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# Rethinking Microfinance in a Dual Financial System: An Agent-based Simulation

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**Abstract**

Critics concerning the real impact of traditional microfinance as a tool for poverty alleviation are becoming frequent. In contrast, the financial crisis brought out interest for Islamic finance, whose models have been increasingly studied. Today, the real challenge lies in evaluating the impact of microfinance in a complex environment, where both Islamic and conventional microfinance institutions exist and address evolving clients in constant interaction. New methods and models are therefore needed in order to test the efficacy and assess the impact of introducing Islamic microfinance products, compared to the conventional system. In this context, this paper proposes an approach to build an Agent-Based Modeling (ABM) framework, which is aiming to test the effects of such products implementation using Islamic interest-free group loans. It also helps assess the impact of the behavioral biases as well as agents' interactions within the repayment process.

**Keywords:** agent-based simulation; dual-financial system; Islamic microfinance; interest-free lending.

**JEL classification:** C63; G21.

## 1. INTRODUCTION

Microfinance plays a great role in promoting financial access to the poor. It offers a large panel of financial services to poor and low-income people. Services such as credit, savings, insurance and remittances are provided on a micro-scale. The last decades have known an enormous growth of conventional microfinance in many countries such as Bangladesh, India, Indonesia, Morocco and Sri Lanka (Obaidullah and Khan, 2008). However, after a long appraisal of the impact of microfinance in poverty and its auspicious development, in recent years, the microfinance model has been criticized and its impact questioned (Hermes and Lensink, 2011).

Khawari (2004) states that the empirical impact of microfinance is yet to be proven since most of the empirical studies are conducted by the microfinance institutions (MFI)

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themselves. Moreover, the microcredit crises in different countries (Morocco, Nicaragua, India...) raised more than a question about the real role of microfinance in poverty alleviation and financial inclusion (Constantinou and Ashta, 2011). One of the relevant issues is the lack of monitoring and the high rates of interest imposed by the MFIs. Indeed, if poor clients cannot earn a return on their investment greater than the interest they may pay, they will become poorer as a result of microcredit, not wealthier (Gonzalez, 2008; Schicks, 2014). The vast majority of the clientele is caught in subsistence activities and they have no specialized skills and so must compete with all the other self-employed poor people in entry-level trades.

Microfinance and Islamic finance have several principles in common. Islam emphasizes on ethical, moral, social, and religious factors to promote equality and fairness for the good of the society as a whole. Principles encouraging risk sharing, individual rights and duties, property rights, and the sanctity of contracts are all part of the Islamic code underlying the financial system. In this light, many elements of microfinance are consistent with the broader goals of Islamic finance. Both advocate entrepreneurship and risk sharing and believe that the poor should take part in such activities. Both focus on developmental and social goals and promote financial inclusion, entrepreneurship and risk-sharing through partnership finance (Gonzalez, 2008; Obaidullah, 2008).

Before assessing the impact of Islamic microfinance, we need to analyze the effects of the implementation of Islamic microfinance in a dual market. However, the nature of the actual microfinance market cannot be apprehended by the classical mathematical and quantitative tools. Indeed, the microfinance system is characterized by a dynamic environment of evolving heterogeneous and bounded rational agents who interact with each other and with their environment. Systems with those properties are called complex systems (Nicolis and Nicolis, 2012). Indeed, in microfinance, the borrowers, the microfinance institutions and governments are always changing and evolving. Moreover, microfinance market can be considered as a complex adaptive system since the agents have the freedom to adapt and learn (Naciri and Tkiouat, 2015; Bourhime and Tkiouat, 2016).

One tool to address the complexity of economic complex systems is Agent-Based Modeling (ABM) and for economics systems it is defined as Agent-Based Computational Economics (ACE) (Arthur, 2006).

In the last decade, a number of studies focused on agent-based modeling in microfinance and microcredit, in particular in Bangladesh (Rashid *et al.*, 2011), Thailand (Barnaud *et al.*, 2008), Nigeria (*Saqalli et al., 2011*) and Mexico (Suarez *et al.*, 2009) The majority of those studies focused on the impact of microfinance in poverty alleviation and the repayment behavior of the borrowers following certain assumptions and hypotheses. The need of agent-based models in Islamic microfinance is relevant since all the existing models focus on conventional microfinance and on interest lending.

This paper, describes an agent-based model of coexisting conventional and Islamic microfinance, where the conventional part can be compared, to a certain degree, to the previous model of Rashid *et al.* (2011). The main objective is to test the effect of the introduction of Islamic products into the microfinance market and their interaction with existing conventional products. We limited our model to the comparison between traditional interest-based individual lending and interest-free group lending. A large number of alternative scenarios are simulated through parametric variation of agent's behavior and the circumstances in which they operate by means of ABM. The aggregate outcomes of the

different interactions of the heterogeneous agents can be analyzed in this approach which gives an effective framework for policy analysis.

