A New Crowdfunding Model for Financial Inclusion Based on Donations and Interest-Free Debt: A Fuzzy Agent-Based Simulation Approach

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A NEW CROWDFUNDING MODEL FOR FINANCIAL INCLUSION BASED ON DONATIONS AND INTEREST-FREE DEBT: A FUZZY AGENT-BASED SIMULATION APPROACH

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ABSTRACT

Purpose — Although microfinance was initially heralded as a promising methodology for reducing poverty, it has become increasingly criticised. Hence, calls for innovative models that promote financial inclusion have intensified. This research aims to fill in this gap by developing a new model that combines donation-based crowdfunding with interest-free lending, and subsequently evaluating its performance using appropriate decision-making tools.

Design/Methodology/Approach — The study adopts an agent-based perspective whereby the idea is to encode the behaviour and decisions of the model's entities in straightforward rules and subsequently analyse the outcomes of their interactions through agent-based simulation (ABS). To address the uncertainty inherent in human agents' judgements, a fuzzy logic inference system has been incorporated as well.

Findings — Findings show that the proposed model has (i) a better success rate in funding new entrepreneurs, (ii) higher collection of management fees, and (iii) a reduced number of failed projects. This model incorporates monitoring to reduce moral hazard risks and provides health and life insurance for entrepreneurs, ensuring both project efficiency and the well-being of the entrepreneurs.

Originality/Value — This study contributes to the Islamic crowdfunding (ICF) literature by introducing a new hybrid model that integrates donations with interest-free loans. It explores the impact of this design on crowdfunding platform success and the well-being of micro-entrepreneurs, using an agent-based perspective.

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Research Limitations/Implications — Despite its merits, the proposed model has certain limitations. Like many crowdfunding models, entrepreneurs who fail to secure financing may be susceptible to the risk of idea theft. Concerning model validation, although a significant portion of the model's data is calibrated using real data, the conception and simulation introduce certain free parameters (such as the learning factor and monitoring efficiency), which renders the validation process somewhat challenging.
Practical Implications — This innovative solution can help crowdfunding platforms refine their policies and interventions to enhance project funding success and contribute significantly to broader financial inclusion efforts.
Keywords — Agent-based simulation, Donation-based crowdfunding, Financial inclusion, Fuzzy logic, Interest-free loan, Microfinance
Article Classification — Research paper

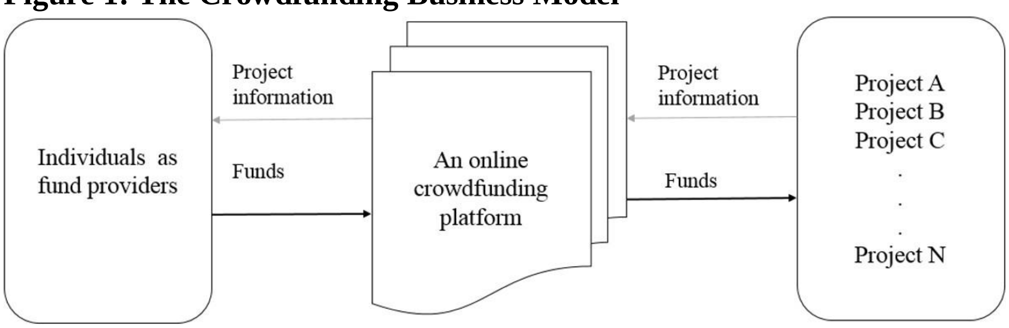
INTRODUCTION

Microfinance schemes fund sections of the society who are unable to access classical channels of financing such as banks due to the lack of collateral, guarantors and/or prior credit history (Wijesiri *et al.*, 2017; Mohammed & Wobe, 2023). This challenge of accessing formal financial services is even greater for those at the bottom of the societal pyramid (Jackson & Young, 2016). At risk of being excluded from the formal loan market, this group often finds itself obliged to borrow through informal means, usually at higher interest rates (De Aghion, 1999; Mia & Lee, 2017). The high interest payments required, however, further exacerbate their poverty level. While microfinance is seen as a mechanism to alleviate poverty and foster development (Mohammed & Wobe, 2023), its role has been largely criticised in the last decades (Bourhime & Tkiouat, 2018), especially in Muslim countries where scepticism about interest-based microfinance loans is high. This leads a large population to be self-excluded from traditional microfinance. Obaidullah (2008) emphasises that the adoption of Islamic banking, as an interest-free system, may help promote financial inclusion through its microfinance programmes. However, Marom (2013) highlights that there is little concrete evidence that microfinance alone can do the job—a view supported by Yunus (2009), who stresses the necessity of additional financial resources to achieve meaningful impact.

Given these limitations, crowdfunding has emerged as a fintech-based solution that democratises capital by connecting individual funders to projects via online platforms (**Figure 1**). According to Massolution (2015), crowdfunding platforms raised USD16.2 billion in 2014, a 167 per cent increase from 2013, and USD34.4 billion in 2015, more than doubling the amount raised in 2014.

Crowdfunding addresses financial exclusion by enabling entrepreneurs to access funding without relying on traditional financial institutions, which often fail to meet specific lending needs due to high costs and risk concerns (Guenther *et al.*, 2018). It is expected to enhance the availability of funds for microfinance operations by using the power of the crowd and democratising the accessibility to capital (Marom, 2013; Felipe *et al.*, 2017; Abdeldayem & Aldulaimi, 2023).

Figure 1: The Crowdfunding Business Model



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With the rising popularity of crowdfunding as an alternative financing option, several studies have been conducted to seek a more in-depth understanding of its theoretical aspects to provide useful guidance for fundraisers, donors, investors, and crowdfunding platform administrators.

The aim is to improve crowdfunding's success by helping more projects to reach their funding goals. Various studies seek to identify and explain the determinants of crowdfunding success and failure, especially those related to the fundraisers and their projects (Xie *et al.*, 2019; Shneor & Vik, 2020; Zhang *et al.*, 2020; Pinkow & Emmerich, 2021; Ryoba *et al.*, 2021; Cosma *et al.*, 2022; Dos Santos Felipe *et al.*, 2022). Other studies focus on predicting fundraising outcomes (i.e., success or failure) (Cheng *et al.*, 2019; Silva *et al*., 2020; Mukherjee *et al*., 2020; Guo *et al.*, 2020; Wang *et al.*, 2020; Song *et al.*, 2020; Woods *et al*., 2020; Gürler & Çağlar, 2021; Bao *et al.*, 2022; Oduro *et al.*, 2022; Tang *et al.*, 2022).

Despite its potential benefits, donation-based crowdfunding—a significant alternative for microbusiness financing—remains underexplored compared to equity or reward-based crowdfunding (Zhang *et al.*, 2020; Kamarubahrin *et al.*, 2023; Hossain *et al.*, 2024). Moreover, existing crowdfunding mechanisms are often constrained by suboptimal donation distribution systems and platform policies, which may limit their effectiveness in addressing financial exclusion (Wash & Solomon, 2014; Lee *et al.*, 2016). Wash and Solomon (2014) explain that platforms with an 'all-or-nothing' policy (e.g., Kickstarter) require fundraisers to reach a specific funding goal to receive any donations, which can encourage donors to contribute to more projects, including higher-risk ones, but may spread contributions too thinly across multiple projects. In contrast, a 'keep-it-all' policy (e.g., Indiegogo) allows creators to retain whatever funds are raised, even if the goal is not met, incentivising donors to coordinate to fully fund projects in markets with limited total donations. This research addresses these gaps by introducing a novel hybrid crowdfunding model that integrates donation and interest-free lending.

Specifically, this research aims at developing a new model that combines donation-based crowdfunding with interest-free lending, and subsequently evaluating its performance using appropriate decision-making tools. The primary objectives of the proposed model are to:

i. overcome the challenges associated with traditional donation-based systems;
ii. create additional funding opportunities for entrepreneurs;
iii. offer insurance benefits to backers; and
iv. reduce moral hazards associated with funding projects.

The performance and effectiveness of the proposed model are demonstrated through a comparison with a purely traditional donation-based model, using a fuzzy agent-based simulation. By bridging the gaps in existing crowdfunding literature, this study contributes to refining platform policies and improving the success rate of projects funding.

The remainder of this paper is organised as follows: the second section presents the literature review; the third section introduces the adopted methodology; the fourth section presents the results and discussion, and the fifth section concludes the study, addressing its limitations and offering suggestions for future research.

LITERATURE REVIEW

Crowdfunding as an Alternative Financing Mechanism

Crowdfunding has rapidly emerged as a popular alternative financing mechanism, offering a platform for diverse projects and initiatives to raise capital through a wide range of models.

While these models generally follow a similar overall process, they differ in terms of objectives, ranging from purely donation-based approaches to profit-oriented ones (Jovanovic, 2019). Based on the review of crowdfunding literature, these models can be categorised into four main types:

- Donation-based crowdfunding: It is a prevalent contemporary approach for raising funds, engaging donors from diverse geographies to make financial contributions (Behl *et al.*, 2022). Donors give their money based on pure charity, expecting nothing in return except self-satisfaction (Astrauskaite & Paškevičius, 2018). Donors usually also have a social or personal motivation (Wahjono & Marina, 2017).
- Debt-based crowdfunding: Also known as peer-to-peer (P2P) lending, under this platform, lenders receive their principal with interest (Astrauskaite & Paškevičius, 2018).
- Equity-based crowdfunding: Investors give their money in exchange for equity or revenue sharing.
- Reward-based crowdfunding: Individual investors do not receive financial returns, but rather, receive rewards in the form of products, or services proposed by the project (Chan *et al.*, 2018). This type of crowdfunding has become not only a financing tool but also a marketing tool that is similar to group buying and pre-sales (Li & Cao, 2023).

