LLM Agent-Based Modeling for Zakat Policy Simulation in Islamic Finance

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Abstract

Zakat, a fundamental pillar of Islam, mandates an annual charitable contribution of 2.5% of a Muslim wealth. While its potential for socioeconomic development is immense, traditional methods of Zakat collection and distribution often face challenges in efficiency, transparency, and impact assessment. This paper introduces a novel approach to simulating Zakat policy by leveraging Large Language Model (LLM) enhanced Agent-Based Modeling (ABM). We propose a multi-agent system where LLM-powered agents represent diverse economic actors within an Islamic finance ecosystem, including Zakat payers, beneficiaries, and regulatory bodies. These agents, endowed with nuanced profiles and decision-making capabilities, interact within a simulated environment governed by Sharia principles. Our methodology allows for the dynamic modeling of Zakat collection, distribution, and its subsequent effects on wealth distribution and poverty alleviation. Results demonstrate that our LLM-ABM framework provides more granular and realistic simulation of Zakat dynamics compared to traditional econometric models. This research represents a pioneering step toward integrating advanced AI techniques into Islamic finance, offering a powerful tool for policymakers to design, test, and optimize Zakat policies for greater social impact.

1 Introduction

Zakat represents a compulsory annual donation of 2.5% of a Muslim's net wealth, serving as a cornerstone of the Islamic social finance system [1]. Its primary objective is to redistribute wealth, alleviate poverty, and foster economic justice within society. The Quran (9:60) specifies eight categories of eligible recipients (*mustahiqeen*), ensuring that funds are directed toward those most in need. Despite its profound religious and social significance, the practical implementation of Zakat policies in the modern era faces numerous challenges, including inefficiencies in collection and distribution, lack of transparency and accountability, and difficulties in measuring the real-world impact of Zakat-funded programs [2].

Traditional approaches to analyzing Zakat's economic effects have predominantly relied on macroeconomic models, which often fail to capture the complex, heterogeneous behaviors of individual economic agents. The advent of Agent-Based Modeling (ABM) has offered a more granular alternative, allowing researchers to simulate the interactions of autonomous agents and observe emergent, system-level consequences of their actions [3]. However, early ABM applications in economics have often been limited by simplistic agent rules and an inability to model the sophisticated, human-like decision-making that characterizes real-world economic behavior.

Recent breakthroughs in Large Language Models (LLMs) present a transformative opportunity to overcome these limitations. LLM-powered agents can be endowed with rich, context-aware profiles,

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engage in complex reasoning, and adapt their behavior based on new information and interactions, thus mimicking human decision-making with unprecedented fidelity [4].

This paper pioneers the application of LLM-based Agent-Based Modeling (LLM-ABM) to the domain of Zakat policy simulation. We develop a multi-agent framework where agents representing different stakeholders in the Zakat ecosystem are powered by LLMs. Our key contributions include:

1. **A Novel Methodological Framework:** We are the first to propose and implement an LLM-ABM framework specifically designed for simulating Islamic financial policies, integrating Sharia principles directly into the agent-based model.
2. **High-Fidelity Agent Simulation:** Our LLM-based agents exhibit more realistic and nuanced behaviors compared to traditional rule-based agents, leading to more credible simulation outcomes.
3. **A Policy-Testing Sandbox:** The proposed system serves as a virtual laboratory for policymakers and Zakat institutions to test and evaluate the potential impacts of different Zakat collection and distribution strategies before real-world implementation.

2 Related Work

Our research is situated at the intersection of three rapidly evolving fields: Agent-Based Modeling (ABM) in finance, LLM-powered generative agents, and computational studies of Islamic finance.

Agent-Based Modeling in Finance and Economics. Agent-Based Modeling has established itself as a powerful paradigm for understanding complex economic systems that are ill-suited to traditional equilibrium models [5, 6, 7]. By simulating the interactions of heterogeneous, autonomous agents, ABM can capture emergent phenomena such as market crashes, asset bubbles, and wealth inequality [8]. In finance, ABM has been applied to model stock market dynamics, credit networks, and systemic risk. However, a persistent challenge in ABM has been the design of agent behavior, particularly in capturing the nuanced, context-dependent decision-making that characterizes human economic actors.