The paper is structured as follows: Section 2 presents an overview of the evolution of microfinance as a complex system and the existing agent-based models in microfinance. Section 3 describes the model, its objectives setup and agents' characteristics while the Section 4 presents the simulation in Netlogo, its setting and the analysis of the outcomes. Finally, the last Section is dedicated to the conclusion and to some possible extensions that will be performed subsequently.

## 2. LITERATURE REVIEW

### 2.1 Microfinance

According to Rosenberg *et al.* (2009), Microfinance can be defined as: "The provision of financial services to poor and low-income clients who have little or no access to conventional banks". The term is often used in a more specific sense, referring to institutions that use new techniques developed over the past 30 years to deliver microcredit-tiny loans-to informal micro entrepreneurs. The range of services can include not only microcredit but also savings, insurance, and money transfers.

Microfinance has known a huge development in the last decades and its growth in 2016 has been estimated to be between 10% and 15% (Etzensperger, 2012). Since the 2000s, microfinance is being linked to a greater scheme called the "financial inclusion" which is: "a state in which all people who can use them have access to a full suite of quality financial services, provided at affordable prices in a convenient manner, and with dignity for the clients. Financial services are delivered by a range of providers most of them private, and reach everyone who can use them, including disabled, poor and rural populations" (Accion International, 2009).

Lending methodologies differ whether the loans are made to groups or to individuals. The group-based approaches lend either to the group itself as one loan, to individuals who are members of a group, or to groups who then on-lend individually to the member (Armendariz de Aghion and Morduch, 2000). According to numerous studies, group lending reduces transaction costs and risks to providers since the group mechanism effectively shifts the responsibility of the screening, monitoring and enforcement from the lender to the borrowers. On the other hand, individual lending requires front up analysis of the clients and their cash flows and even sometimes physical collateral or guarantees (Giné and Karlan, 2009). To better assess the risk of default, the microcredit provider usually has to collect a number of data such as bills, rental payments and other predictive variables that can help build a score that represents the probability of future repayment (Frankiewicz and Churchill, 2011).

### 2.2 Islamic microfinance

Islamic finance is controlled by the legal framework of Islam "Sharia". This framework provides guidelines to be followed by people in their decision-making in all aspects of life. Financial transactions are one of the more important dealings controlled by Sharia, in order to ensure the more equitable distribution of income and wealth in Islamic economies (El-Zoghbi and Tarazi, 2013)

The general principles are as follows: (i) the prohibition of Riba (usury or excessive interest) and the removal of debt-based financing from the economy; (ii) the prohibition of Gharar, encompassing the full disclosure of information and removal of any asymmetrical information in a contract; (iii) the exclusion of financing and dealing in sinful and socially irresponsible activities and commodities such as gambling and the production of alcohol; (iv) risk-sharing, the provider of financial funds and the entrepreneur share business risk in return for shares of profits and losses; (v) materiality, a financial transaction needs to have a 'material finality', that is a direct or indirect link to a real economic transaction; and (vi) justice, a financial transaction should not lead to the exploitation of any party to the transaction (Gait and Worthington, 2007).

Within the field of Islamic finance, the slow-but-steady growth of Islamic microfinance has recently become more dynamic, encouraged by an increased attention from government, donors and commercial Islamic finance institutions (Kustin, 2015). The Report of TechNavio (2014) estimates projecting a global Islamic microfinance five-year CAGD of 19.7% from 2013 to 2018.

According to CGAP, Islamic microfinance can be seen as the confluence of two rapidly growing sectors: microfinance and Islamic finance. Islamic microfinance institutions can earn profits in three ways: trading (Murabahah), leasing (Ijara) and by direct financing in Profit loss sharing contracts (Mucharakah, Mudarabah). They can also lend with no interest (Qard Al-Hassan) (Al-Omar and Abdel-Haq, 1996). Therefore, Islamic microfinance is supposed to involve not only debt finance but also equity financing. Those financing mechanisms have to be endorsed by savings schemes, money transfer and insurance.

Ahmed (2002) has drawn a table in order to summarize the several characteristics that distinguish Islamic microfinance from conventional one. Those possible differences are presented in the following table.

**Table no. 1 – Differences between MFI and IMFI**

| | **Conventional MFI** | **Islamic MFI** |
|---|---|---|
| Liabilities | External funds, savings of clients | External funds, saving of clients, Islamic charitable source |
| Assets | Interest-based | Islamic financial instrument |
| Financing the poorest | Poorest are left out | Poorest can be included by integrating with microfinance |
| Funds transfer | Cash given | Goods transferred |
| Deductions at inception of contract | Part of the funds deducted at inception | No deduction at inception |
| Target group | Women | Family |
| Objective of targeting women | Empowerment of women | Ease of availability |
| Liability of the loan | Recipient | Recipient and spouse |
| Work incentive of employees | Monetary | Monetary and religious |
| Dealing with default | Group/center pressure and threats | Group/Center/Spouse/ Guarantee, and Islamic Ethic |
| Social Development Program | Secular, behavioral, ethical and social development | Religious (includes behavior, ethics and social) |

*Source: Ahmed (2002)*

There are a number of shariah compliant microfinance schemes, notably those operated by Hodeibah microfinance program in Yemen, the UNDP Murabahah based

microfinance initiatives at Jabal al-Hoss in Syria, Qardhul Hasan based microfinance scheme offered by Akhuwat in Pakistan, various schemes offered by Bank Rakyat Indonesia, and Bank Islam Bangladesh.

