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Managing Operational Risk Related to Microfinance Lending Process using Fuzzy Inference System based on the FMEA Method: Moroccan Case Study

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Abstract

Managing operational risk efficiently is a critical factor of microfinance institutions (MFIs) to get a financial and social return. The purpose of this paper is to identify, assess and prioritize the root causes of failure within the microfinance lending process (MLP) especially in Moroccan microfinance institutions. Considering the limitation of traditional failure mode and effect analysis (FMEA) method in assessing and classifying risks, the methodology adopted in this study focuses on developing a fuzzy logic inference system (FLIS) based on (FMEA). This approach can take into account the subjectivity of risk indicators and the insufficiency of statistical data. The results show that the Moroccan MFIs need to focus more on customer relationship management and give more importance to their staff training, to clients screening as well as to their business analysis.

Keywords: FMEA method; fuzzy logic inference system; microfinance lending process; operational risk management.

JEL classification: G21; G32; C02.

1. INTRODUCTION

To serve the poor and low-income individuals excluded from the traditional banking, the MFIs develop several innovative solutions such as group lending and dynamic incentive. The MFIs provide a web of different financial products including microcredit, saving services, insurance, payment services (Ledgerwood *et al.*, 2013) and even micro-pensions (Littlefield *et al.*, 2003). MFIs may also provide different activities like skill training and entrepreneurial education, directly or in partnership with other institutions.

Although microfinance seeks, chiefly, to cut down poverty, MFIs disregard this customer aspect in favor of their financial sustainability (Bennouna and Tkiouat, 2016).

Various studies pinpointed the positive impact of microfinance on eradicating poverty, promoting children's education, improving health outcomes for women and children and

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empowering women (Dunford, 2006; Hermes and Lensink, 2007). Nevertheless, other studies reported no explicit impact of microfinance on poverty alleviation (Duvendack and Palmer-Jones, 2012).

Processes management and improvement, in any organization, is a fundamental device to guaranty the service quality and its delivery (Dumas *et al.*, 2013). Whilst many studies addressed the processes management question in manufacturing industry, this aspect was scarcely addressed in the microfinance sector. Ortolani (2006) notes that for each microfinance financial or socio-ethical activity certain processes are established to allow the production of the services and their distribution to the beneficiaries. She argues that managing these processes sufficiently can help the MFIs to achieve both their social and financial objectives.

Since 2007, the Moroccan microfinance sector has been considered as a leader in the Middle East and North Africa (MENA) region and one of the most successful microfinance sectors in the world (Reille, 2009). However, in 2008 the sector experienced a crisis due to an uncontrolled growth. To deal with this crisis, the leading MFIs in Morocco undertook a number of changes including strengthening their lending process (JAIDA, 2009). Nevertheless, according to International Finance Corporation (2014), not all responses have been effective.

In this context, this article is an attempt to identify, assess and prioritize accurately the root causes of delinquencies in MLP (Table no. 1) giving an example from Moroccan microfinance sector. Firstly, the FMEA method is performed based on the experts and stakeholders' judgment and then a fuzzy logic based FMEA system is established to improve its credibility. The study shows also a framework where process management techniques as six sigma and FMEA are deeming useful for microfinance industry.

Table no. 1 – Microfinance lending process

Supplier: MFIs	**Inputs**	**Process**
-NGOs -Credit unions -Cooperatives -Commercial banks -Government banks	-Poor individuals' requirements -Resources (staff, material, methods, technology…)	1-Products planning 2-Staff training 3-promotion 4-Clients' recruitment and application 5-Loan approval & disbursement 3-Collection and recovery

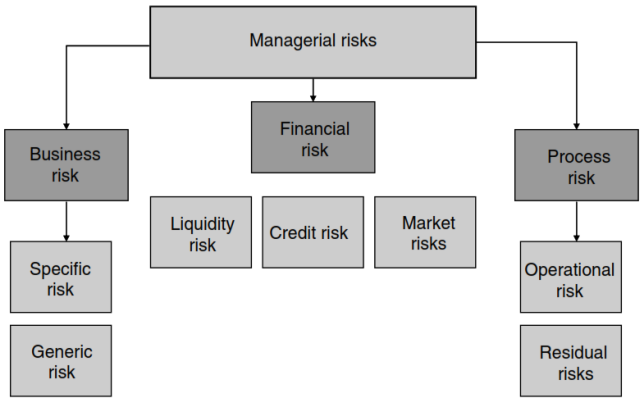
Customer	**Outputs**
-Low incomes individual - Self-employed in the informal economy (trade, agriculture, breeding…) - Small entrepreneur that lack capital …	-Appropriate product & service -Clients satisfaction -MFI performance -Improving the living conditions of the poor