Except for debt-based crowdfunding, all other models are accepted in Islamic jurisdictions (Saiti *et al.*, 2018). Abdeldayem and Aldulaimi (2023) assert that, from an Islamic perspective, crowdfunding is highly encouraged as it nurtures generosity and encourages collaboration. However, they stress the necessity of ensuring that all crowdfunding practices strictly adhere to Sharīʿah (Islamic law) principles. Purwatiningsih *et al.* (2024) define Islamic crowdfunding (ICF) as a financing model that combines technology with Islamic principles and ethics to support socially responsible and inclusive initiatives. Various Islamic contracts (e.g., *mushārakah*, *muḍārabah*, *ṣadaqah*, *qarḍ ḥasan*) are used to build mechanisms for ICF platforms. ICF platforms are also advised to have a Sharīʿah board to ensure that all projects align with Sharīʿah principles and are not prohibited (Wahjono & Marina, 2015; Arzam *et al.*, 2023). ICF offers a Sharīʿah-compliant alternative for financing startups, promoting ethical values such as risk-sharing and avoiding interest-based transactions. It provides an inclusive platform for entrepreneurs, particularly those with limited access to traditional financing, enabling innovation and economic growth (Arzam *et al.*, 2023; Djaber & Lotfi, 2023).

Some notable ICF platforms include Yomken, Liwwa, EthisCrowd, KapitalBoost, Shekra, and Danadidik (Muneeza *et al.*, 2018). ICF can offer practical solutions for bridging funding gaps, especially for small projects and startups, by leveraging fintech innovations such as blockchain technology.

Many factors influence the viability of crowdfunding platforms and the success of projects. These include project characteristics, such as compelling descriptions, status, quality, and geographical proximity, which significantly impact donor engagement (Felipe *et al.*, 2017; Courtney *et al.*, 2017; Di Pietro, 2019). Donor behaviour is shaped by empathy, perceived credibility, campaign popularity, content quality, and herding behaviour, where individuals are influenced by others' funding decisions (Renwick & Mossialos, 2017; Chan *et al.*, 2018; Bao *et al.*, 2022; Arzam *et al.*, 2023). Platform parameters like funding goals, campaign duration, minimum investment amounts, and effective marketing also play critical roles in ensuring success (Wati & Winarno, 2018; Purwatiningsih *et al.*, 2024). In ICF, shared values, social capital, and religiosity further enhance donor appeal (Purwatiningsih *et al.*, 2024).

While it holds significant potential, ICF faces several challenges, including Sharīʿah supervision, regulatory issues, limited public awareness, inadequate marketing efforts, and technological barriers such as internet access in developing regions (Purwatiningsih *et al.*, 2024; Hossain *et al.*, 2024). Trust issues, low financial literacy, and transparency concerns between investors and entrepreneurs add to these difficulties (Alshater *et al.*, 2022). However, robust management, strategic marketing, and effective risk management can address these obstacles and position ICF as an ethical funding alternative (Arzam *et al.*, 2023; Djaber & Lotfi, 2023).

Blockchain technology offers transformative solutions for crowdfunding platforms, particularly ICF. As a decentralised, secure ledger, it ensures transaction transparency, traceability, and immutability. Features like smart contracts and cryptocurrencies automate processes, eliminate intermediaries, and reduce fraud risks (Muneeza *et al.*, 2018; Sanjaya & Akhyar, 2022). Blockchain also aligns with Sharīʿah principles by promoting ethical operations and fair contract management (Unal & Aysan, 2022; Said, 2023). Its integration with technologies such as artificial intelligence, big data, and internet of things (IoT) expands its potential applications (Hassan *et al.*, 2022). Platforms like Ata Plus and Crowdo in Malaysia demonstrate blockchain's ability to enhance trust, efficiency, and operational transparency (Muneeza *et al.*, 2018).

Agent-Based Modelling

The success of crowdfunding platforms hinges on the effective interaction and collaboration between three participating agents: donors, entrepreneurs, and the crowdfunding platform (Xie *et al.*, 2019; Zhang *et al.*, 2020). These interactions are dynamic and can be influenced by various factors such as donor behaviour, entrepreneur strategies, and platform policies. Agent-based modelling allows researchers to model these interactions in a detailed and nuanced way, revealing how donors' and entrepreneurs' behaviour, and platform designs, affect outcomes. According to Yen *et al.* (2017), agent-based modelling can simulate and reproduce the dynamics of a crowdfunding system without affecting the actual system, making it highly effective for scenario analysis. Consequently, this approach may provide valuable insights into how to optimise strategies for increasing funding success and system resilience.

An agent-based model (ABM), as its name suggests, relies on computer simulation involving agents interacting as autonomous decision-making bodies with behavioural rules (Wilensky, 2015). In this model, for example, entrepreneurs serve as agents with attributes such as 'project', 'wealth', and 'productivity', along with a decision-making process for selecting new projects. Macal and North (2006) highlight that the pivotal characteristic of an agent resides in its ability to autonomously make decisions, spanning from basic rules to complex adaptive ones. To ensure the reliability of outcomes in an ABM, it is crucial to follow specific foundational steps:

Choosing ABM: ABM is a valuable option for addressing a problem involving autonomous and diverse entities (agents) evolving over time, and when there is interest in both their micro-level behaviour and the outcomes of their interactions (macro-level patterns) (Rand & Rust, 2011; Wilensky, 2015). ABM is particularly well-suited for situations where interactions between agents is non-linear, allowing them to learn from past experiences and adjust their strategies.

***Designing the model*:** This step is key in developing an ABM (Macal & North, 2006). This is where the model's agents, their properties, their behaviour and the environment in which they operate are identified. These are important for identifying the inputs as well as the outputs of the model.

***Choosing a simulation software*:** Numerous ABM toolkits are available, including SWARM, Mason, Repast, and NetLogo. However, NetLogo is the most widely used (Wilensky, 2015). Using monitors and plots, the NetLogo interface allows better dynamic visualisation of the agents' interaction results.

***Validating and verifying the model*:** To assess the performance of an ABM and enhance confidence in its simulation, two key activities are typically carried out: verification and validation. Validation involves confirming whether the conceptual model and simulation output faithfully represent the real world (Zou *et al.*, 2014). Verification, on the other hand, is the process of ascertaining whether the simulation code or implemented model aligns with the conceptual model (Zou *et al.*, 2014), ensuring that the programme performs as intended (David, 2006).

According to Xiang *et al.* (2005) and Yilmaz (2006), verification refers to solving 'the problem right' while validation deals with solving 'the right problem'. By fulfilling both activities, the model can become a tool that aids in decision-making (Rand & Rust, 2011). However, Rand and Rust (2011) argue that both validation and verification have the possibility of falsifying the proposed model. Ormerod and Rosewell (2006) note that there is no universal way to validate an ABM. To remedy such shortcomings, several methods are used to ensure the viability of the validation and verification process:

- Empirical input validation relies on calibrating the model's inputs to actual and real data (Rand & Rust, 2011).
- Empirical output validation relies on comparing the model's output to real data when they become available or to an already validated model (Rand & Rust, 2011). The model is also considered valid if it produces a clear stylised fact (e.g., an S-shaped technology adoption curve).
- Face validity relies on expert opinion as to whether the model's output is an adequate representation of reality (Xiang *et al.*, 2005; Yilmaz, 2006; Epstein, 2008; Rand & Rust, 2011).
- Sensitivity analysis involves changing the values of the input parameters and observing the effect on the model's outputs to identify zones of uncertainty and thresholds (Xiang *et al.*, 2005; Epstein, 2008). Validating an ABM is not a straightforward task, especially for events with no past occurrence. Thus, a good description of the model design and its implemented code is an important part of the validation process (Ormerod & Rosewell, 2006; Rand & Rust, 2011).

Although ABMs are extensively used in academic research, their application in crowdfunding is relatively limited. A review of the literature reveals only a few notable studies. Lee *et al.* (2016) employed agent-based modelling to assess the impact of different donation distribution methods on the success of donation-based crowdfunding. Yen *et al.* (2017) developed an ABM to explore how factors such as project visibility, perceived quality, and donor strategies affect the efficiency and success of crowdfunding platforms. Theerthaana and Sheik Manzoor (2020) used an ABM to forecast crowdfunding adoption by examining individual preferences and risk perceptions. Lamrani Alaoui *et al.* (2020) introduced an ABM for project selection in donation-based crowdfunding platforms. Koch *et al.* (2021) created an ABM to evaluate the performance of a new funding redistribution mechanism on crowdfunding platforms.

METHODOLOGY

Model Description

The model developed in this research is an extension of the crowdfunding models developed by Lutfi and Ismail (2016) and Lamrani Alaoui *et al.* (2020). The main goal of the proposed model is to ensure more entrepreneurial financing while maintaining the provision of health and life insurance for entrepreneurs. The model is based mainly on two Islamic contracts: *ṣadaqah* (donation) and *qarḍ ḥasan* (interest-free loan). In contrast to zakat (compulsory annual levy on wealth) and waqf (perpetual trust), *ṣadaqah* is a flexible form of charity without any pre-specified restrictions from Islamic law (Lutfi & Ismail, 2016; Sulaeman, 2020). Furthermore, *qarḍ ḥasan* appears to be more appropriate for funding microentrepreneurs who have good potential to make full repayment (Naciri, 2016). Arzam *et al.* (2023) note that *qarḍ ḥasan* risks can be mitigated using fintech tools, such as blockchain, for project monitoring and staged payments.

The model runs through the interaction of four agents: the entrepreneurs, the suppliers, the crowdfunding platform, and the donors (**Figure 2**).