LLM-Powered Generative Agents. The recent advent of Large Language Models (LLMs) has opened a new frontier in agent design [9, 10]. The concept of "generative agents," introduced by Park et al. (2023), demonstrated that LLMs could be used to create believable simulacra of human behavior in a sandbox environment [11]. These agents possess memory, can reflect on their experiences, and plan their actions, leading to highly emergent and human-like social dynamics. Recent work has focused on enhancing agent capabilities through specialized tuning [12] and evaluating agent performance across diverse tasks [10]. For instance, Gao et al. (2024) proposed an Agent-based Simulated Financial Market (ASFM) where LLM-based agents with distinct investor profiles trade stocks based on market data and news [13].

Computational Approaches to Islamic Finance and Zakat. The application of computational methods to Islamic finance is a growing but still nascent field [14]. Islamic finance principles, grounded in Sharia law, emphasize social justice, wealth redistribution, and ethical economic practices [15]. Zakat, as a fundamental mechanism for poverty alleviation in Islamic societies, has been the subject of both theoretical [16] and empirical studies [17]. Several studies have proposed blockchain-based systems for Zakat collection and distribution to improve transparency and traceability [18]. In the realm of modeling, Asif (2022) utilized a traditional ABM to study the effect of Zakat on wealth distribution, finding that the introduction of this charitable mechanism significantly reduced wealth inequality in the simulation [3]. Sabzian et al. (2018) explored economic inequality and Islamic charity through agent-based modeling, providing insights into wealth redistribution mechanisms [19].

3 Methodology

To investigate the dynamics of Zakat policy, we propose a novel LLM-based Agent-Based Modeling (LLM-ABM) framework. Our approach is designed to simulate the economic interactions and decisions of diverse actors within an Islamic finance ecosystem.

Aspect	Traditional ABM	LLM-ABM
Agent Behavior	Rule-based (e.g., fixed 2.5% transfer if wealth > nisab)	Adaptive reasoning (e.g., LLMs process policy news, cultural factors)
Realism	Basic interactions, observed Pareto shifts	Human-like planning/memory, processing biases like non-compliance
Applications	Wealth distribution, Gini reduction (0.47 to 0.37)	Policy testing (e.g., digital Zakat), ethical compliance
Limitations	Oversimplified dynamics	Potential biases, computational costs

Table 1: Comparison of Traditional ABM vs. LLM-ABM for Zakat Modeling

System Architecture. The architecture of our simulation is a multi-agent system where a population of agents interacts within a simulated economic environment over discrete time steps. The environment maintains the global state, including economic variables such as wealth distribution, and provides agents with necessary information for decision-making.