Source: authors' elaboration

The remainder of the paper is organized as follows: Section 2 presents the operational risk management (ORM) framework and detects the root causes of MLP risks and failure using fishbone diagram and FMEA method. In Section 3 we introduce the fuzzy logic theory and then we develop a model that combines FMEA method with fuzzy logic inference system. The study results are reported in Section 4. Finally, conclusion and some perspectives are provided in Section 5.

2. ASSESSING OPERATIONAL RISK RELATED TO THE MLP: MOROCCAN CASE STUDY

Like all financial institutions, MFIs are subject to risks (Figure no. 1) that need to be managed efficiently and effectively. However, managing risks is more important for MFIs since their performance is evaluated according to both financial and social objectives rather than profit only (Steinwand, 2000).



Source: La Torre and Vento (2006)
Figure no. 1 – Risks in microfinance

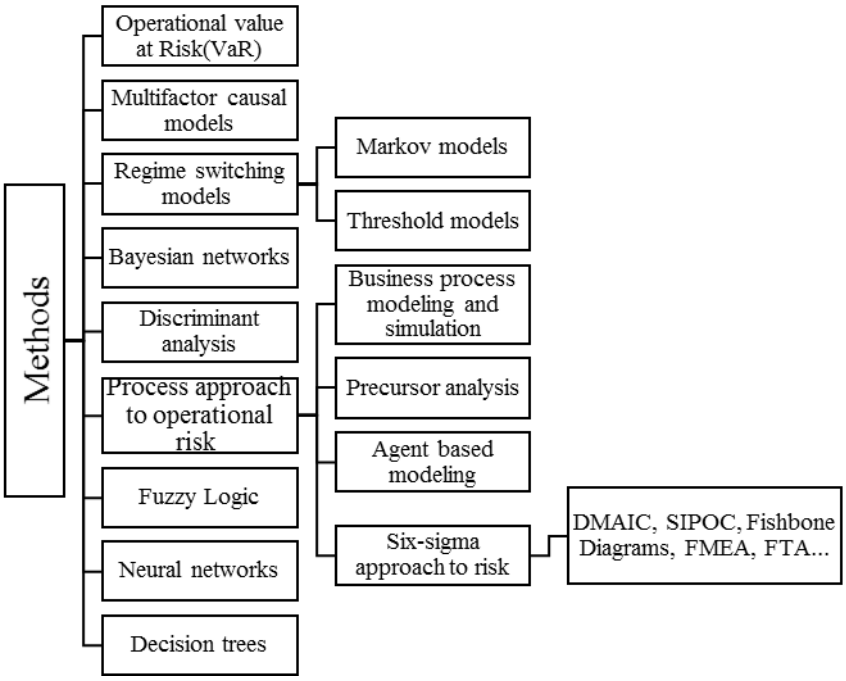
MFIs are required to incorporate risk management into their organizational design, lending methodologies, saving services, and operational procedures in order to develop strategies to mitigate the risks impact. Risk management involves identifying, understanding, assessing and prioritizing the risks that can have a negative impact on the institution performance (Steinwand, 2000). One of the main risks that the MFIs need to manage accurately is the operational risk. This risk is more complex as it includes non-linear, multidimensional and heterogeneous factors (Reveiz and León, 2009). From risk management point of view, MFIs are required to consider ORM as an essential phase (La Torre and Vento, 2006).

According to Basel II, operational risk is defined as "the risk of loss resulting from inadequate or failed internal processes, people, and systems or from external events". These risks may occur if the processes related to the production activity have not been clearly defined and, therefore, are not managed correctly. That can affect the achievement of the objectives and, consequently, the satisfaction of the client's needs (La Torre and Vento, 2006).

Pinto and Magpili (2015) define ORM as the design and control processes that will affect any type of the institution financial and non-financial operations. Tarantino and Cernauskas (2009) note that ORM encompasses all the process of identifying, assessing, and developing strategies to manage and mitigate operational risk.

Unlike Market, credit, and insurance risks that rely mainly on the analysis of statistical data for their quantification, operational risk is characterized by scarce availability of data. Collecting data on each business process within an organization to quantify its failures is not always easy. So, professional and academics find difficulties in identifying, measuring, modeling and managing several risks that fall under the canopy of operational risk (Tarantino and Cernauskas, 2009).