When donations are received by the crowdfunding platform, they are channelled to innovative entrepreneurs in the form of interest-free loans. The loan repayments are used to: (1) cover the cost of loan monitoring, (2) provide micro-insurance, and (3) fund new projects. Therefore, it is established that the crowdfunding platform has three types of funds (**Figure 3**):

- *Qarḍ ḥasan* fund: It includes all collected donations as well as some parts of the accumulated amounts of the repaid loans.
- Micro-*takāful* fund: It is built using some parts of the repaid loans. This fund is used for giving health and life insurance to borrowers.
- Monitoring fund: It is also built using some parts of the accumulated amounts of the repaid loans. It helps in mitigating against the moral hazard problem that can lead to entrepreneurial default.

For a better understanding of the mechanism of the proposed model, it can be described through different steps (**Figure 4**).

Figure 2: A Simplified Class Diagram of the Agent-Based Model

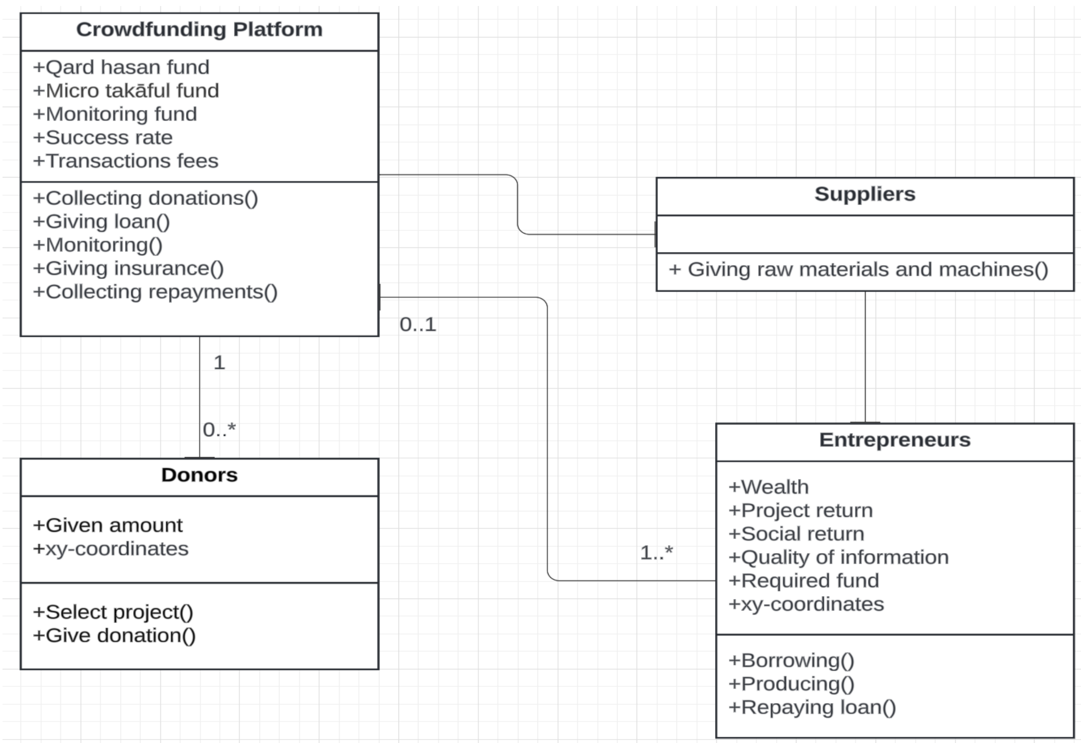

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Figure 3: The Proposed Agent-Based Model

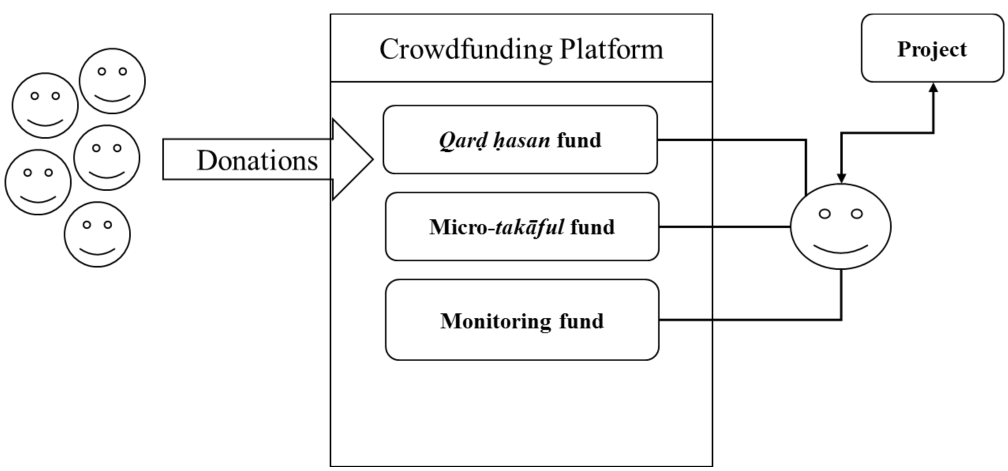

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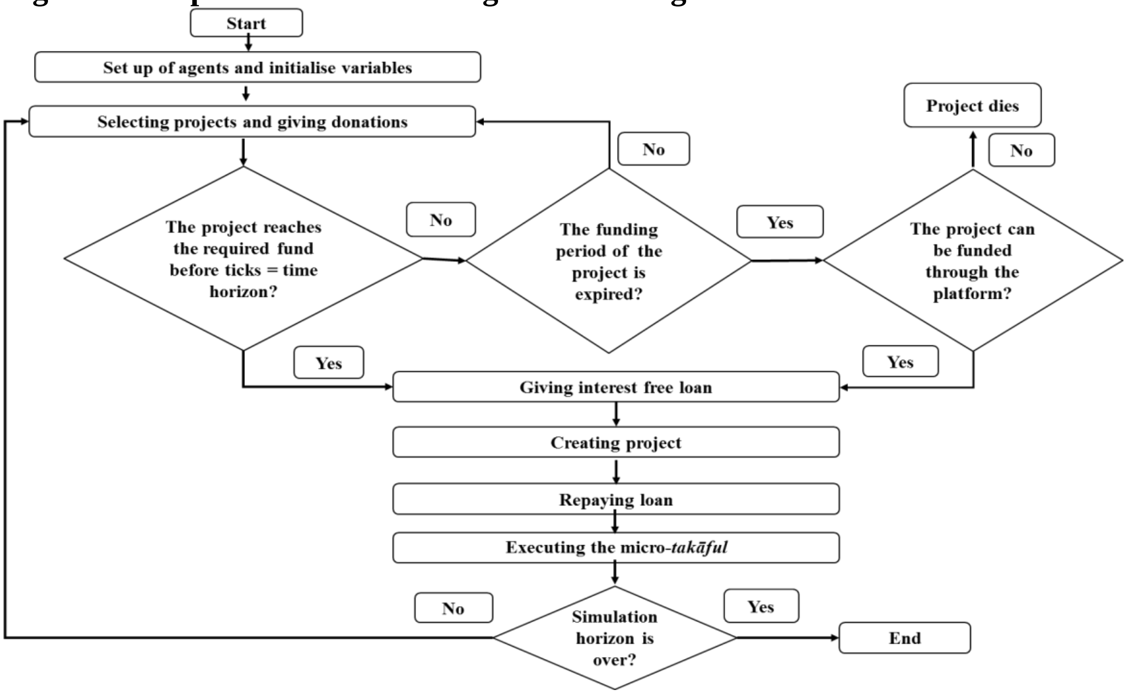
Figure 4: Simplified Flowchart Diagram of the Agent-Based Model



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Project mechanism:

1. Entrepreneurs display their ideas through the online crowdfunding platform.
2. The platform does a first screening and makes sure that the proposed projects are adequate according to the Islamic principles, that is, they are Sharīʿah-compliant. The selected projects can get financing from donors for a specific period.
3. Each donor selects one project and contributes a small amount of money to its financing.
4. If the funding target of a project is met within its funding period, it benefits from an interest-free loan.
5. For a project that did not meet the funding goal within the given funding period, if it has reached a specific threshold fixed beforehand, it will also benefit from an interest-free loan using its corresponding collected fund, the received funds for failed projects or some parts of the reimbursed loans. Otherwise, the entrepreneur gets nothing, and his project will be excluded from the platform.
6. Entrepreneurs who received interest-free loans (benevolent loans) have to repay their debts. The repaid loan will be subdivided between the *qarḍ ḥasan* fund, micro-*takāful* fund and monitoring fund. The percentage assigned to each fund is fixed by the platform.
7. The platform provides micro-insurance against unforeseen risks and uncertainties resulting in loss of livelihood and sickness using the micro-*takāful* fund.
8. The management fees of the platform are paid by the crowd as part of the entrepreneurs' required funding.