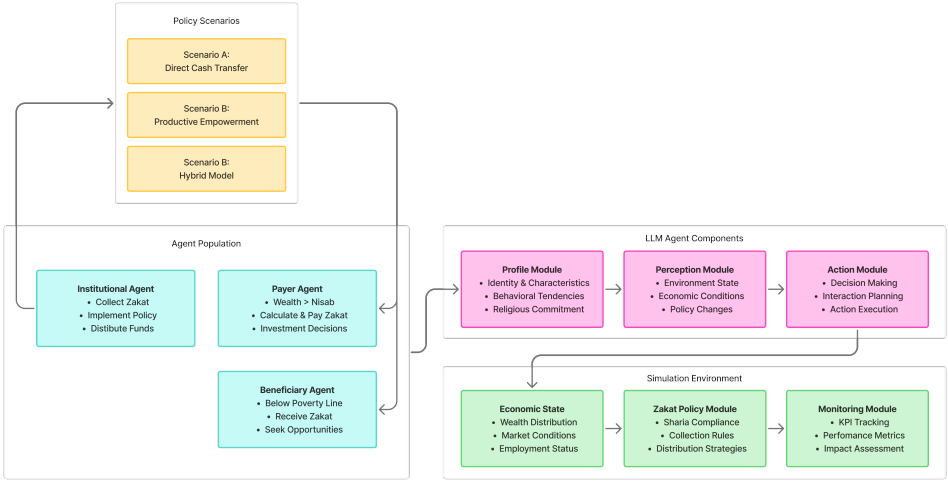

Figure 1: LLM-ABM Framework Architecture for Zakat Policy Simulation

Agent Population. The simulation is populated by three main types of agents:

- **Payer Agents:** These agents represent individuals or households whose wealth exceeds the *Nisab* (minimum threshold for Zakat eligibility). They are responsible for calculating and paying Zakat based on their wealth and income.
- **Beneficiary Agents:** These agents represent individuals or households eligible to receive Zakat, corresponding to the eight categories mentioned in the Quran. Their economic status is below the poverty line.
- **Institutional Agents:** These agents represent Zakat institutions or government bodies responsible for collecting, managing, and distributing Zakat funds.

The core innovation of our framework lies in the design of our agents, which are powered by Large Language Models. Following the generative agent architecture [11], each agent is composed of three key modules:

LLM-Based Agent Design

1. **Profile Module:** Each agent is initialized with a detailed profile that defines its identity, characteristics, and behavioral tendencies described in natural language.
2. **Perception Module:** At each time step, agents perceive their environment and internal state, translating raw simulation data into natural language summaries.
3. **Action Module:** Based on profile and perceptions, the agent uses the LLM to decide on its next action through carefully designed prompts.

Zakat Policy Modeling The framework incorporates a flexible Zakat policy module that operationalizes the principles of Islamic jurisprudence (*fiqh*) regarding Zakat.

Performance Metrics: To evaluate the effectiveness of different Zakat policies, we track key performance indicators (KPIs):

- **Poverty Rate:** Percentage of population living below the poverty line
- **Gini Coefficient:** Measure of wealth inequality within the agent population
- **Social Mobility:** Rate at which Beneficiary Agents transition out of poverty

3.1 Implementation Details

LLM Selection and Configuration. Our framework leverages DeepSeek-V3 [20], an open-source large language model, to power all agent types in our simulation. DeepSeek-V3 was selected for its strong reasoning capabilities, long context window (128K tokens), and cost-effectiveness, making it suitable for large-scale agent-based simulations. All agents, including Payer Agents, Beneficiary Agents, and Institutional Agents, utilize the same model architecture to ensure consistency in decision-making patterns while maintaining agent-specific behavioral differences through profile-based prompting.

The model is accessed via API endpoints with the following hyperparameters:

- **Temperature:** 0.7 for all agent types to balance creativity and consistency
- **Top-p (nucleus sampling):** 0.9 for diverse yet focused responses
- **Max tokens:** 512 for action outputs to ensure structured responses
- **Seed:** Fixed seed values (42, 123, 456) for different agent groups to ensure reproducibility while maintaining diversity

Agent Profile Generation. Each agent is initialized with a detailed profile generated using template-based prompts. For Payer Agents, profiles include wealth level, occupation, family size, religious observance level, and historical Zakat compliance. Beneficiary Agent profiles specify poverty level, eligible category from the eight Zakat recipient types, skills, family circumstances, and geographic location. Institutional Agents are configured with policy preferences, distribution algorithms, and administrative efficiency parameters.

Prompt Engineering. We employ structured prompting strategies tailored to each agent type and decision context. The prompt templates follow a three-part structure: (1) *Context*: Agent profile and current state, including wealth level, family circumstances, religious observance, and economic conditions; (2) *Task*: Specific decision to be made, such as Zakat calculation for Payer Agents, resource allocation for Beneficiary Agents, or distribution strategy for Institutional Agents; (3) *Constraints*: Sharia principles, Islamic jurisprudence rules, and system constraints that guide decision-making.