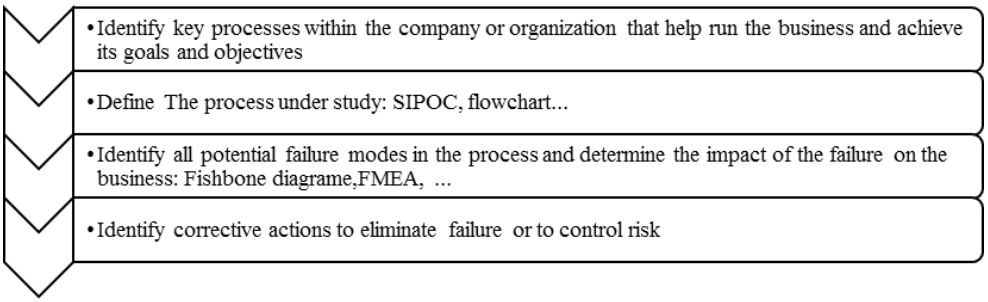
Figure no. 2 shows some quantitative methods to measure and manage operational risk as reported by Tarantino and Cernauskas (2009) and Shah (2002).



Source: adapted from Tarantino and Cernauskas (2009) and Shah (2002)

Figure no. 2 – Quantitative methods to manage operational risk

One of these proposed methods is the six-sigma approach to risk (Figure no. 3). It is a well-known process improvement tool and a helpful way to understand risks within a process.



Source: Tarantino and Cernauskas (2009)

Figure no. 3 – Six-sigma approach to risk

This approach is based on some key concepts such as:

– DMAIC approach, it is the acronym of Define, Measure, Analyze, Improve and Control;

– The SIPOC process analysis approach which stands for Supplier, Input, Process, Output, and Customer;

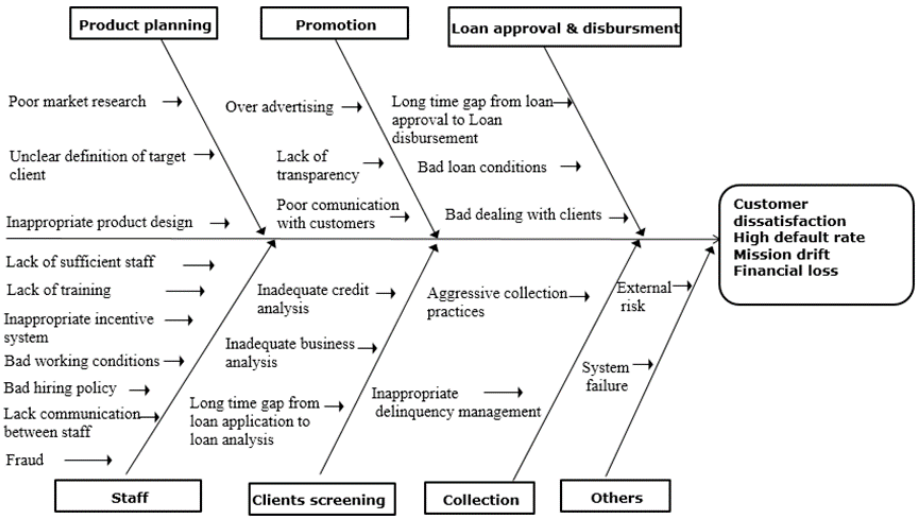
– The FMEA: Unavailability of reliable historical data on each business process within a company makes it hard the quantification of the process related risks. FMEA as a tool of six sigma programs is intended to deal with this issue by identifying the failure modes, their effects and causes and then prioritizing those who can affect the process performance based on experts' judgment. Noteworthy, FMEA takes into consideration any level of details about the system of interest with adequate the multidimensional nature of risk management (Tarantino and Cernauskas, 2009). Ravi Sankar and Prabhu (2001) reported that based on the FMEA results, corrective actions can be made to eliminate the causes of failure with the higher risk priority number (RPN) values or to reduce their effects.

2.1 Detecting the root causes of defect and failure in the Moroccan MLP

FMEA was used to identify, assess and prioritize the potential failures in the Moroccan MLP; our approach consists to:

Firstly, the possible cause of defects are documented from the literature and then discussed with some microfinance practitioners (Figure no. 4).