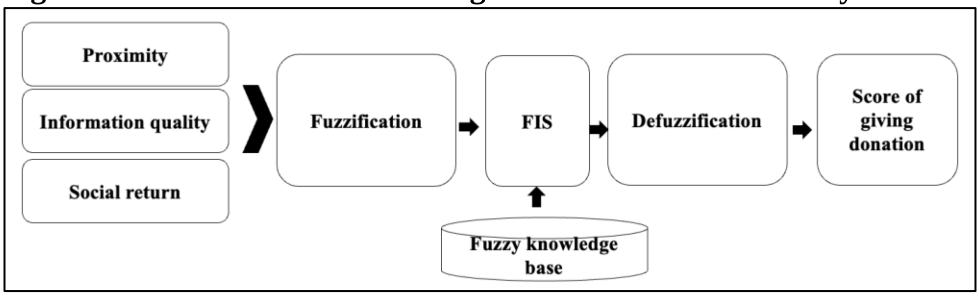
As with many crowdfunding models, the proposed model is subject to several risks, mainly those related to information asymmetry such as adverse selection and moral hazard (Renwick & Mossialos, 2017). Adverse selection, in this context, is the risk of allocating loans to entrepreneurs with undesirable characteristics such as a high level of risk-taking or poor creditworthiness (Godquin, 2004). Moral hazard is the risk that the entrepreneur behaves in an undesirable way, such as exercising insufficient effort or diverting the loan to unproductive purposes (Godquin, 2004; Abdeldayem & Aldulaimi, 2023). Both adverse selection and moral hazard can increase the percentage of unpaid loans. Other risks can also influence the performance of the model such as the entrepreneur's illness, or death, or the failure of their business. To limit the issues of information asymmetries, several mechanisms are suggested; for instance, the online platform can require more information about entrepreneurs (e.g., credit history, personal data, biographical data) (Yan *et al.*, 2015). Moreover, before allowing a project to collect funds, the platform operator must do a preliminary screening to eliminate projects with high adverse selection. In that context, the platform can benefit from big data and related technologies (e.g., machine learning, deep learning) to assess the creditworthiness of entrepreneurs. It is worth noting that such technologies must be used carefully, because they can have unexpected consequences (Cummins *et al.*, 2019). It is also suggested that an appropriate monitoring mechanism can help in reducing moral hazard problem (El Fakir & Tkiouat, 2016). To reduce the other aforementioned risks, especially those related to the entrepreneur's illness, death or business failure, micro-insurance can be provided (Wahid & Noordin, 2014).

Model Procedures

In this section, the procedures, inputs, and outputs of the model are described.

Project selection and giving donation: This depicts a donor's decision to choose a project and, consequently, give a donation. The multitude of factors influencing the donor's assessment of a project's quality results in a complex interplay of considerations within the donor's mind. This complexity provides an optimal setting for addressing the donor's decision using a fuzzy system (Papageorgiou *et al.*, 2016). The power of fuzzy logic lies in its ability to merge the interference of factors and provide outputs that guide decision-making. Fuzzy logic may offer significant benefits in developing agent-based models, as highlighted by Izquierdo *et al.* (2015). In this framework, to decide whether to donate or not, a donor (acting as an agent) is provided with a Fuzzy-Inference-System (FIS) (see **Figure 5**). The donor's decision-making process relies on specific characteristics of the entrepreneurs: (i) their proximity (geographic, familial, social connections, etc.), (ii) the quality of information shared, and (iii) the anticipated social return from the project. Upon accessing the platform, the donor evaluates each entrepreneur and subsequently chooses the one with the highest rating to receive a donation.

Figure 5: Donors' Decision-Making Process as an Inference System



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The characteristics and configurations of the various membership functions used in the simulation are outlined as follows:

- *Proximity*: it has two fuzzy sets, 'Neutral' and 'Close'. They represent a donor's perception with respect to proximity of each entrepreneur on the crowdfunding platform. The membership functions (MFs) associated with these fuzzy sets have a Gaussian curve and are given as follows:

$$MF_{Neutral}(x) = e^{-\frac{(x-m_n)^2}{2s^2}};\ MF_{close}(x) = e^{-\frac{(x-m_c)^2}{2s^2}}$$

  Where $x \in [0, 21]$ represents the Euclidean distance (spacial) between the donor and the entrepreneur, $mn = 0, mc = 21$ and $s = 5$.

- *Social return*: It has three fuzzy sets, 'Low', 'Medium', and 'High'. They represent a donor's perception with respect to the social return of each entrepreneur on the crowdfunding platform. Their membership functions are given as follows:

$$MF_{Low}\ (x) = e^{-\frac{(x-m_l)^2}{2s^2}};\ MF_{Medium}\ (x) = e^{-\frac{(x-m_m)^2}{2s^2}}; MF_{High}\ (x) = e^{-\frac{(x-m_h)^2}{2s^2}}$$

  Where $x \in [0, 10]$ represents the social return of the entrepreneur, $m_l = 0, m_m = 5$, $mh = 10$ and $s = 2 + noise$. $Noise$ is a uniform distribution in the range $[-1, 1]$; it represents the donors' diversity with respect to the social return perception.

- *Quality of information*: This linguistic variable also has three fuzzy sets, 'Bad', 'Medium', and 'Good'. They refer to a donor's perception with respect to the quality of the information provided about the projects. The membership functions associated with this variable are given as follows:

$$MF_{bad}\ (x) = e^{-\frac{(x-m_b)^2}{2s^2}}; MF_{Medium}\ (x) = e^{-\frac{(x-m_m)^2}{2s^2}}; MF_{High}\ (x) = e^{-\frac{(x-m_h)^2}{2s^2}}$$

  Where x ∈ [0, 10] represents the quality of information provided about the entrepreneur and their project, $m_b = 0, m_m = 5, m_h = 10\ and\ s = 2 + noise$. *Noise* is a uniform distribution in the range $[-1, 1]$; it represents the donors' diversity regarding their perception of the information quality.

- *Giving donation*: It refers to the final decision of a donor about giving a donation. This linguistic variable has two fuzzy sets, 'Unlikely' and 'Likely'. Their corresponding membership functions are given as follows:

$$MF_{unlikely}\ (x) = e^{-\frac{(x-m_u)^2}{2s^2}};\ MF_{likely}\ (x) = e^{-\frac{(x-m_k)^2}{2s^2}}$$

  Where $x \in [0, 10]$ represents an entrepreneur's aggregated score, $m_u = 0, m_k = 10\ and\ s = 2$.

The fuzzy computation of the giving donation score using 'if-then-rules' is shown in **Table 1.** L refers to Likely and UL refers to Unlikely.

Table 1: Fuzzy Computation of Giving Donation Score

Giving Donation	**Proximity = Neutral Social Return**			**Proximity = Close Social Return**		
Information quality	Low	Medium	High	Low	Medium	High
Bad	UL	UL	UL	UL	UL	L
Medium	UL	UL	L	UL	UL	L
Good	UL	UL	L	UL	L	L

Source: Authors' own

Giving an interest-free loan: Entrepreneurs automatically receive an interest-free loan if they achieve their funding goal within the specified period. If, at the end of the funding period, an entrepreneur has not achieved their funding goal, but their collected funds exceed a fixed threshold, they can also receive an interest-free loan, although they will need to obtain the remainder from other sources. This loan is financed using both the project's collected funds and funds collected from failed projects or from other loan repayments. If the collected donations for a project are below the fixed threshold, the entrepreneurs will be excluded from the platform. The threshold should be optimally chosen to maximise the platform's success.

Paying transaction fees**:** Each borrower must pay transaction fees. These fees are deducted from the donations received by the platform before being transferred to the entrepreneur.
Production**:** The period needed for a project to start producing depends on its activity.

Default: In the simulation, it is assumed that every day, each borrower can become unable to repay his/her debt with a given probability. When an entrepreneur defaults, they cannot repay the rest of their debt and, hence, are excluded from the system.

Repaying loan*:* Entrepreneurs start repaying their loans after a grace period, which is greater than the time they need to start producing. The periodicity of repayment depends on the entrepreneur's activity. It is assumed that an entrepreneur repays their loan only if they have not defaulted. Each payment is divided into three parts: the *qarḍ ḥasan* fund (35%), the micro-*takāful* fund (55%), and the monitoring fund (10%).

Executing insurance: The platform starts providing micro-*takāful* (health and death insurance) after 360 days of its operation. To encourage entrepreneurs to repay their loans, only those who have not defaulted can benefit from insurance. It is assumed that each borrower may fall ill or die with a given likelihood. In such situations, the platform can provide coverage if there is enough money in the insurance fund (micro-*takāful* fund). The coverage amount changes from one case to another.

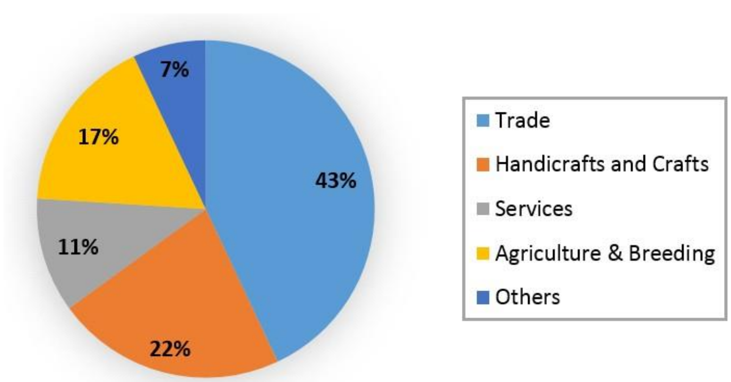
In the case of a hospitalisation for a limited time, in the context of Morocco for instance, a daily allowance of Moroccan Dirhams (MAD) 100 is paid during the hospitalisation period, with an annual ceiling of MAD10,000. The insurance procedure can be executed only if the hospitalisation period is greater than three days. In the case of a permanent disability, an entrepreneur benefits from MAD10,000 per year. In the case of death, the beneficiary receives the difference between the principal borrowed and the outstanding capital. The micro-*takāful* fund also contributes to funeral expenses by 20 per cent of the principal borrowed. In the case of business failure, the crowdfunding platform supports defaulters and does not seek to recover the unpaid amount.

Model Inputs and Outputs

The model has various inputs, including the number of donors per day, the number of projects to be launched per period on the crowdfunding platform, the amount of donations given, the probability of business failure, the funding period of each project, the probability of illness or death, and the simulation time horizon. In this research, the model was simulated based on data from Moroccan micro-financing across five areas of activity (**Figure 6**).

Many of the model's input parameters (**Table 2, Table 3, Table 4**) were calibrated based on various studies (El Fakir & Tkiouat, 2016; Benouna & Tkiouat, 2016; Bourhime & Tkiouat, 2018; Rashid *et al.*, 2011; Lee *et al.*, 2016) using primary data from the Moroccan microfinance sector (e.g., default rate). Alternatively, this was done by running simulations with different values and comparing the resulting outputs to identify the value that best aligned with the desired system behaviour (e.g., the threshold for project funding success).

