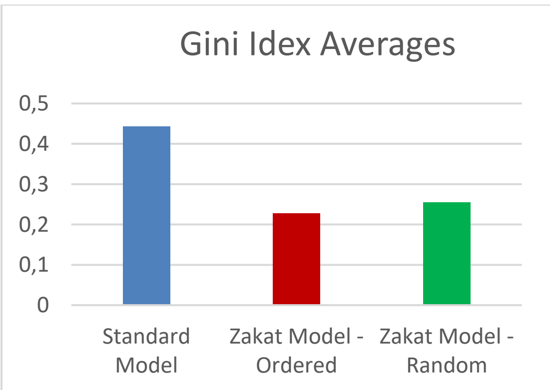

Figure 6. Average Gini Coefficients: Standard Model Vs. Zakat Models

Another important measure of the inequality (or equality) in wealth distribution is Lorenz Curve. Lorenz curves of the representative run each of standard and the two Zakat models have been produced in Figure 7 and Figure 8. The two figures have been drawn separately because the two Zakat model curves almost overlap after that first 20% on both axis. These curves clearly show the reduction in the area between the equality line and the Lorenz curve under the Zakat model (effectively the measure of Gini coefficients) when compared to the standard model. There's however, an initial dip in the curve which is because of the reduction in average wealth of poor under the two Zakat models in absolute terms. However, there's a relative increase in wealth together with reduction in number of poor agents.

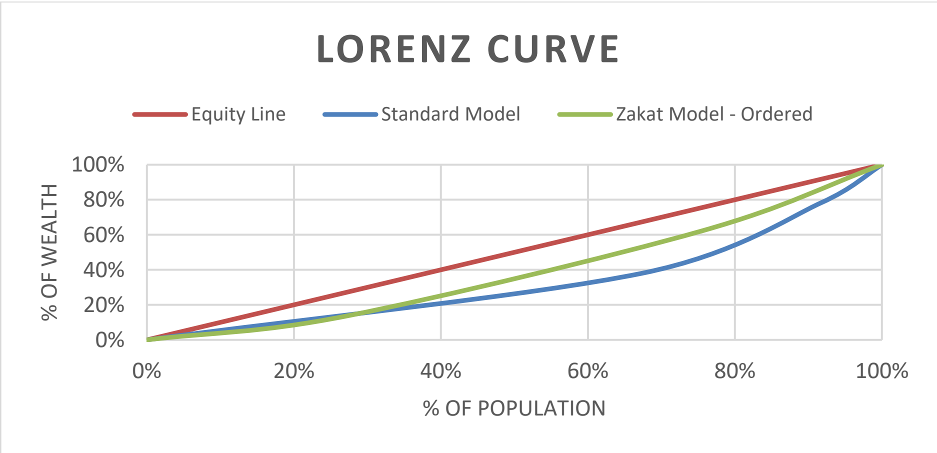

Figure 7. Lorenz Curves

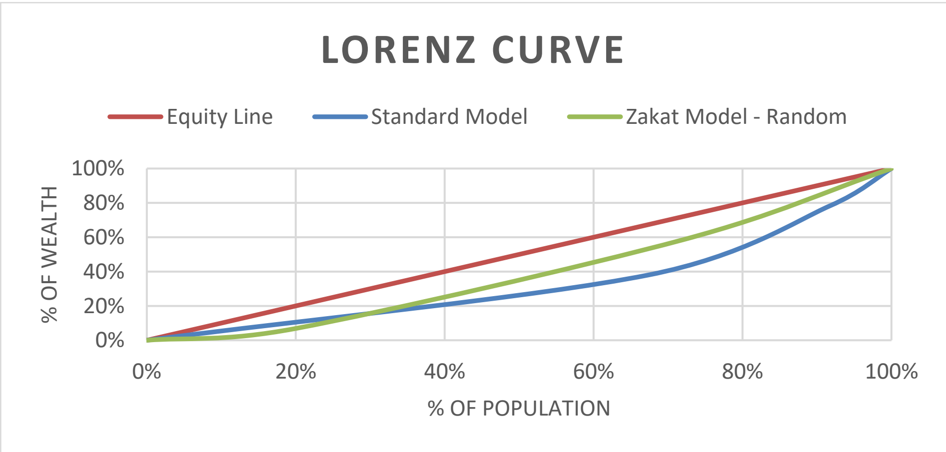

Figure 8. Lorenz Curve: Standard Model Vs. Zakat Model – Random

Table 4. Total Wealth

Models	*Runs*	*Initialized*	*Average*	*Compound Growth*
Standard Model	Run 1	5102	40346	7.9 times
	Run 2	4624	36882	8.0 times
	Run 3	4811	44182	9.2 times
Zakat Model - Ordered	Run 1	5339	55484	10.4 times
	Run 2	5230	52111	10 times
	Run 3	5132	52436	10.2 times
Zakat Model - Random	Run 1	4932	42065	8.5 times
	Run 2	5103	50996	10.0 times
	Run 3	4754	47601	10.0 times

Apart from reducing inequalities in wealth distribution, the Zakat model improved the model economy in one novel way. It increased the total wealth of the economy as a whole as compared to standard models. Following statistics summarize this fact.