### 2.3 Agent-based modelling and simulation

According to the Invisible Hand theory of Adam Smith (1776), the agents act in their own-interest in order to reach an optimal allocation of scare resources. This theory induced the study of market microstructures by which markets aggregate and disseminates information dynamically in a world of uncertainty and asymmetric information. Many investigations found that the theoretical analysis suggested by Adam Smith can only be tractable in a simplest stylized model (McCauley, 2000). An alternative of this theoretical approach is experimental economics where agents are placed in controlled market setting and given certain endowments and are allowed to trade with each other. The limitations of the experimental study are that even if the experimenter controls the environment and market structure, motives, information-processing abilities and decision making processes are hardly controllable. Therefore, analyzing the impacts of risk-aversion, learning abilities or limitations of rationality is difficult under the hypotheses of either theoretical or experimental approaches (Smith, 1976; Loewenstein, 1999).

The limitations of the classical methods can be addressed by a third approach that uses artificially intelligent agents whose preferences and learning algorithms are transparent. Moreover, the outcomes of the experiments conducted using his approach are more readable and can be interpreted. This approach is commonly called "Agent-Based Modelling" (ABM) and allows analyzing the increasing complexity of different systems in our world (Tesfatsion, 2006).

Agent-based modeling is the computational study of social agents as evolving systems of autonomous interacting agent (Janssen and Ostrom, 2006). The key feature of agent-based modeling is that it involves a bottom-up approach to understand a system's behavior. It starts at the level of the units, characterizes the behavior of each and how they are interrelated (De Marchi and Page, 2014). The aggregation of these individual behaviors simulated in software produces macro-level outcomes that can be referred to as emergent or bottom-up (Epstein, 2006).

Ferber (1999) notes that the multi-agent simulation allows the study of complex systems. It represents the complexity of a phenomenon through the interaction of a set of simple entities called agents. Each agent can:

- Communicate with other agents in order to exchange information;
- Perceive and act in some or all the part of its environment. It is idiosyncratic in the sense that it has its own rules and logic of perception and action;
- Apply its knowledge, skills and other resources to fulfill its individual personal objectives.

Instead of quantitative forecasts, agent-based models in economics provide insights. Hence, they are "good for determining what scenarios might occur rather than exactly what will occur" (Turrel, 2016). In the last decade, a number of studies used agent-based modeling in order to apprehend some microfinance issues (impact, default risk, rules, etc…). Those aspects were before addressed through empirical studies.

## 3. AN AGENT-BASED MODEL

### 3.1 Model objectives

The key objective of the model is to evaluate the impact of Islamic Microfinance and behavioral biases on the income level of the poor and the repayment ratio of microcredit over time. It was carried out by a simulation in an agent-based modeling environment in NetLogo. It emulates the behavior of different agents in a simplified environment and shows the outcome as a result of the interactions among agents. Agent-based modeling is an efficient way to get a lucid picture of the impacts of both conventional and Islamic microfinance in the same environment, because it can model the structures and procedures of microfinance from the perspectives of different agents in a real economy, and thus can give the aggregate result of the interactions and the emergence of new phenomena.

As presented in Figure no. 1, this model considers 6 types of agents related to Microfinance: the poor in the population, the middleclass, the rich in the population, a conventional Microfinance institution (referred here as "MFI"), an Islamic Microfinance Institution (referred here as "IMFI"), and suppliers of machines and raw materials. Each agent group is heterogeneous, because they are under different situations and pursue different objectives from the interactions. At the beginning the poor people get microcredit either from MFI or IMFI, depending on the initial conditions and fund limit, to start a microenterprise according to their productivity level. After the production process, they need to trade it in the market and repay the microcredit. Poor with insufficient productivity and who have enough willingness to work can become employees in other poor's businesses and enhance their productivity. The middleclass and the rich represent the demand for the traded products. These procedures require rules to direct the motion of the system and procedures to update and keep track of the agent's situation; this involves many variables such as wealth level, productivity level, amount of loan, volume of production, trade of the products, repayment rules and behavior over time. An agent-based approach replicates these activities in a virtual environment and shows the aggregate outcomes in different time periods.