Figure 6: Distribution of Activities Financed by Microfinance in Morocco



Source: Benouna and Tkiouat (2016)

Table 2: Input Parameters of the Model (Part 1)

Procedure	Variable		Settings
Selecting project and giving donation	Minimum amount of donation		50
	Given donation		N (250,40)
Borrowing	Required fund		N (15000,2000)
To pay transaction fees	Transaction fees		0.3
To default	Probability of business failure		0.2%
Giving insurance	The probability of illness or death		0.1%
	The probability of selecting each type of insurance	Disability	10%
		Hospitalisation	85%
		Death	5%

Source: Authors' own

Table 3: Input Parameters of the Model (Part 2)

Procedure	Variable		Settings
Production	Learning factor		0.1
	Monitoring efficiency		0.7
	Moral hazard factor		0.35
	Monitoring cost		0.03
	Project return per year	Services	N (30,5)
		Agriculture	N (30,5)
		Crafts	N (30,5)
		Trade	N (40,5)
		Others	N (40,10)
	Period needed to start producing in months	Services	2 months
		Agriculture	6 months
		Crafts	2 months
		Trade	1 month
		Others	3 months

Source: Authors' own

Table 4: Input Parameters of the Model (Part 3)

Procedure	Activity	Periodicity (Months)	Duration (Months)	Grace Period (Months)
To repay loan	Services	1	12	3
	Agriculture	7	44	7
	Crafts	1	12	3
	Trade	1	12	2
	Others	1	12	4

Source: Authors' own

The project's return also depends on the type of activity and can be influenced positively by experience (learning) and negatively by moral hazard. It is shown that, over time, the experience can lead, through a learning factor L, to higher productivity (Argote & Epple, 1990). El Fakir and Tkiouat (2016) note that monitoring, although costly and with a certain degree of efficiency, can reduce moral hazard M_h. Therefore, considering learning, monitoring, and moral hazard, they proposed the wealth production function as follows:

$$Wealth_{t+1} = Wealth_t \times [1 + r(1 + L)(1 - (1 - M_{ef})M_h)]$$

Where: r is the project return, Wealth represents the wealth of the entrepreneur. Its initial value is the borrowed amount. L is the learning factor; M_{ef} is the monitoring efficiency and M_h is a moral hazard factor.

The aim is to simulate these activities in a virtual environment using ABM, and then the results of the agents' interactions are shown. As stated earlier in the introduction section, the main outputs of interest, enabling a comparison between the proposed model and a purely donation-based model, relate to: success rate or percentage of projects being funded, failed projects, monitoring, management fees, projects funded by the platform itself, defaulting projects, and insurance coverage.

FINDINGS AND DISCUSSION

This study aims to contrast two models:

- Model 1: The developed approach, where donors contribute funds to the crowdfunding platform based on the potential of selected projects. The platform then channels the funds to entrepreneurs through *qarḍ ḥasan* (interest-free loans).
- Model 2: A conventional donation-based crowdfunding model without any loan obligation, where funds are directed to the entrepreneurs, and they are not required to repay them.

The two models are executed according to three scenarios (**Table 5**) using NetLogo as an agent-based simulation software (version 5.3.1). For both scenarios, the model operates over a period of six years, conducting ten distinct runs with different random seeds (experiments).

Table 5: Simulation Scenarios

Models Characteristics	Scenario 1	Scenario 2	Scenario 3
Number of donors	5	6	7

Source: Authors' own

For each scenario, the standard statistics are presented—minimum, maximum, median, and mean—of the number of launched projects during the simulation horizon, the success rate of the crowdfunding platform, the percentage of insurance beneficiaries among loan recipients, and several other indicators. This comprehensive analysis ensures a clear and meaningful comparison between the two models.

To ensure the integrity of the results, simulations for both models adhere to identical parameters in each scenario. The only differences between the two models are three specific characteristics—loan obligation, monitoring fund, and insurance provision—which distinguish Model 1 from Model 2 (refer to **Table 6**).

Table 6: Similarities and Differences Between the Two Models

Characteristics	**Model 1**	**Model 2**
Number of entrepreneurs	10	10
Funding period (in months)	2	2
Donors' number (per day)	5, 6, 7	5, 6, 7
Transaction fees	0.3%	0.3%
Probability of project failure	0.2%	0.2%
Donation mean	250	250
Moral hazard	Yes	Yes
Simulation horizon	6 years	6 years
Platform threshold	30 %	30 %
Learning factor	10 %	10 %
Probability of death or illness	0.1 %	0.1 %
Monitoring	Yes	Yes
Monitoring fund	Yes	No
Loan obligation	Yes (interest-free loan)	No
Insurance provision	Yes	No

Source: Authors' own

The findings of the three scenarios are outlined in **Table 7, Table 8, and Table 9** respectively.

Table 7: The Models' Outputs According to Scenario 1 (Donors = 5)

	Model 1				**Model2**			
	Min	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Success rate (%)	46.5	48.07	**47.85**	50	35.12	35.86	**35.68**	37.23
Number of failed projects	123	158	**161**	181	220	234	**234**	250
Management fees	235889	239264	**237388**	256856	21266	**24527**	24957	27856
Monitoring cost	79589	81099	**81115**	82013	56487	58025	**57896**	58796
Number of defaulters	109	114	**114**	118	-	-	-	-
Insurance beneficiaries	68	70	**70.5**	72	-	-	-	-
Funding from platform	28	32	**32**	37	-	-	-	-
Monitoring fund	94959	95841	**96042**	96042	-	-	-	-
Micro-*takāful* fund	102356	103409	**103372**	104523	-	-	-	-
Qarḍ ḥasan fund	45789	47398	**47854**	48965	-	-	-	-

Source: Authors' own

Table 8: The Models' Outputs According to Scenario 2 (Donors = 6)

	Model 1				**Model 2**			
	Min	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Success rate (%)	59	61	**60**	65	42	46	**47**	48
Number of failed projects	128	138	**139**	151	179	191	**193**	201
Management fees	225456	228716	**229196**	229856	25463	**26231**	26156	26983
Monitoring cost	95004	95807	**95941**	96845	75314	75674	**75732**	75962
Number of defaulters	121	125	**125**	130	-	-	-	-
Insurance beneficiaries	78	81.5	**82**	83	-	-	-	-
Funding from platform	42	43	**44**	47	-	-	-	-
Monitoring Fund	124589	128693	**129455**	129652	-	-	-	-
Micro-*takāful* fund	211542	213222	**213255**	215236	-	-	-	-
Qarḍ ḥasan fund	182475	185438	**185055**	189607	-	-	-	-

Source: Authors' own

Table 9: The Models' Outputs According to Scenario 3 (Donors = 7)

	Model 1				Model2			
	Min	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Success rate (%)	67	70	**69**	73	52	55	**55**	58
Number of failed projects	92	198	**99**	103	157	162	**162**	171
Management fees	324282	325385	**325376**	326391	31452	**32667**	32559	35263
Monitoring cost	113889	114119	**114156**	114205	84253	86192	**86024**	88897
Number of defaulters	144	150	**151**	153	-	-	-	-
Insurance beneficiaries	107	110	**110.5**	114	-	-	-	-
Funding from platform	55	59	**59**	63	-	-	-	-
Monitoring fund	158565	161564	**161974**	163456	-	-	-	-
Micro-*takāful* fund	193656	197218	**197872**	198865	-	-	-	-
Qarḍ ḥasan fund	124535	126911	**125840**	131458	-	-	-	-

Source: Authors' own

Taking the median as an unbiased measure of comparison, the following is observed: in terms of the success rate and the percentage of entrepreneurs receiving funding, the developed model outperforms the standard crowdfunding model across all scenarios, including various numbers of donors, by providing financial support to more entrepreneurs. This is illustrated graphically in **Figure 7(a).**

In terms of management fees collected by the platform, the proposed model (Model 1) generates more fees compared to the standard crowdfunding model (Model 2). This provides a substantial source of income for the crowdfunding platform (**Figure 7(b)**), as the platform in the proposed model can finance new projects with the redeemed loans.

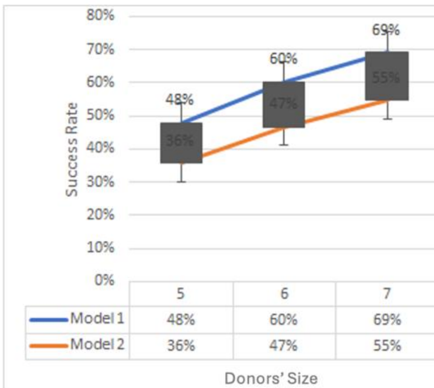
In terms of monitoring costs, the proposed model incurs higher expenses than Model 2 (**Figure 7(c)**), primarily due to the larger number of projects financed. However, unlike Model 2, the proposed model effectively mitigates these costs through a dedicated monitoring fund. This fund is replenished by repayments from redeemed loans, thereby offsetting the financial burden associated with monitoring activities. Simulation results show that the monitoring fund in the proposed model not only covers its expenses but also generates a surplus. As a result, Model 1 achieves a cash surplus, in contrast to Model 2, which operates with a monitoring deficit (**Figure 7(e)**).