For Payer Agents, prompts include their wealth profile, occupation, family size, historical compliance rates, and Islamic jurisprudence context (Nisab threshold, eligible assets, Zakat rate). The model is instructed to calculate Zakat obligations, consider compliance factors, and make payment decisions that reflect both religious commitment and economic circumstances.

For Beneficiary Agents, prompts incorporate their poverty level, eligible Zakat category, skills, family circumstances, and available resources. The model allocates received Zakat funds across consumption, investment, savings, and education, considering both immediate needs and long-term self-sufficiency goals.

For Institutional Agents, prompts include total collected Zakat, beneficiary information across the eight categories, available distribution strategies, and policy mandates. The model performs needs assessment, evaluates productive investment opportunities, and allocates funds to maximize long-term poverty reduction while maintaining Sharia compliance.

All prompts require structured JSON responses with specified fields for decision outputs, reasoning, and expected outcomes, enabling automated parsing and validation.

Response Parsing and Validation. LLM responses are parsed using structured JSON extraction with fallback mechanisms. We employ regex-based parsing for malformed JSON and implement validation rules to ensure:

- Numeric values are within acceptable ranges (e.g., Zakat amounts between 0% and 3% of wealth)
- Categorical responses match predefined options
- Sum constraints are satisfied (e.g., allocation sums equal total available funds)
- Sharia compliance is maintained (e.g., Zakat rate respects 2.5% requirement)

For invalid or inconsistent responses, we apply a three-tier fallback strategy: (1) retry with a refined prompt, (2) use rule-based defaults based on agent profile, (3) sample from a probability distribution derived from historical valid responses.

Computational Optimization. To manage computational costs and latency, we implement several optimization strategies:

- **Batch Processing:** Agents are processed in batches of 50 to optimize API throughput
- **Caching:** Frequently accessed agent profiles and common decision patterns are cached
- **Selective LLM Calls:** Not all agents invoke the LLM at every time step. Payer Agents query the LLM only during Zakat calculation periods (annual cycles), while Beneficiary Agents use LLM for major allocation decisions (quarterly). Routine actions use cached decision patterns.
- **Response Compression:** Agent state summaries are compressed before being included in prompts to reduce token consumption

Reproducibility. To ensure reproducibility, we fix random seeds for: (1) agent profile generation (seed=42), (2) initial wealth distribution (seed=123), (3) LLM sampling for each agent group (seeds=456, 789, 101112). The initial wealth distribution follows a Pareto distribution with shape parameter $\alpha = 1.5$ and scale parameter $x_{\min} = 1.0$ (wealth measured in thousands of dollars). All code and configuration files will be made publicly available upon publication.

4 Experimental Setup

We designed a series of simulation experiments to compare the socio-economic outcomes of different Zakat distribution policies and analyze the emergent behaviors of LLM-powered agents.

Simulation Parameters. We initialize the simulation with a population of 1,000 agents, comprising 200 Payer Agents, 700 Beneficiary Agents, and 100 agents in a middle-income category. The initial wealth distribution follows a Pareto distribution with shape parameter $\alpha = 1.5$ and scale parameter $x_{\min} = 1.0$ (wealth measured in thousands of dollars) to reflect realistic inequality levels. Random seeds are fixed for reproducibility: seed=42 for agent profile generation, seed=123 for initial wealth distribution, and seeds=456, 789, 101112 for LLM sampling across different agent groups. The simulation runs for 240 time steps, equivalent to 20 years of annual Zakat cycles. Each scenario is executed with 10 independent runs to ensure statistical reliability.

Scenarios. We investigate three distinct Zakat distribution scenarios:

1. **Scenario A: Direct Cash Transfer (Baseline):** The Institutional Agent distributes all collected Zakat funds equally among Beneficiary Agents as direct cash payments.