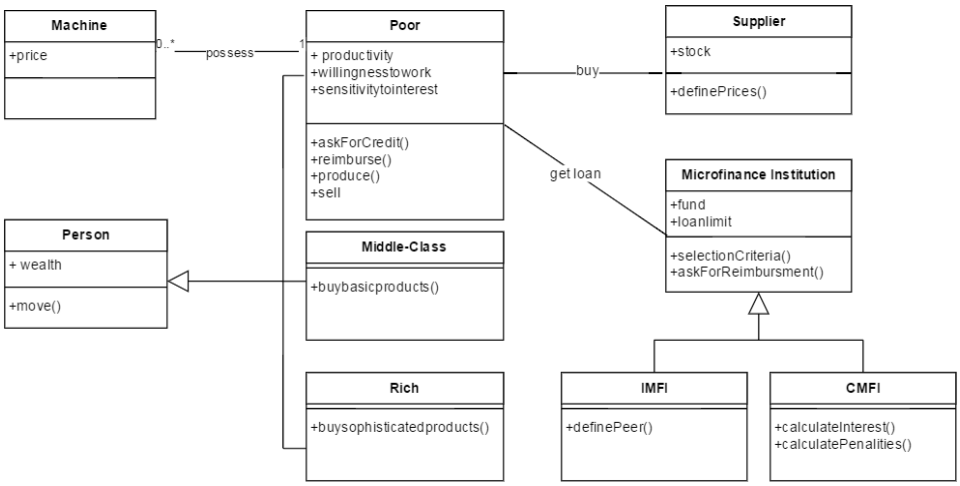


**Figure no. 1 – A simplified class diagram of the model**

### 3.2 Setup and agents characteristics

The model creates an environment where different agents interact with each other and with their world. This environment is a virtual dual economy space where economic transactions such as borrowing, repaying, manufacturing, employing and trading happen as time goes on. This space mimics economic activities in the actual world and helps us to capture the outputs of economic transactions.

The model starts with a given number of people living in the space. The distribution of initial wealth and vulnerability and poverty thresholds follows those of rural areas in Morocco (Haut-Commissariat au Plan, 2011).

A portion of the whole population is assumed to be 'poor' agents in this model who have relatively low wealth level and are the main focus of the model throughout the entire procedures. The rest of the population is the middleclass and the rich. They are included in the model to reflect the economic interactions with the poor (being the buyers) and to reflect the economic disparities. Initially individual agents in the population are randomly distributed throughout the space. Each poor individual has a number of characteristics such as wealth, sex, productivity, willingness to work and repayment-relativity (i.e. a predisposition to repay or not based on personality, social norms and cultural environment) which define their participation and evolution in the model.

The model assumes two microfinance institutions located in the center of the economy space, one is conventional and the other is Islamic. Their common objective is to distribute microcredit to help the poor start their own business. Different parameters of the loans are provided to measure their impact on the poor and on the overall outcome of microcredit process:

- The total amount of fund which can be used for loans. To reflect a late introduction of Islamic finance in a market, the IMFI fund represents the half of the MFI fund;
- The maximum amount of money for each loan. The amount is supposed to be the same for both MFI and IMFI;
- The interest rate charged by MFI can be defined by the user.

After getting a loan either from the MFI or from IMFI, the poor gets ready to start a microenterprise. For this purpose, he needs to buy a machine and raw materials. Due to the scarcity of suppliers, the individuals with money to invest have to spend some time to move and buy the machine and raw materials from them.

With the execution of the model each one of the agents starts to perform his defined job. The poor, as well as the non-poor, start to move randomly throughout the space. This movement represents the everyday transactions which are carried out by individuals.

To have access to financing, the poor have two choices, conventional or Islamic financing. In the model, the choice is based on sensitivity to interest. The selection criteria for Islamic financing are more restricting to prevent high probabilities of default since no financial penalties are applicable in case of late repay. In order to have a loan from IMFI, the funds must be sufficient, a level of productivity is required and the poor seeking financing must find an associate (poor) and their joint productivity (i.e. the sum of their mean productivities) have to exceed a defined threshold. Seeking an associate depends on the neighborhood of the poor. The poor with no sensitivity to interest and with productivity higher than the predefined threshold for individual lending can be financed by MFI. Note that in this model the level of productivity doesn't affect the process of the production after getting a loan, but plays a role towards accessibility to financing. After a loan is given, joint

individuals in IMFI become tied and their debt increase by the amount of the loan, while individual borrowers assume their own responsibility which is riskier (Giné and Karlan, 2009). Updating debts and funds is essential to keep accounts over time and report the available funds.

Access to financing is limited since there is a limit of available funds. Moreover, in case of Islamic financing, the individual may not find a partner with the required profile. Under these circumstances, the poor with enough motivation and willingness to work can become employed in other poor microenterprise, which will allow them to enhance their initial productivity through a learning process and upgrade their wealth. After a certain time or at a presented opportunity, an employee can quit and apply to get a loan or a joint loan depending on his profile and sensitivity to interest.

After a poor agent gets a loan either from MFI or from IMFI, he (or they in the case of a joint loan) should get ready to start the business, i.e. he needs to buy a machine. To ensure that the objectives of the microcredit are met, we suppose that the machines are bought from local suppliers who have contracts with the microfinance institutions so that the borrowers don't waste their loan in personal expenses or in reimbursing another loan. Purchasing raw material is possible only after procuring a machine. Besides buying raw material and expanding its business, the agent can hire other poor persons who live in the same neighborhood to be employed as workers rather than engage in self employment.