In terms of failed projects, Model 2 has more failed projects than Model 1 (**Figure 7(d)**). This can be explained by:

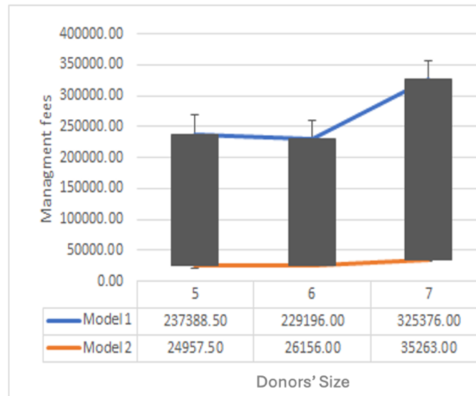
- The excess capacity of Model 1 in terms of monitoring. This ensures that the entrepreneurs are aligned with the objectives they set in the first place.
- The fact that Model 1 has a loan obligation attached to it, which should in principle induce the entrepreneur to work harder as opposed to when they get a free donation.
- The number of failed projects decreases for both models as the number of donors increases. This is an attractive sign for donors to engage in donation crowdfunding.

Figure 7: Models' Output Comparison

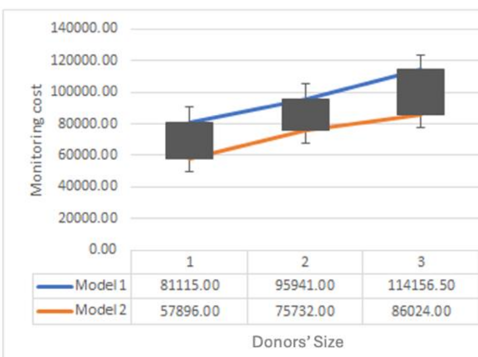
(a) Success Rate



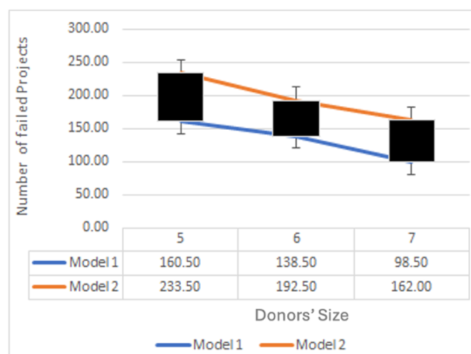
(b) Management Fees



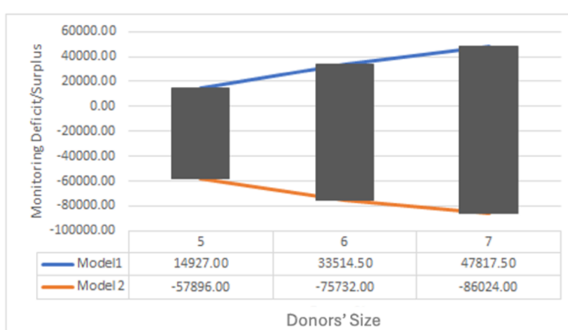
(c) Monitoring Cost



(d) Failed Projects



(e) Monitoring Deficit/Surplus



Source: Authors' own

Due to the nature of the two models, there are outputs which are typical to the developed model and lacking in Model 2. As it has been stated, Model 2 has no *qarḍ ḥasan* fund, micro-*takāful* fund and monitoring fund attached to it. Therefore, there are no figures for these outputs in **Tables 7, 8** and **9**. This constitutes a comparative advantage of Model 1 over Model 2. In fact, the developed model has a micro-*takāful* fund and, hence, has insurance beneficiaries. This number increases as the number of donors increases (**Figure 8(b)**). This is an important social feature that can attract both entrepreneurs and donors alike (as the first is interested in health protection while the latter is interested in a social return). The fact that insurance is attached to the model can also be a motivating factor for the entrepreneurs to exercise higher efforts in running their projects.

Nevertheless, it is worth noting one of the limitations of the insurance mechanism in the suggested model. It can be noticed from **Figure 8(d)** that the micro-*takāful* fund does not increase proportionally with the number of insurance beneficiaries. This discrepancy can be attributed to the continuous increase in the number of beneficiaries over time, while the number of new donors is assumed to remain constant. This imbalance suggests the need to impose limits on insurance claims, both in terms of the maximum amount and the time horizon, to ensure the fund's sustainability. It also highlights the need for innovative strategies to continually increase the number of donors.

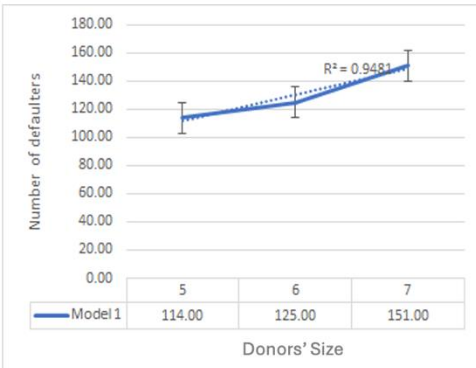
Another comparative advantage is that the developed model proposes a monitoring fund. This fund is replenished in part through redeemed loans. This should support the crowdfunding platform, under Model 1, in recovering its monitoring cost as well as using its monitoring surplus to even exercise more monitoring. More monitoring would ensure loans are used correctly. This can also be an attractive tool for more donors to engage in this model's platform.

Finally, the number of defaulters under Model 1 increases as the number of donors increases (**Figure 8(b)**). This is quite normal as with more donors, more projects are financed and, hence, there is a higher chance of projects defaulting. Despite this fact, Model 1 is at least recovering part of the funds it has lent to the entrepreneur. In contrast to Model 1, no money is redeemed back to the platform under Model 2 as there are no loan obligations attached to it. The funds redeemed back under Model 1 can be used to further support other projects. This constitutes another source of funding besides the donors' contributions (**Figure 8(c)**). While this does not eradicate the need for further donations, it does, however, provide a buffer to support other projects in case of donation shortage.

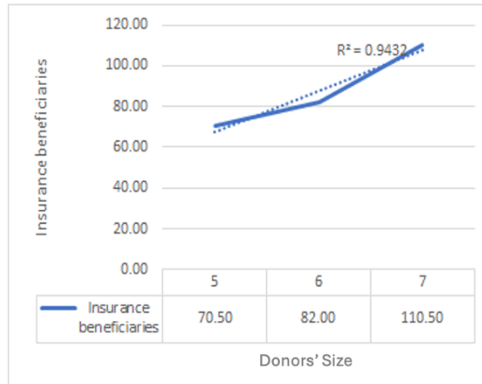
The potential for defaulting projects to drain platform resources is a critical concern. In this study, the default rate is determined using primary data from the Moroccan microfinance sector. However, a more comprehensive analysis may be needed to assess the impact of defaults on platform sustainability, including potential mitigation strategies. Such an analysis would offer a clearer understanding of the long-term effects of defaults on platform resources.

Figure 8: Models' Output Comparison

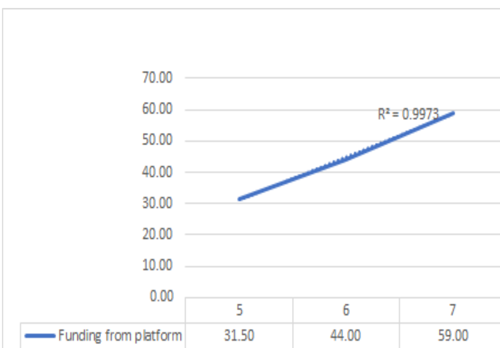
(a) Number of Defaulters



(b) Number of Insurance Beneficiaries



(c) Projects Funded from the Platform Itself



(d) Micro-*Takāful* Fund

Source: Authors' own

CONCLUSION

In this research, a new hybrid model was introduced that combines donation and debt-based crowdfunding. The debt portion of the model, however, bears no interest charges. The proposed model is compared to a pure donation-based model where funded entrepreneurs have no loan obligations to redeem back their given funds.

The measure of comparison focused on the abilities of the developed model to improve the financial inclusion of entrepreneurs by ensuring more funding is available as well as improving their well-being.

There was simulation evidence that the developed model can generate more funding and would, hence, enable more entrepreneurial financial inclusion. The typical feature of the developed model, in having insurance attached to it, ensures more health and life insurance for many entrepreneurs. This protective element can have a positive impact on the well-being of entrepreneurs.

While both models ensure project monitoring is in place, the developed model suffers from a higher monitoring cost, given the loan feature attached to it. However, this cost is mitigated by having a monitoring fund. This ensures excess capacity in terms of monitoring compared to a donation-based model. The advantages of higher monitoring costs are evidenced by the lower number of failed projects under this model compared to a standard donation one. This higher monitoring capacity can have a positive impact on donors as they are reassured that their donations are invested wisely.

It was also found that there is simulation evidence that the developed model can generate more management fees for the platform. This can ensure the platform can self-maintain its operation and continuity.

It is worth noting that the developed agent-based simulation model has some limitations. While most of the data in the model were calibrated using real data, the conception and simulation has some free parameters (learning factor, monitoring efficiency) which make its validation a little arduous. However, users can address this issue by calibrating these parameters to the specific contexts they are studying.

Future research could enhance the ABM by incorporating the contagion effect, where donors influence each other's project selection, and by using a diffusion model to estimate the daily number of donors. Furthermore, input parameters—such as the threshold for project funding success and the allocation percentages for the *qarḍ ḥasan* fund, the micro-*takāful* fund, and the monitoring fund could be optimised to improve the platform's success rate. Genetic algorithms are particularly suitable for this task.

The platform could also expand its financing options by allowing investors to participate through mechanisms such as *muḍārabah* (profit-sharing investment). While this study primarily focuses on the perspectives of the platform and donors, future research should explore entrepreneurs' perspectives to provide a more holistic understanding of the system.

The model's adoption of Islamic social contracts such as donations and interest-free loans has the potential to significantly enhance its acceptance within the community. However, building trust in the platform requires considerable effort, particularly through transparency and adherence to Islamic and ethical principles. Additionally, implementing effective marketing strategies will be essential to raise awareness, promote the platform's values and benefits, and motivate both donors and entrepreneurs to actively participate.