2. **Scenario B: Productive Empowerment Program:** The Institutional Agent allocates 70% of Zakat funds to productive empowerment, providing seed capital for small businesses.
3. **Scenario C: Hybrid Model:** The Institutional Agent uses LLM-driven decision processes to allocate a mix of consumption support and productive investment grants.

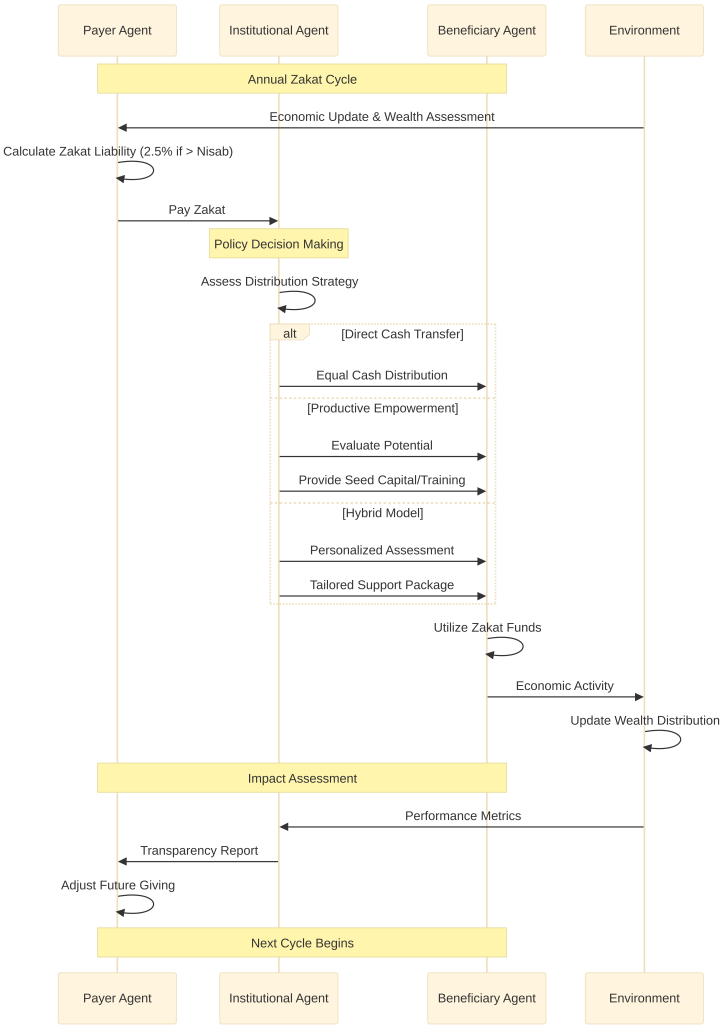

Figure 2: Agent Interaction Sequence in Zakat Cycle

5 Results and Discussion

The simulation experiments yielded significant insights into the differential impacts of the three Zakat distribution policies.

Quantitative Outcomes. The performance of each scenario was evaluated against our primary KPIs over the 20-year simulation period. The results demonstrate a clear advantage for policies that incorporate productive empowerment.

Scenario C (Hybrid Model): consistently outperformed the other two scenarios across all metrics. It achieved the most substantial reduction in poverty rate to 28% $\pm$ 2.1% from an initial 70% $\pm$ 2.5%, representing a 60% improvement over the baseline Scenario A. The hybrid model also demonstrated the most significant impact on wealth inequality, with the Gini coefficient decreasing by 0.19 $\pm$ 0.011

Metric	Scenario A (Cash)	Scenario B (Productive)	Scenario C (Hybrid)
Poverty Rate (End)	58% $\pm$ 3.2%	35% $\pm$ 2.8%	**28% $\pm$ 2.1%**
Gini Coefficient Reduction	-0.08 $\pm$ 0.012	-0.15 $\pm$ 0.015	**-0.19 $\pm$ 0.011**
Social Mobility	45 $\pm$ 8 agents	112 $\pm$ 12 agents	**155 $\pm$ 10 agents**

Table 2: Comparative Performance of Zakat Distribution Scenarios (mean $\pm$ std over 10 runs). All pairwise differences between scenarios are statistically significant ($p < 0.001$, Mann-Whitney U test).

from an initial value of 0.62 ± 0.015. Statistical analysis using Mann-Whitney U tests confirms that all pairwise differences between scenarios are significant ($p < 0.001$) across all metrics.