As explained before, Poor individuals who fail to get a loan and willing to work may give up the idea of starting their own business and decide to be employees. For the employees, earnings from employment are an alternative way to overcome poverty and develop new skills and experience.

The production cost (PC) of p products combines machine costs (MC) raw materials (RM) and labor (L), depending on the profile of the produced (Self-employed or Employer). To become an employer, the producer needs to fulfill a production threshold x. This can be reflected by the following equation:

$$PC_{p,x} = p(RM + MC) + \beta_{p,x}L \quad (1)$$

where: $\beta_{p,x} = \begin{cases} 0 \; if \; p \leq x \\ p \; if \; p > x \end{cases}$

When a poor agent successfully completes the production process, he then sells the product. It was specified in the model that an agent can sell only after he gets an inventory greater than a predefined threshold.

Once a week, the producer can head to one of the market place to sell his products. The selling price (S) of p products assumes a profit margin of m and depends on the profile of the producer and can be given by the following equation:

$$S_{p,x} = (1 + m)P_{p,x} \quad (2)$$

In order to measure the evolution of disparities and to avoid the redistribution of wealth between the poor, the model assumes that the transaction can only occur between one of the poor and one from the middleclass (for basic producer) and one from the rich (for producer-employer). Competition is represented by the ability to sell of each producer. Indeed, the ability to sell is defined as the capacity of a producer to find a vacant place to sell his products. The experience plays a great role in this ability.

At the end of each installment period, the borrowers have to repay their debts. The rules differentiate the type of repayment between IMFI and MFI. The amount of repayment to MFI is calculated following compound interest's formula and the poor must have enough net profit to repay. For each delay, the MFI takes drastic measures to ensure the minimum rate of non-performing loans. For example, once the poor buys a machine it's considered as collateral by the IMF: in case of default, the IMF can sell back the machine and get reimbursed for a certain portion of the loan (selling price is assumed to be 70% of the initial price). The IMFI on the other hand supports the probability of defaults since the interest-free loans' fund is usually financed by Islamic charity funds (Ashraf *et al.*, 2013). Figure no. 1 provides a flow chart of the model which graphically shows the whole procedure followed in the model.

### 3.3 Additional hypotheses

In practice, there can be many interactions and phenomena whose impact cannot be predicted by linear models. In our case, several hypotheses were made to reflect the complexity and the emergent behaviors of the agents and their environment. For example, crisis that can affect the demand in the market can occur anytime at a certain probability; and would affect the income of individuals with products to sell so that there will be no gain from the transactions.

The model also includes assumptions about repayment behavior since in real life a number of interactions and social links influence the repayment behavior of microfinance clients (Morvant-Roux *et al.*, 2012). In fact, the poor have a predisposition to repay or not depending on their personalities and social and religious norms. Nonetheless, this predisposition can be impacted by the repayment behavior of their neighbors or their partner in case of joint credit (Gangopadhyay *et al.*, 2005).

## 4. SIMULATION

With the development of agent-based models and their increasing importance in studying complex systems, the need for software platforms became more imminent. Since the nineties many platforms have been developed and can be enumerated to 24 up to 2015. The most used and adapted for artificial life and behavioral observation are, but not limited to: Jason, Cougaar, Netlogo, GAMA, AnyLogic and SeSAm (Kravari and Bassiliades, 2015). In our case, we used Netlogo due to its popularity and its features that allow exploring emergent phenomena.

### 4.1 Initialization and setup

The design of the simulation in Netlogo was developed in a way it allows to the user to test the impact of certain parameters on income level of poor and their repayment ratio (i.e. loan availability, crisis, dependence in repayment, etc.). The change of those parameters is allowed either through sliders (for numerical parameters) or through switchers (for binary values). Before each simulation, the setting of the environment and the agent can be specified and the global variables are initialized. An example of this setting is given in Table no. 2.

**Table no. 2 – Simulation settings in Netlogo**

| Classification | Agent/procedure | Variable | Settings |
|---|---|---|---|
| Setup | General | Periods | 5 |
| | MFI | Number | 1 |
| | | Fund | 300000 |
| | | Interest rate of microcredit | 10% |
| | | Maximum amount of microcredit | 3000 |
| | IMFI | Number | 1 |
| | | Fund | 150000 |
| | | Maximum amount of microcredit | 3000 |
| | Machine and Raw material supplier | Number | 4 |
| | Market Place | Number | 2 |
| | Poor | Number | 100 |
| | | Wealth distribution | N(1500,500) |
| | | Productivity of a woman | N(4,1) |
| | | Productivity of a man | N(5,1.5) |
| | Middle class | Number | 200 |
| | | Wealth distribution | N(4500,500) |
| | Rich | Number | 200 |
| | | Wealth distribution | N(7500,500) |
| Go | Move | Wealth decrease | 0.5 per movement |
| | Borrow | Productivity requirement | Productivity > 4 |
| | | Group formation requirement | Sum of productivities > 8 |
| | | Wealth condition | 1000 < wealth < 3000 |
| | Buy Machine and raw material | Machine price | 2000 |
| | | Raw material Precondition | Buy a machine, net wealth > 0 |
| | | Bargaining condition | 10 wealth, 1 material |
| | Employ | Precondition | x= 5 and netprofit > 200 |
| | | Employee requirement | Wealth < 3000, no loan, willing to work |
| | | Bargaining condition | 1 labor, 15 wealth |
| | Produce | Precondition self-employed | RM > 4 |
| | | Precondition employer | RM > 6 and L > 0 |
| | | Machin cost per production | 5 |
| | | Production Cost Self-employed | 25 |
| | | Production Cost Employer | 40 |
| | Trade | Precondition | inventory ≥ 2 |
| | | Margin | 0.2 |
| | | Bargaining condition self-employed | 30 |
| | | Bargaining condition employer | 48 |
| | Idiosyncratic disaster | Probability | 5% |
| | | Loss when happens | Selling Price = Production Cost |