Despite its advantages, implementing the proposed crowdfunding model in real-world contexts may face practical challenges, particularly in countries lacking regulations for crowdfunding platforms. Further investigation is needed to examine the feasibility of implementing this model in diverse regulatory and cultural contexts.

Policymakers could play a significant role in supporting the adoption of the proposed model by developing a supportive legal framework to ensure compliance, protect stakeholders, and foster trust in the system. Additionally, instituting policies to encourage broader participation—such as offering tax incentives for donors and raising public awareness about the ethical and community-oriented benefits of socially driven crowdfunding models could enhance the model's acceptance and drive greater engagement from both donors and entrepreneurs.

REFERENCES

Abdeldayem, M. & Aldulaimi, S. (2023), 'Developing an Islamic crowdfunding model: a new innovative mechanism to finance SMEs in the Middle East', *International Journal of Organizational Analysis*, Vol. 31 No. 6, pp. 2623–2644.

Alshater, M.M., Saba, I., Supriani, I. & Rabbani, M.R. (2022), 'Fintech in Islamic finance literature: a review', *Heliyon*, Vol. 8 No. 9, pp. 1–24

Argote, L. & Epple, D. (1990), 'Learning curves in manufacturing', *Science*, Vol. 247, pp. 920–924.

Arzam, A., Fauzi, M., Efendi, F. & Sulastri, W. (2023), 'Islamic crowdfunding: a review literature', *Review of Islamic Economics and Finance*, Vol. 6 No. 2, pp. 171–186.

Astrauskaite, I. & Paškevičius, A. (2018), 'An analysis of crowdfunded projects: KPI's to success', *Entrepreneurship and Sustainability Issues*, Vol. 6 No. 1, pp. 23–24.

Bao, L., Wang, Z. & Zhao, H. (2022), 'Who said what: mining semantic features for success prediction in reward-based crowdfunding', *Electronic Commerce Research and Applications*, Vol. 53.

Behl, A., Dutta, P., Luo, Z. & Sheorey, P. (2022), 'Enabling artificial intelligence on a donation-based crowdfunding platform: a theoretical approach', *Annals of Operations Research*, Vol. 319, pp. 1–29.

Benouna, G. & Tkiouat, M. (2016), 'Studies and research on microfinance sector in Morocco: an overview', *Asian Journal of Applied Sciences*, Vol. 4 No. 3, pp. 585–599.

Bourhime, S. & Tkiouat, M. (2018), 'Rethinking microfinance in a dual financial system: an agent-based simulation', *Scientific Annals of Economics and Business*, Vol. 65 No. 1, pp. 13–29.

Chan, C.R., Park, H.D., Patel, P. & Gomulya, D. (2018), 'Reward-based crowdfunding success: decomposition of the project, product category, entrepreneur, and location effects', *Venture Capital*, Vol. 20 No. 3, pp. 285–307.

Cheng, C., Tan, F., Hou, X. & Wei, Z. (2019), 'Success prediction on crowdfunding with multimodal deep learning', *IJCAI*, pp. 2158–2164, https://doi.org/10.24963/ijcai.2019/299

Cosma, S., Grasso, A.G., Pattarin, F. & Pedrazzoli, A. (2022), 'Platforms' partner networks: the missing link in crowdfunding performance', *European Journal of Innovation Management*, Vol. 25 No. 6, pp. 122–151.

Courtney, C., Dutta, S. & Li, Y. (2017), 'Resolving information asymmetry: signaling, endorsement, and crowdfunding success', *Entrepreneurship Theory and Practice*, Vol. 41 No. 2, pp. 265–290.

Cummins, M., Lynn, T., Mac an Bhaird, C. & Rosati, P. (2019), 'Addressing information asymmetries in online peer-to-peer lending', *Disrupting Finance: Fintech and Strategy in the 21st Century*, pp. 15–31.

David, N. (2006), 'Validation and verification in social simulation: patterns and clarification of terminology', in *International Workshop on Epistemological Aspects of Computer Simulation in the Social Sciences*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 117–129.

De Aghion, B.A. (1999), 'On the design of a credit agreement with peer monitoring', *Journal of Development Economics*, Vol. 60 No. 1, pp. 79–104.

Di Pietro, F. (2019), *Deciphering Crowdfunding*, Springer, pp. 1–14.

Djaber, S. & Lotfi, Z.N. (2023), 'Challenges and opportunities of Islamic crowdfunding as a new innovative mechanism to finance startups', *The Journal of Contemporary Issues in Business and Government*, Vol. 29 No. 4, pp. 281–299.

Dos Santos Felipe, I.J., Mendes-Da-Silva, W., Leal, C.C. & Santos, D.B. (2022), 'Reward crowdfunding campaigns: time-to-success analysis', *Journal of Business Research*, Vol. 138, pp. 214–228.

El Fakir, A. & Tkiouat, M. (2016), 'The behavioral and social implications of sequential grouplending: a multi-agent comparative approach between ROMCA, debt financing and ROSCA', *Journal of Applied Economic Sciences (JAES)*, Vol. 11 No. 2, pp. 294–296.

Epstein, J.M. (2008), 'Why model?', *Journal of Artificial Societies and Social Simulation*, Vol. 11 No. 4, pp. 1–12.

Felipe, I.J.D.S., Mendes-Da-Silva, W. & Gattaz, C.C. (2017), 'Crowdfunding research agenda', in *IEEE 11th International Conference on Semantic Computing (ICSC)*, pp. 459–464.

Godquin, M. (2004), 'Microfinance repayment performance in Bangladesh: how to improve the allocation of loans by MFIs', *World Development*, Vol. 32 No. 11, pp. 1909–1926.

Guenther, C., Johan, S. & Schweizer, D. (2018), 'Is the crowd sensitive to distance? How investment decisions differ by investor type', *Small Business Economics*, Vol. 50, pp. 289–305.

Guo, Y., Zhou, X., Zhan, C., Zeng, Y. & Zhong, L. (2020), 'Prediction and analysis of success on crowdfunding projects', in *Proceedings of the 4th International Conference on Electronic Information Technology and Computer Engineering*, pp. 785–789.

Gürler, C. & Çağlar, M. (2021), 'Success prediction of a crowdfunding project in art categories', *Crowdfunding in the Public Sector: Theory and Best Practices*, pp. 147–166.

Hassan, M.K., Rabbani, M.R., Rashid, M. & Trinugroho, I. (2022), 'Islamic fintech, blockchain and crowdfunding: current landscape and path forward', in *FinTech in Islamic Financial Institutions: Scope, Challenges, and Implications in Islamic Finance*, Springer International Publishing, Cham., pp. 307–340.

Hossain, B. & Hossain, G.M.S., Kumar, S. & Mridha, R. (2024), 'Exploring the potential of Islamic crowdfunding as an alternative financing source for entrepreneurs in Bangladesh', *International Journal of Science and Business*, Vol. 41 No. 1, pp. 56–68.

Izquierdo, L.R., Olaru, D., Izquierdo, S.S., Purchase, S. & Soutar, G.N. (2015), 'Fuzzy logic for social simulation using NetLogo', *Journal of Artificial Societies and Social Simulation*, Vol. 18 No. 4, https://doi.org/10.18564/jasss.2885

Jackson, L. & Young, L. (2016), 'When business networks "kill" social networks: a case study in Bangladesh', *Industrial Marketing Management*, Vol. 58, pp. 148–161.

Jovanovic, T. (2019), 'Crowdfunding: what do we know so far?', *International Journal of Innovation and Technology Management*, Vol. 16, https://doi.org/10.1142/S0219877019500093

Kamarubahrin, A.F., Muhamed, N.A., Radzi, R.M., Nazarie, W.N.F.W.M. & Kamaruddin, M.I. H. (2023), 'Donation-based crowdfunding: systematic literature review', *Journal of Islamic Finance*, Vol. 12 No. 2, pp. 11–20.

Koch, J.A., Lausen, J. & Kohlhase, M. (2021), 'Internalizing the externalities of overfunding: an agent-based model approach for analyzing the market dynamics on crowdfunding platforms', *Journal of Business Economics*, Vol. 91 No. 9, pp. 1387–1430.

Lamrani Alaoui, Y., Fakir, A.E. & Tkiouat, M. (2020), 'Towards new framework for modelling project selection in crowdfunding platforms', in *International Conference on Advanced Intelligent Systems for Sustainable Development*, Springer International Publishing, Cham., pp. 713–720.

Lee, Y.C., Yen, C.H., & Fu, W.T. (2016), 'Improving donation distribution for crowdfunding: An agent-based model', in *Social, Cultural, and Behavioral Modelling: 9th International Conference, SBP-BRiMS 2016*, Washington, DC, USA, June 28–July 1, 2016, Proceedings 9, Springer International Publishing, pp. 3–12.

Li, H. & Cao, E. (2023), 'Competitive crowdfunding under asymmetric quality information', *Annals of Operations Research*, Vol. 329 No. 1, pp. 657–688.

Lutfi, M.A. & Ismail, M.A. (2016), 'Sadaqah-based crowdfunding model for microfinancing and health care', *The Journal of Muamalat and Islamic Finance Research*, pp. 31–51.

Macal, C.M. & North, M.J. (2006), 'Tutorial on agent-based modelling and simulation part 2: how to model with agents', in *Proceedings of the 2006 Winter Simulation Conference*, pp. 73–83.

Marom, D. (2013), *Crowd-Empowered Microfinance*, Springer, pp. 127–151.

Massolution (2015), 'Crowdfunding Industry Report', available at: https://www.scirp.org/reference/referencespapers?referenceid=1931363 (accessed 12 January 2024).

Mia, M.A. & Lee, H.A. (2017), 'Mission drift and ethical crisis in microfinance institutions: What matters?', *Journal of Cleaner Production*, Vol. 164, pp. 102–114.