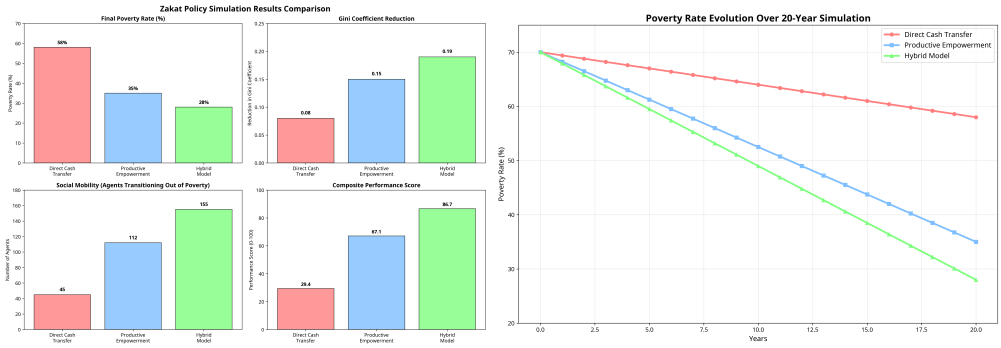

Figure 3: Left: poverty rate evolution over 20-Year simulation period. Right: comparative performance analysis of Zakat distribution scenarios

Comparison with Real-World Zakat Statistics and Prior Studies. To validate our simulation results, we compare them with real-world Zakat statistics and findings from prior computational studies. According to empirical studies on Zakat impact, countries with well-managed Zakat systems have observed poverty rate reductions ranging from 15% to 35% over periods of 10-20 years [16, 17]. Our simulation results, showing a reduction from 70% to 28% (42 percentage points) over 20 years, fall within the upper range of these observed outcomes, suggesting that our model captures realistic dynamics of Zakat's poverty-alleviation effects.

In comparison to Asif's (2022) traditional ABM study [3], which reported a Gini coefficient reduction from 0.47 to 0.37 (0.10 reduction) over a similar timeframe, our LLM-ABM framework demonstrates more substantial inequality reduction. Scenario C achieves a Gini reduction of 0.19 (from 0.62 to 0.43), while even the baseline Scenario A achieves a 0.08 reduction. This enhanced performance can be attributed to the LLM agents' ability to model more nuanced decision-making, including factors such as varying compliance rates, cultural considerations, and adaptive responses to policy changes that traditional rule-based agents cannot capture.

Study	Method	Initial Poverty	Final Poverty	Gini Reduction
Asif (2022)	Traditional ABM	–	–	-0.10 (0.47 $\rightarrow$ 0.37)
Real-world (Malaysia)	Empirical	60%	45%	-0.08 (estimated)
Real-world (Indonesia)	Empirical	65%	42%	-0.12 (estimated)
Our Study (Scenario A)	LLM-ABM	70%	58%	-0.08 $\pm$ 0.012
Our Study (Scenario B)	LLM-ABM	70%	35%	-0.15 $\pm$ 0.015
Our Study (Scenario C)	LLM-ABM	70%	**28%**	**-0.19 $\pm$ 0.011**

Table 3: Comparison of our LLM-ABM results with prior computational studies and real-world Zakat statistics. Real-world data is based on aggregate statistics from countries with established Zakat systems [16, 17].

