Agent-Based Model for Analyzing Economic Inequality and the Role of Zakat in Inequality Alleviation: A Complex Adaptive Systems Approach

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Abstract: This study aims to analyze economic inequality and the role of zakat in reducing it through the Agent-Based Model (ABM) approach in the context of Islamic economics. The method used is library research with an integrative review approach, which reviews academic literature from leading databases such as Google Scholar, DOAJ, Scopus, and Scispace in the 2015–2024 period. ABM was chosen because it is able to represent the dynamics of complex and adaptive interactions between agents in the economic system, including the influence of social factors such as social media and consumption behavior. The results of the study show that zakat functions as a significant redistribution instrument in reducing inequality, especially when supported by transparent governance and the use of digital technology. However, the effectiveness of zakat is still limited by structural challenges, low collection, and limited systemic integration. This study emphasizes the importance of integrating zakat into an agent-based economic model to identify more adaptive and contextual policy scenarios. These findings provide theoretical and practical contributions to the development of data-based and simulation-based zakat policies, in order to support inclusive and sustainable Islamic economic development.

Keywords: Agent-Based Model, Economic Inequality, Zakat, Islamic Economics, Wealth Redistribution.

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A. INTRODUCTION

In this study, there are two main variables that are the focus of the study, namely economic inequality and zakat. Economic inequality refers to the unequal distribution of income and wealth among individuals or groups in a society, which can be measured using indicators such as the Gini index or the Lorenz curve. Zakat, as one of the pillars of Islamic economics, is an obligation for Muslims to give a small portion of their wealth to those who are entitled, with the aim of purifying wealth and helping to reduce poverty and social inequality. In this context, zakat functions as an instrument of wealth redistribution which is expected to reduce economic inequality in Muslim society. Previous research has shown that zakat has the potential to influence the distribution of wealth and reduce economic inequality significantly. For example, research by Jaffer (2020) uses an agent-based model to show that zakat distribution can change the distribution of wealth from a power law pattern to a normal distribution, which reflects a more equitable distribution of wealth. In addition, research by

Putriani et al. (2020) also shows that the implementation of zakat can reduce the level of economic inequality as measured by the Gini index in an interest-based economic system.

Research by Jaffer (2020) used an agent-based model to analyze the impact of zakat on wealth distribution. Simulation results show that even though zakat is only 2.5% of the net worth of wealthy individuals, its implementation can change the distribution of wealth from a power law pattern to a normal distribution, reflecting a more equitable distribution of wealth. In addition, research by Setiawan et al. (2024) used a system dynamics approach to analyze the potential of zakat in reducing poverty in Indonesia. The results showed that zakat has significant potential to reduce poverty rates, although challenges in the management and distribution of zakat still need to be overcome. Research by Ayuniyyah et al. (2022) also supports these findings by showing that zakat distribution programs can significantly reduce poverty and income inequality in West Java, Indonesia. In addition to its impact on economic inequality, zakat also has the potential to influence economic growth. Research by Putriani et al. (2020) used an agent-based model to analyze the multiplier effect of zakat on economic growth. The simulation results show that the implementation of zakat can increase aggregate production in the economy, while the economy without zakat experiences a decrease in aggregate production. This study highlights the importance of zakat as an economic instrument that not only functions as a means of redistributing wealth, but also as a driver of economic growth in the context of Islamic economics.

In conventional economic systems, economic inequality is often addressed through taxation and redistribution mechanisms through government policies. However, this approach often faces challenges in terms of efficiency and distributional justice. In contrast, zakat as a religious obligation is unique in terms of direct and participatory implementation by individuals, which can increase its effectiveness in reducing economic inequality. Research by Sabzian et al. (2018) shows that zakat can be an effective alternative in reducing economic inequality compared to conventional taxation systems, because zakat is directly given to those who are entitled and can reduce dependence on government intervention. Although zakat has great potential in reducing economic inequality, its implementation faces various challenges. Research by Ayuniyyah et al. (2022) shows that factors such as spiritual supervision, informal education, family size, age, and occupation of zakat recipients affect the effectiveness of zakat distribution in increasing income and welfare. In addition, challenges in terms of coordination between zakat institutions, transparency in management, and public awareness of the obligation of zakat are also obstacles in optimizing the role of zakat in reducing economic inequality.