Mohammed, A.F. & Wobe, M.H. (2023), 'Factors affecting loan repayment performance of microfinance institution borrowers: the case of Omo Microfinance at Wondo Genet Woreda, Ethiopia', in *Research Anthology on Microfinance Services and Roles in Social Progress*, IGI Global, pp. 338–355.

Mukherjee, P., Badr, Y. & Karvekar, S.N. (2020), 'Prediction of success in crowdfunding platforms', in *International Conference on Decision Aid Sciences and Application (DASA)*, pp. 233–237.

Muneeza, A., Arshad, N.A. & Arifin, A.T. (2018), 'The application of blockchain technology in crowdfunding: towards financial inclusion via technology', *International Journal of Management and Applied Research*, Vol. 5 No. 2, pp. 82–98.

Naciri, N. (2016), 'Complex systems and agent-based modelling and simulation: review and applications in economic systems and Islamic financial engineering', Ph.D. thesis, Mohammadia School of Engineering.

Obaidullah, M. (2008), *Introduction to Islamic Microfinance*, IBF Net Limited.

Oduro, M.S., Yu, H. & Huang, H. (2022), 'Predicting the entrepreneurial success of crowdfunding campaigns using model-based machine learning methods', *International Journal of Crowd Science*, Vol. 6 No. 1, pp. 7–16.

Ormerod, P. & Rosewell, B. (2006), 'Validation and verification of agent-based models in the social sciences', in *International Workshop on Epistemological Aspects of Computer Simulation in the Social Sciences*, Springer, Berlin Heidelberg, pp. 130–140.

Papageorgiou, E.I., Kokkinos, K., & Dikopoulou, Z. (2016), 'Fuzzy sets in agriculture', *Fuzzy Logic in its 50th Year: New Developments, Directions and Challenges*, pp. 211–233.

Pinkow, F. & Emmerich, P. (2021), 'Re-examining crowdfunding success: how the crowdfunding goal moderates the relationship of success factors and crowdfunding performance', *Central European Business Review*, Vol. 10 No. 2, pp. 91–114.

Purwatiningsih, A., Purnamasari, S., Setyawati, H., Indriani, A., Prawitasari, D. & Fitria, S. (2024), 'Bibliometric analysis of Islamic crowdfunding: a literature review of its journey', *F1000Research*, Vol. 13 No. 531, https://doi.org/10.12688/f1000research.146797.2

Rand, W. & Rust, R.T. (2011), 'Agent-based modelling in marketing: guidelines for rigor', *International Journal of Research in Marketing*, Vol. 28 No. 3, pp. 181–193.

Rashid, S., Yoon, Y. & Kashem, S.B. (2011), 'Assessing the potential impact of microfinance with agent-based modelling', *Economic Modelling*, Vol. 28 No. 4, pp. 1907–1913.

Renwick, M.J. & Mossialos, E. (2017), 'Crowdfunding our health: economic risks and benefits', *Social Science & Medicine*, Vol. 191, pp. 48–56.

Ryoba, M.J., Qu, S. & Zhou, Y. (2021), 'Feature subset selection for predicting the success of crowdfunding project campaigns', *Electronic Markets*, Vol. 31, pp. 671–684.

Said, M.B.B. (2023), 'Role of blockchain in enhancing Islamic crowdfunding mechanisms', *Islamic Accounting and Finance: A Handbook*, pp. 485–511.

Saiti, B., Musito, M.H. & Yucel, E. (2018), 'Islamic crowdfunding: fundamentals, developments and challenges', *Islamic Quarterly*, Vol. 62 No.3, https://hdl.handle.net/20.500.12436/861

Sanjaya, Y.P.A., & Akhyar, M.A. (2022), 'Blockchain and smart contract applications can be a support for MSME supply chain finance based on Shari'ah crowdfunding', *Blockchain Frontier Technology*, Vol. 2 No.1, pp. 44–49.

Shneor, R. & Vik, A.A. (2020), 'Crowdfunding success: a systematic literature review 2010–2017', *Baltic Journal of Management*, Vol. 15 No. 2, pp. 149–182.

Silva, L., Silva, N.F. & Rosa, T. (2020), 'Success prediction of crowdfunding campaigns: a two-phase modelling', *International Journal of Web Information Systems*, Vol. 16 No. 4, pp. 387–412.

Song, C., Luo, J., Hölttä-Otto, K., Seering, W. & Otto, K. (2020), 'Crowdfunding for design innovation: prediction model with critical factors', *IEEE Transactions on Engineering Management*, Vol. 69 No. 4, pp. 1565–1576.

Sulaeman, S. (2020), 'A conceptual and empirical study on the development of the Islamic donation-based crowdfunding platform model for micro small and medium-sized enterprises (MSMEs) in times of COVID-19 pandemic in Indonesia', *Asian Journal of Islamic Management (AJIM)*, pp. 107–122.

Tang, Z., Yang, Y., Li, W., Lian, D. & Duan, L. (2022), 'Deep cross-attention network for crowdfunding success prediction', *IEEE Transactions on Multimedia*, Vol. 25, pp. 1306–1319.

Theerthaana, P. & Sheik Manzoor, A.K. (2020), 'A signalling paradigm incorporating an agent-based model for simulating the adoption of crowd funding technology', *Journal of Simulation*, Vol. 14 No. 3, pp. 169–188.

Unal, I.M. & Aysan, A.F. (2022), 'Fintech, digitalization, and blockchain in Islamic finance: retrospective investigation', *FinTech*, Vol. 1 No. 4, pp. 388–398.

Wahid, F.N.A. & Noordin, K. (2014), 'Skim takaful sumbangan rendah serta prospek pelaksanaan takaful mikro di Malaysia', in paper presented at the *International Conference on Postgraduate Research (ICPR), Kuala Lumpur*, pp. 24–35.

Wahjono, S.I. & Marina, A. (2017), 'Islamic crowdfunding: alternative funding solution', in Paper presented at *1st World Islamic Social Science Congress (WISSC 2015)*, Putrajaya, Malaysia, pp. 30–38.

Wang, W., Zheng, H. & Wu, Y.J. (2020), 'Prediction of fundraising outcomes for crowdfunding projects based on deep learning: a multimodel comparative study', *Soft Computing*, Vol. 24 No. 11, pp. 8323–8341.

Wash, R. & Solomon, J. (2014), 'Coordinating donors on crowdfunding websites', in *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*, pp. 38–48.

Wati, C.R. & Winarno, A. (2018), 'The performance of crowdfunding model as an alternative funding source for micro, small, and medium-scale businesses in various countries', *KnE Social Sciences*, pp. 16–33.

Wijesiri, M., Yaron, J. & Meoli, M. (2017), 'Assessing the financial and outreach efficiency of microfinance institutions: do age and size matter?', *Journal of Multinational Financial Management*, Vol. 40, pp. 63–76.

Wilensky, U. (2015), *An Introduction to Agent-Based Modelling: Modelling Natural, Social, and Engineered Complex Systems with Netlogo*, The MIT Press.

Woods, C., Yu, H. & Huang, H. (2020), 'Predicting the success of entrepreneurial campaigns in crowdfunding: a spatio-temporal approach', *Journal of Innovation and Entrepreneurship*, Vol. 9, pp. 1–23.

Xiang, X., Kennedy, R., Madey, G. & Cabaniss, S. (2005), 'Verification and validation of agent-based scientific simulation models', in *Agent-Directed Simulation Conference*, Vol. 47, The Society for Modelling and Simulation International, San Diego, CA, USA.

Xie, K., Liu, Z., Chen, L., Zhang, W., Liu, S. & Chaudhry, S.S. (2019), 'Success factors and complex dynamics of crowdfunding: empirical research on Taobao platform in China', *Electronic Markets*, Vol. 29, pp. 187–199.

Yan, J., Yu, W. & Zhao, J.L. (2015), 'How signaling and search costs affect information asymmetry in P2P lending: the economics of big data', *Financial Innovation*, Vol. 1, pp. 1–11.

Yen, C.H., Lee, Y.C. & Fu, W.T. (2017), 'Improving the efficiency of allocating crowd donations with agent-based simulation model', in *Social, Cultural, and Behavioral Modeling: 10th International Conference, SBP-BRiMS 2017*, Washington, DC, USA, July 5–8, 2017, Proceedings 10, pp. 248–253, Springer International Publishing.

Yilmaz, L. (2006), 'Validation and verification of social processes within agent-based computational organization models', *Computational & Mathematical Organization Theory*, Vol. 12, pp. 283–312.

Yunus, M. (2008), 'Creating a world without poverty: social business and the future of capitalism', *Global Urban Development Magazine*, Vol. 4, pp. 1–19

Zhang, Y., Tan, C.D., Sun, J. & Yang, Z. (2020), 'Why do people patronize donation-based crowdfunding platforms? An activity perspective of critical success factors', *Computers in Human Behaviour*, Vol. 112, https://doi.org/10.1016/j.chb.2020.106470

Zou, G., Gil, A. & Tharayil, M. (2014), 'An agent-based model for crowdsourcing systems', in *Proceedings of the Winter Simulation Conference 2014*, pp. 407–418.

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DECLARATION

Credit Authorship Contribution Statement

- Youssef Lamrani Alaoui contributed to the research problem, conceptualization, methodology, data analysis, validation, writing, editing, and visualization.
- Adil El Fakir contributed to data analysis, validation, writing, editing, and visualization.
- Mohammed Tkiouat contributed to validation, investigation, and supervision.

Declaration of Competing Interest

The authors declare no conflict of interest.

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The authors confirm their understanding of the Ethical Guidelines and affirm full adherence to all ethical standards in publishing. They also declare that this paper is original, has not been published elsewhere, and is not under consideration by any other journal.

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