The sliders in the simulation are: (1) Available funds, (2) Amount of loan, (3) Period of loan, (4) Period of simulation, (5) Number of Poor, (6) Interest Rate for the MFI, (7) Repayment behavior, (8) Level of cooperation and (9) Sensitivity to interest. The switched integrated are: (1) Seed number (allows to save the number of the simulation), (2) Crisis, (3) Dependency on neighbors in repayment, (4) Dependency on partner in repayment.

### 4.2 Outputs

Netlogo interface (Figure no. 2) allows showing the interactions among the agents and their evolution over time in dynamically changing monitors and plots. The monitors show resulting numbers while plots show graphical evolution. The monitors included in the simulation are: (1) Evolution of MFI fund, (2) Evolution of IMFI fund, (3) Evolution of wealth of IMFI clients, (4) Evolution of wealth of MFI clients, (5) Evolution of net wealth of MFI clients (6) Evolution of net wealth of IMFI clients (7) Number of basic-producers, (8) Number of producers-employers, (9) Number of employees, (10) Amount of productions (11) Average productions (12) Amount of trade, (13) Average trade by producer (14) Average Net profit. The simulation also contained the following plots: (1) Average wealth either for MFI and IMFI clients, (2) Debts from MFI and IMFI, (3) Repayment for MFI and IMFI, (4) Evolution of repayment behavior, (5) Evolution of number of producers either with Islamic or conventional loans, (6) Impact of cooperative behavior and greedy behavior on net profit report.

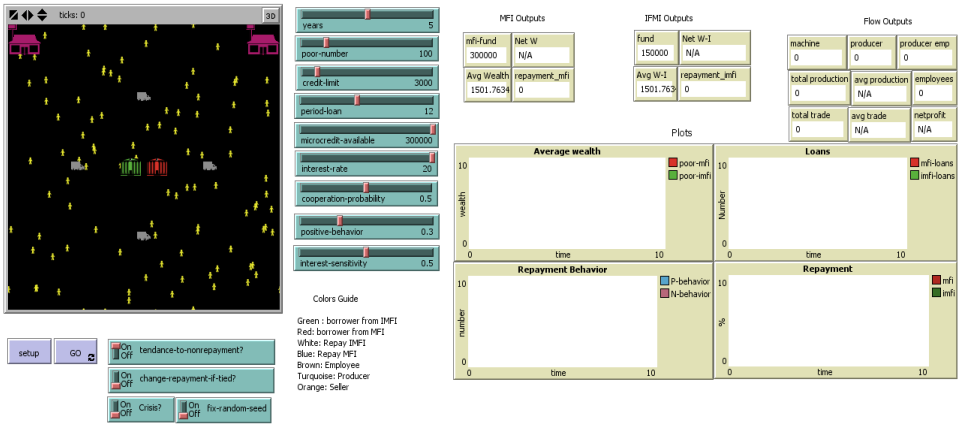


**Figure no. 2 – The simulation interface**

### 4.3 Analysis of Results

Three simulations were conducted through which we tested the impact of certain parameters on the environment and on the wealth of the poor. Table no. 3 describes the settings of each simulation. For each scenario, ten simulations were conducted through the Behavior Space of Netlogo and exported with Excel and R. We considered the median for the analysis of the results.

**Table no. 3 – The scenarios settings**

| Parameters | Value | | |
|---|---|---|---|
| | 1st Simulation | 2nd Simulation | 3d Simulation |
| interest-sensitivity | 0.5 | 0.5 | 0.5 |
| change-repayment-if-tied? | false | true | true |
| crisis? | false | false | true |
| positive-behavior | 0.5 | 0.5 | 0.5 |
| interest-rate | 10 | 15 | 10 |
| cooperation-probability | 0.5 | 0.5 | 0.5 |
| tendency-to-nonrepayment? | false | true | true |

***First scenario: Neutral environment***

The first simulation was conducted in a neutral environment with an interest rate of 10% and no tendency to non repayment. The objective of this simulation is to test the impact of group lending over recovery rates.