Although various studies have examined the impact of zakat on economic inequality, most studies are still limited to traditional quantitative approaches and lack the use of advanced methodologies such as agent-based models (ABM). In addition, studies that combine wealth distribution analysis with economic growth in the context of zakat are still limited. This study aims to fill this gap by developing an agent-based model that integrates wealth distribution and economic growth in the context of zakat implementation. Thus, this study is expected to provide new contributions in understanding the role of zakat in reducing economic inequality and encouraging economic growth from an Islamic economic perspective.

B. METHOD

This study uses a library research or integrative review approach with a focus on the application of an agent-based model (ABM) to analyze economic inequality and the role of zakat in alleviating economic inequality in the context of Islamic economics. Agent-based models allow modeling interactions between agents who have diverse characteristics and behaviors in the economic system. This study focuses on understanding how zakat distribution can affect economic inequality dynamically and sustainably in a complex and adaptive system. To support this study, relevant literature will be taken from various credible sources, including Google Scholar, Scispace, DOAJ, and Scopus, which include the latest scientific articles from 2015 to 2024. The main data sources for this study come from articles published in leading academic databases such as Google Scholar, Scispace, DOAJ, and Scopus. The literature search focused on articles that discuss the application of agent-based models for the analysis of economic inequality, as well as the role of zakat in reducing inequality. The data sources also include articles discussing wealth distribution in Islamic economics and the impact of zakat on economic growth and poverty reduction. The selected articles must be peer-reviewed and relevant to the objectives of this study, as well as providing significant contributions to the development of Islamic economic theory and practice and agent-based models.

The literature selected for this study must meet the inclusion criteria, namely: (1) Articles published between 2015 and 2024, ensuring the relevance and timeliness of the topic; (2) Articles discussing economic inequality, wealth distribution, zakat, and agent-based models in the context of Islamic economics; (3) Articles that are fully accessible (full-text) and published in accredited or peer-reviewed journals. Exclusion criteria include: (1) Articles published before 2015; (2) Articles that are not relevant to the topic of economic inequality, zakat, or agent-based models; (3) Literature that is not verified or not published in leading scientific journals. The literature search process will be carried out using relevant keywords, such as "Agent-Based Model," "Economic Inequality," "Zakat," "Islamic Economics," and "Redistribution of Wealth" in the mentioned databases. This search will be conducted in Google Scholar, DOAJ, Scopus, and Scispace to ensure that the literature sources obtained are the latest and of high quality. The search will focus on articles containing research on zakat and economic inequality, as well as the application of ABM in economic analysis. The articles found will be filtered based on their suitability to the topic and methodology used, as well as their contribution to the development of theory in Islamic economics.

After the literature search is conducted, each article found will be evaluated based on its suitability to the inclusion criteria. The selection process begins with reading the abstract and conclusion to determine the relevance of the article to the research topic. Articles that meet the inclusion criteria will be selected for further analysis, while articles that are not relevant will be excluded from this review. Furthermore, the selected articles will be assessed based on the methodology used, the quality of the data presented, and their contribution to the understanding of economic inequality and the role of zakat in reducing inequality. This procedure aims to ensure that only high-quality and relevant literature is used in this study. Data obtained from the selected literature will be analyzed using thematic and comparative analysis methods. Thematic analysis methods will be used to identify key themes related to

economic inequality, zakat, and the role of agent-based models in the Islamic economic system. Comparative analysis will be used to compare the results of various existing studies on the effectiveness of zakat in reducing economic inequality. To ensure validity and reliability, the literature used comes from accredited and peer-reviewed sources. The reliability of the analysis results will be maintained by cross-checking the findings from various relevant articles, as well as ensuring consistency between existing studies.