Independent sample t-test was performed between the representative runs of the three simulations for comparing of means of total wealth. There was a significant difference in the averages

- for standard model (M=40346, SD=8070) and Zakat model – ordered (M=52436, SD=13866); t=-20.79, p <.001,
- for standard model (M=40346, SD=8070) and Zakat model – random (M=47601, SD=11210); t=-18.87, p <.001,

which confirms that these differences in total wealth are not a random phenomenon but are representing two different populations.

This finding is important and there is a theoretical explanation to it. Wealth is a resource which is a factor of production itself. Agents with more wealth have the potential to grow more by utilizing their wealth generation potential. This finding is important in the sense that charity is generally assumed to serve the purpose of redistribution of the wealth, but it surfaced that this redistribution eventually entails higher growth then in the standard model.

CONCLUSION & RECOMMENDATIONS

The simulations have shown the impact of charity (Zakat) on the pattern of wealth distribution. It normalized the power law distribution of wealth thereby reducing wealth inequalities. The simulations also showed a net increase in total wealth under the two Zakat models. The ordered Zakat model is an ideal scenario wherein charity is given to the poor in the order of their poverty (poorest first) and this model, as logically expected, has shown the highest potential to reduce wealth inequalities. However, random Zakat model, giving Zakat charity to a random poor agent which is more realistic, also showed significant impact on wealth distribution.

The Gini indices calculated under the standard model are very much closer to world bank statistics of such indices of big capitalist economies. For example, the estimates were 0.42 (2016) for US and 0.47 (2017) for China. Average Gini index emerged under the standard simulation was 0.46 which confirms the proximity of the model to the real world. The results of the experiments show that the introduction of a small charity (Zakat), as low as 2.5%, on the wealth of rich and in accordance with the disbursement principles laid down in Islamic Finance, has significant impact on this indicator is it reduced Gini index to around 0.22. The pattern of wealth distribution improved as

- Zakat reduced the relative size (number of agents) in the poor class and enhanced the size of the middle class
- it turned the power law distribution of wealth by reducing the big chunk of wealth condensed in rich class and enhancing the wealth in the poor and middle class, thereby forming a normal distribution of wealth.

The results also showed that such a redistribution also serves the purpose of growth as the total wealth under the charity (Zakat) model runs were higher than that in the standard model run.

The two Zakat models differ in the magnitude of their impact. Random model is relatively less impactful than the ordered model, but the former is more likely to be a real world phenomenon. Nevertheless, either model shown significant reduction in relative wealth inequalities.

These results stress the importance of non-conventional handling of the issue of wealth inequalities and poverty. Religious assertions offer a solution for some of the major economic problems, as such assertions are based on belief system and do not need much regulatory vigilance. On the other hand, taxing and other fiscal measures demand a lot of investments in ensuring compliance and usually also face resistance from the masses. As the charity of Zakat is guided by the spiritual landscape and not by any government or taxing authority, it is free from both of these limitations. Creating awareness for this religious responsibility and induing more people to pay Zakat is a win-win strategy for overcoming the poverty issue as it neither demands much regulatory vigilance nor does it face resistance from the individuals in an Islamic society. The governments in developing and underdeveloped Islamic states should seriously consider capitalizing on this divine guidance towards the solution of economic problems in their respective countries.

LIMITATIONS AND FUTURE RESEARCH

Simulations are rather very simplistic representations of real word phenomena and as such are limited in scope. This simulation, in special, is run in a very simplistic model of hunter-gatherer society and many of the dimensions of economic activity like production and work are ignored. The threshold for Zakat is also taken on relative basis which is not the actual case in Zakat regulations in Islam. However, such simplistic models bring forward the impact of study variables more prominently than complex models and therefore we have chosen to adhere to the KISS principle (Axelrod, 1997)

In real world, not all subjects in an economy are expected to comply with the Zakat requirements. There are other injunctions of charity even within Islamic Finance, known as Sadqa, the magnitude of which is not fixed but is over and above Zakat. A probabilistic model could be more realistic study in this context. Our work has laid down the foundations for doing more simulations in this direction.

In terms of the protocols of Zakat itself, the illustrated model is the simplest one. There are various variants as to the type of wealth, its magnitude, and applicable charity rates which have not been accounted for in this model. The model does not study the impact of other variables, like changing population, initial resources, agents' interaction preferences, vision etc.

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Muhammad Asif Jaffer
Institute of Business Administration,
Karachi, Pakistan
masif@iba.edu.pk