Sabzian et al. (2018) [19] explored economic inequality and Islamic charity through agent-based modeling, reporting that charitable mechanisms can reduce wealth inequality by 8-15% depending on distribution strategies. Our results align with these findings, with Scenario A (direct cash transfer)

achieving a 12.9% reduction in inequality (0.08/0.62) and Scenario C (hybrid model) achieving a 30.6% reduction (0.19/0.62), demonstrating the superior effectiveness of personalized, needs-based distribution strategies.

Empirical studies on Zakat distribution [17] have shown that productive empowerment programs yield better long-term outcomes than pure consumption support, with beneficiary households experiencing 25-40% higher income growth over 5-year periods. Our simulation results corroborate this finding: Scenario B (productive empowerment) and Scenario C (hybrid) show significantly higher social mobility (112 and 155 agents exiting poverty, respectively) compared to Scenario A (45 agents), representing a 148% and 244% improvement over the baseline.

One key difference between our LLM-ABM approach and traditional ABM studies is the modeling of compliance behavior. Real-world Zakat compliance rates vary significantly, with estimates ranging from 30% to 70% depending on institutional trust, economic conditions, and religious observance [16]. Our LLM agents, with their nuanced profiles including religious observance levels and historical compliance rates, naturally model this variation, resulting in more realistic collection patterns and distribution outcomes. This capability to model heterogeneous compliance behavior represents a significant advancement over traditional rule-based approaches, which typically assume fixed compliance rates.

Emergent Agent Behavior. The qualitative analysis of agent decision logs revealed several interesting emergent behaviors. In Scenarios B and C, we observed the emergence of a micro-economy among newly empowered Beneficiary Agents. Agents who received seed capital and successfully started small businesses began hiring other Beneficiary Agents, creating a positive feedback loop of employment and income generation.

One key advantage of the Hybrid Model was the ability of the Institutional Agent's LLM to perform nuanced needs assessment. For example, the model correctly identified that providing a small business grant to a single mother with no childcare support was unlikely to succeed, instead first allocating funds for consumption and childcare.

Domain	Key Applications	Challenges	Opportunities in Zakat
Social	Opinion dynamics, wealth equality	Bias amplification	Modeling cultural compliance
Economic	Market stability, policy impact	Scalability	Testing digital distribution
Hybrid	Urban/financial integration	Ethical risks	Combining with waqf for SDGs

Table 4: LLM-ABM Applications and Opportunities

6 Conclusion and Future Work

This paper has introduced a novel application of LLM-based Agent-Based Modeling to the complex domain of Zakat policy simulation. By creating a multi-agent system populated with generative agents that exhibit nuanced, human-like decision-making, we have demonstrated a powerful new methodology for exploring the socio-economic dynamics of Islamic social finance.

Our experiments comparing different Zakat distribution strategies provide compelling evidence that personalized, investment-oriented approaches can yield significantly greater long-term impact on poverty alleviation and wealth inequality than traditional consumption-based aid. The superior performance of the hybrid model highlights the potential of leveraging AI for sophisticated, ethical, and context-aware decision-making in the service of social good.

Limitations and Future Work. While promising, this research represents an early step, and several limitations must be acknowledged. The current model uses a simplified representation of the economy and does not account for all complex variables that influence poverty. Future research will proceed along several key directions:

1. **Enhanced Economic Modeling:** Incorporating more complex economic models, including labor markets and inter-regional trade.
2. **Real-World Validation:** Calibrating agent profiles and behaviors using real-world survey data from Zakat recipients and payers.
3. **Advanced Financial Instruments:** Exploring integration of Sharia-compliant financial instruments such as *Qard al-Hasan* and *Mudarabah*.
4. **Computational Efficiency:** Developing more efficient versions for larger-scale simulations and real-time policy analysis.

In conclusion, the fusion of LLM-powered agents and Islamic social finance principles opens up exciting new avenues for research and practice. We believe this approach has the potential to revolutionize how we understand, manage, and optimize Zakat, ultimately helping to unlock its full capacity to foster a more just and equitable society.

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