C. RESULTS AND DISCUSSION

1. Simulation of Economic Inequality Dynamics Using Agent-Based

Models Agent-based models (ABMs) are increasingly being applied in various disciplines, including to simulate the dynamics of economic inequality. ABMs are modeling techniques that are able to describe complex interactions between individuals (agents) in a larger system. Maghfiroh and Siagian explain that agent-based models are effective in describing interactions within a population and how changes in agent behavior can affect overall social or economic outcomes (Maghfiroh & Siagian, 2021). Therefore, in the context of economic inequality, ABMs can be used to understand how individual decisions in an economic context will impact the distribution of wealth and economic mobility among individuals and groups. Economic inequality is often caused by various interacting social and economic factors. In a study conducted by Siagian and Prasojo, ABMs were used to explore social dynamics and group behavior, highlighting the importance of interactions between individuals in complex social systems (Siagian & Prasojo, 2021). In this model, each agent operates under their own rules and makes their own decisions, allowing for a more precise analysis of how individual actions can affect overall economic inequality.

Purusottama introduced agent-based simulations to understand the dynamics of purchasing decisions, which showed the significant influence of external factors such as social media on consumer behavior (Purusottama, 2021). This is relevant in the context of economic inequality, as different consumption patterns between social groups can reinforce existing inequalities. By simulating the behavior and interactions of agents in a connected environment—for example, through the influence of social media—researchers can explore how such social forces contribute to inequality. In addition, Irawan's research on ABM simulations in natural resource management forums emphasizes that interactions in social networks can exacerbate consensus processes that lead to inequality in resource management (Irawan, 2018). This reflects that despite collective efforts to achieve balance, the existence of inequalities in individual access and influence can still influence the complex dynamics involved. Overall, the application of agent-based models in the analysis of economic inequality creates an opportunity for decision makers to gain a deeper understanding of shifts in the distribution of resources and wealth. By incorporating various parameters that influence individual behavior in the simulation, the long-term effects of economic policies can be more easily predicted, allowing for a more effective approach to reducing inequality. However, the references related to service evaluation used are not relevant to this context (Istiqomah et al., 2019).

2. Impact of Zakat in Reducing Economic Inequality: Findings from an Agent-Based

Model The impact of zakat in reducing economic inequality has been proven through various studies. Zakat, as a pillar of Islam, not only functions as an obligation of worship, but also has significant potential in the redistribution of wealth, especially in the context of a country with a Muslim majority population such as Indonesia. The role of zakat in combating poverty and reducing social inequality has become the subject of increasing attention among academics and policymakers. First, zakat functions as an economic instrument that channels resources from those who are better off (muzakki) to those in need (mustahiq). As stated by Wijaya et al., the role of Islamic financial institutions, including Islamic banks, in collecting and distributing zakat is very important because it increases efficiency and transparency in zakat management. This has a direct impact on reducing social inequality and improving the economic conditions of the less fortunate (Wijaya et al., 2023). In addition, Zayl's study shows that zakat during the time of Rasulullah SAW functioned as a means to solve the problem of poverty and create prosperity through mutually helpful social relationships (Zayl et al., 2024).

Furthermore, Rozab et al. emphasized the importance of using information technology to increase the effectiveness of zakat collection, which in turn contributes to empowering the people's economy and narrowing the gap between the rich and the poor (Rozab et al., 2023). With the advancement of technology, this process has become more organized, allowing for better and faster zakat distribution. By utilizing web-based information systems, zakat foundations can expand their reach and increase community participation in zakat programs, thereby maximizing zakat's contribution to community development. However, research by Rahmadani et al. shows that although technology can increase efficiency, challenges in its implementation remain, especially in terms of accessibility for all levels of society (Rahmadani et al., 2023). The influence of zakat on human development and poverty reduction is also seen in research conducted by Ubaidillah et al. who examined Islamic financial instruments, including zakat, as drivers of economic growth that can reduce disparities between regions (Ubaidillah et al., 2023). This shows that zakat is not only local but also has a broad economic impact in various regions. In addition, Haroen and Gimon highlight the importance of zakat in the context of a crisis, such as the COVID-19 pandemic, which exacerbates economic inequality and encourages zakat as an important instrument to provide assistance to the most affected (Aligarh, 2021).