**Table no. 4 – Statistics of recovery rate and average wealth in the first scenario**

| | Rate of Recovery | | Average Wealth | |
|---|---|---|---|---|
| | R_MFI | R_IMFI | Avg_Wealth_C | Avg_Wealth_I |
| Min | 0.00 | 0.00 | 1248 | 1929 |
| 1st Qu. | 58.23 | 89.67 | 1597 | 2294 |
| **Median** | **76.45** | **95.27** | **1780** | **2412** |
| mean | 67.98 | 88.43 | 1772 | 2425 |
| 3rd Qu. | 82.13 | 98.12 | 1956 | 2581 |
| Max. | 88.06 | 98.93 | 2692 | 2845 |

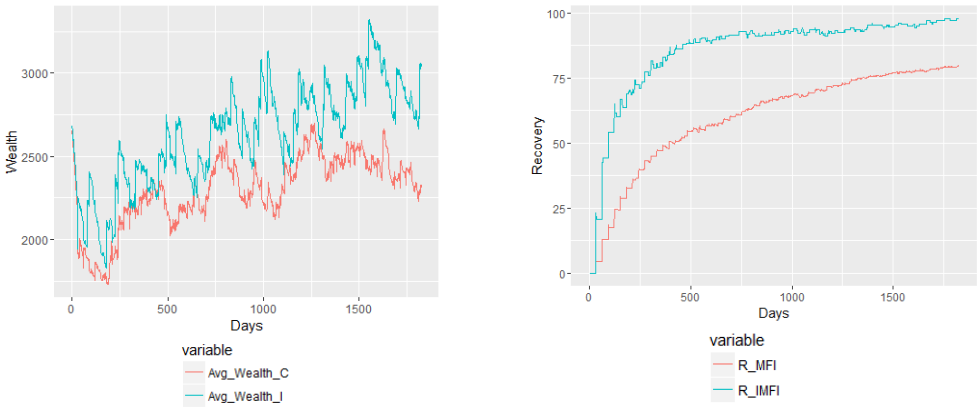


**Figure no. 3 – Evolution of *Wealth* and *Recovery* rate over time in a neutral environment**

Table no. 3 presents and aggregation of the recovery rate and average wealth outcomes of both conventional and Islamic microfinance clients. We observe an average rate of recovery of 95.27% for the group interest free lending and 76.45% for the conventional interest-based loan. This reflects the impact of joint liability over the repayment process but also the impact of interest rate. Indeed, the average wealth of the group loan clients is 2412

wealth units, which suggests an average net wealth of 912 wealth units (i.e. the level of wealth is enhanced by 60%). However, the net wealth of the MFI clients is only 280 (i.e. the level of wealth is enhanced by 19%). This can be explained by the interest rate and by the penalties imposed by the MFI.

***Second scenario: Impact of interest rate and peers influence***

In the second scenario, we isolated the impact of interest rate and the influence of the neighbors on the repayment behavior of the clients.

**Table no. 5 – Statistics of recovery rate and average wealth in the second scenario**

| | Rate of Recovery | | AverageWealth | |
|---|---|---|---|---|
| | **R_MFI** | **R_IMFI** | **Avg_Wealth_C** | **Avg_Wealth_I** |
| Min | 0.00 | 0.00 | 912.2 | 2017 |
| 1st Qu. | 52.06 | 85.71 | 1434.3 | 2478 |
| **Median** | **75.04** | **91.89** | **1634.5** | **2650** |
| mean | 66.72 | 84.77 | 1597.5 | 2654 |
| 3rd Qu. | 81.58 | 93.55 | 1777.6 | 2844 |
| Max. | 85.62 | 96.77 | 2543.5 | 3349 |

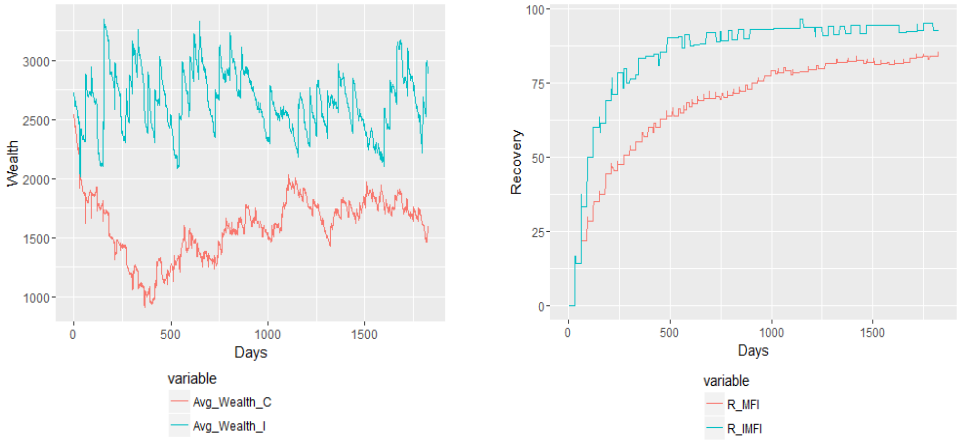


**Figure no. 4 – Evolution of *Wealth* and *Recovery* Rate over time for r =15%**

In this case, we can draw two conclusions. The first is the impact of increasing interest rate with 5%. The average wealth of the conventional MFI clients is 1634.5, corresponding to a net wealth of +9%. This also impacted the repayment rate that decreased with 1.41%.

The second conclusion is related to the impact of the neighbors' behavior. The impact of the behavior is greater than increasing the interest rate. Indeed, the repayment ratio of the Islamic free-interest group loan decreased by 3.38% while the net wealth is 1150. This can be explained by the fact the borrowers choose to default willingly under the influence of their peers.

***Third Scenario : Presence of an exogenous crisis***

Finally, we tested the impact of an exogenous crisis on the repayment behavior and on the average wealth of the borrowers.

**Table no. 6 – Statistics of recovery rate and average wealth in the third scenario**

| | Rate of Recovery | | AverageWealth | |
|---|---|---|---|---|
| | **R_MFI** | **R_IMFI** | **Avg_Wealth_C** | **Avg_Wealth_I** |
| Min | 0.00 | 0.00 | 995.6 | 1187 |
| 1st Qu. | 55.88 | 80 | 1099.1 | 1268 |
| **Median** | **68.52** | **85.71** | **1143.9** | **1791** |
| mean | 61.26 | 80.5 | 1217.6 | 1771 |
| 3rd Qu. | 75.38 | 91.11 | 1213.8 | 2266 |
| Max. | 79.55 | 94.65 | 2667.4 | 2625 |

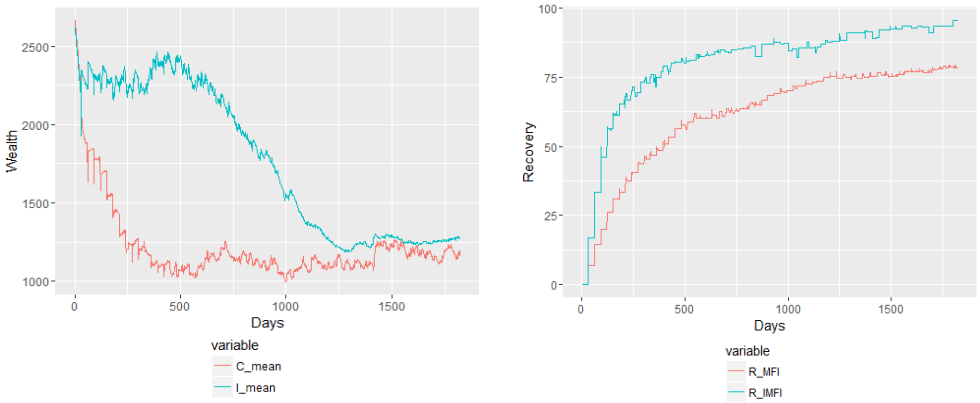


**Figure no. 5 – Evolution of *Wealth* and *Recovery* Rate over time in case of crises**

The rate of recovery of the MFI is 68.52% and 85.71% for the IMFI. The evolution of the wealth explains those rates, since most of the borrowers don't make any profit from their businesses. Moreover, the MFI clients suffer more from the crisis since they have to pay interest and penalties. This reflects the importance of the Return on Investment (ROI), which must be greater than the rate of interest in order to allow to the poor to overcome their poverty.

## 5. CONCLUSION

The objective of our simulations was to test the impact of both Islamic and conventional microfinance and whether the Islamic one can be more effective. For this we compared an interest-based group loan and an interest-based individual loan. The results showed that many parameters play a role in the impact that can be generated. For example, the impact of joint liability has a considerable effect on enhancing the rate of recovery and can be used by MFIs, especially in case of low enforcement. On the other hand, the neighbors' default and the tendency to non repayment that can exist depending on the cultural environment and social norms of a certain area can influence the decisions of the borrowers and hence, must be taken into consideration by the MFIs. Moreover, applying high interest rates limit the role of microcredit as a poverty alleviation tool, especially in the case of exogenous crisis, since the ROI of the borrowers' businesses have to be greater than the interest rate in order to make profit. Those results are in line with the findings of Rashid *et al.* (2011).

The Islamic free-interest group loan is a potential contract that can be implemented by MFIs since it can have a considerable effect on both the repayment ratio, because of the joint

liability, and the average net wealth of the borrowers, since there are no interest rates or penalties. In order to limit the probabilities of default, the MFI must take into consideration the social norms and cultural similitude of the considered implementation area.

Islamic microfinance is in need for more quantitative and agent-based simulation to embrace the complexity of its mechanism. The simulations allow testing the effectiveness of Islamic policies' implementation, especially since the majority of IMFI exist in dual markets. In further works, we aim to develop agent-based models to test innovative microfinance products such as profit and loss products. Moreover, information asymmetry remains a major issue in microfinance and developing models to limit it can encourage the implementation of profit and loss micro-financing schemes.

Finally, we must insist that the poverty alleviation either in Islamic or conventional financing systems cannot be restricted to financial access and income growth. It must be endorsed to services such as public safety, basic education, public health and infrastructure since they increase the productivity and employability of the poor, and thus their income and well being.

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