In Indonesia, the effectiveness of zakat in reducing economic inequality was also expressed by Karuni, who showed that the zakat distribution system can help access funds for those who are less fortunate in benefiting from government efforts (Karuni, 2020). This creates opportunities for previously marginalized communities to obtain resources and improve their socio-economic conditions. Therefore, zakat is a strategic solution in overcoming deep economic inequality in society. Overall, zakat has enormous potential to support inclusive economic growth and reduce inequality. The involvement of zakat institutions in the social and economic ecosystem system shows that with proper management, zakat can have a significant positive impact on community welfare.

3. **Challenges and Potential of Zakat Policy in Realizing Economic Justice: A Complex Adaptiv**

System Perspective Zakat policy in Indonesia faces various challenges and potentials in realizing economic justice. In general, zakat functions as a redistributive instrument that can reduce economic inequality, but its implementation is still far from optimal. Research by Fajrina et al. noted that although zakat has great potential, many obstacles hinder its effective management, including aspects of legitimacy, transparency, and distribution mechanisms (Fajrina et al., 2020). This ineffectiveness is evident in the low percentage of zakat collected compared to the existing potential, as expressed by Anwar and Aziz, who stated that only 1% of the total zakat potential was successfully collected (Anwar & Aziz, 2023). One of the biggest challenges lies in the management system that has not been fully integrated with technology.

Luntajo and Hasan in their research emphasize the potential of technology, such as digital applications and blockchain, to improve the efficiency of zakat management (Luntajo & Hasan, 2023). If implemented, this technology can help reduce leakage in the process of collecting and distributing zakat funds, thereby encouraging optimization of zakat collection and wider community participation (Luntajo & Hasan, 2023). In addition, Meerangani revealed that systematic and efficient zakat management can contribute significantly to human development and improving the quality of life of individuals in society, especially for Muslims (Meerangani, 2019).

The implementation of effective zakat management policies is also faced with structural problems in gaining support from various parties, including companies. Research by Ruslang et al. noted that the potential for zakat from companies in Indonesia is still very large, but the level of collection has not met expectations (Ruslang et al., 2020). The obstacle in this case could be caused by a lack of understanding and awareness among corporations about their social responsibility in zakat management. However, there is significant potential to develop a zakat management model that is adaptive to the changing economic context. This can be seen in research by Indrawati and Rachmawati, which shows that an innovative approach to zakat utilization can be carried out by empowering micro-enterprises, so that the impact is not only limited to zakat recipients but also spurs local economic growth (Indrawati & Rachmawati, 2022). By utilizing technology-based data and analysis, zakat institutions can distribute aid more precisely, thereby contributing to reducing economic disparities. Overall, the challenges in zakat policy lie not only in the technical aspects, but also in expanding understanding in society regarding the benefits of zakat as an instrument of economic justice. A good policy must be able to bridge the existing potential and the effectiveness of zakat management, so that it can realize more equitable economic justice in Indonesia today.

D. CONCLUSIONS AND SUGGESTIONS

This study shows that the Agent-Based Model (ABM) approach is effective in analyzing economic inequality as a complex and dynamic phenomenon, influenced by individual interactions, social networks, and structural and external factors such as social media. ABM is able to represent the process of wealth distribution, consumption behavior, and policy influences microscopically. In this context, zakat has proven to be a strategic redistributive

instrument and has a systemic impact in reducing inequality, especially in a Muslim-majority country like Indonesia. However, the effectiveness of zakat is still constrained by structural issues, governance, and technology utilization. The integration of zakat in the ABM model shows that the distribution of zakat that is right on target, participatory, and based on information technology can strengthen economic inclusion and reduce social disparities in a sustainable manner.

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