Secondly, the severity (Sev), occurrence (Occ), and detection (Det) of each risk are calculated according to the experts' judgment, then all the risks are classified as per their risk priority number (RPN) considered as the product of the three risk factors. i.e severity, occurrence, and detection. Hence, the failure modes with the higher RPN values are given the higher priority compared to those having the lower RPN values.



Source: Authors' elaboration

Figure no. 4 – Risk related to MLP

In this study, the severity and occurrence are scored from 1 to 10 while detection is scored from 1 to 5. Twelve experts are selected from the three principal Moroccan MFIs i.e. Al Amana, Albaraka, and Attawfik. The population (experts) is composed principally of

consultants, market research executives and credit officers, who are supposedly well-informed about the study field. The data are collected using both face-to-face and online questionnaires. The main issue addressed by the questionnaire is assigning scores for the different risks related to Moroccan MLP. The experts assign scores based on their experience within their institutions and according to their knowledge about the Moroccan MLP. For each risk, the scores assigned by the different experts are combined using the arithmetic average. Table no. 2 shows the FMEA results for the MLP in Moroccan MFIs according to the selected domain experts.

Table no. 2 – FMEA table: Moroccan MFIs case study

Item	Potential failure mode	Sev	Occ	Det	RPN	rank	Effect
Product planning	Poor market research	5.75	5.25	1.75	53	13	Inappropriate product design
	Unclear definition of target client	5.5	3	2.87	47	8	
	Poor communication with clients	5	4.75	3.2	76	11	
Human Resource	Lack of training	6	5.75	3.75	129	3	Weak productivity Bad dealing with clients High Employees turnover rate Financial loss
	Lack of sufficient staff	7.25	3	2	44	15	
	Inappropriate incentive system	3.25	3.5	1.25	14	21	
	Bad working conditions	8	6.25	2	100	5	
	Lack of communication between staff	5.5	6.25	3.5	120	4	
	Lack of skill	7	4	3.25	91	12	
	fraud	7.75	5.25	2.12	86	6	
	Bad dealing with clients	7.25	5.75	3.62	151	2	
Promotion	Over advertising	2	1.75	2	7	22	Reputation loss Poor definition of the institution and its products Low market share
	Lack of transparency	6.5	5	2	65	10	
	Poor Communication with customers	4.5	3.75	2	34	18	
Client screening	Inadequate credit analysis	3.75	3.75	2.5	35	17	Customers' dissatisfaction Customer default
	Inadequate business analysis	7.75	7,5	2.5	145	9	
	Long time gap from loan application to loan analysis	6.25	3	1.25	23	20	
Loan approval and disbursement	Long time gap from loan approval to Loan disbursement	5.75	3.25	2.75	51	14	Customers' dissatisfaction Customer default
	Bad loan conditions	5.25	4.5	3.12	74	7	
Collection	Aggressive collection practices	7.5	7	4.13	217	1	Reputation loss Customers' dissatisfaction Financial loss
	Inappropriate delinquency management	6.7	3	3	60	19	
Others	External risk and system failure (hardware, software, telecommunication)	6.75	3.5	1.75	41	16	Financial loss

The classification of the first 10 potential failure modes according to the traditional FMEA method is shown in Table no. 3.

Table no. 3 – Ranking the potential risks of the MLP according to FMEA RPN

Risk	FMEA RPN	Rank
Aggressive collection practices	217	1
Lack of communication between staff	151	2
Inadequate business analysis	145	3
Lack of training	129	4
Lack of skill	120	5
Bad working conditions	100	6
Fraud	91	7
Bad dealing with clients	86	8
Bad loan conditions	74	9
No clear definition of target client	71	10

Although still widely used, classical FMEA has been criticized because of its several limitations (Haq *et al.*, 2015; Duminica *et al.*, 2011; Keskin and Ozkan, 2009). The severity, occurrence, and detections are subjective and generally described qualitatively in natural language. Moreover, different score combinations of these three criteria may lead to the same RPN, even when the importance of the risks involved is not the same. To overcome these weaknesses, a fuzzy logic approach is proposed for the FMEA in order to assess and rank risks accurately. In the absence of a quantitative probability model, fuzzy logic can rank the key risks in a consistent way, considering both the available data and experts' opinions (Shang and Hossen, 2013).

3. A FUZZY LOGIC BASED FMEA: APPLICATION TO THE MLP

According to (Reveiz and León, 2009; Zadeh, 1983), fuzzy logic can help to deal with subjective, incomplete or unreliable knowledge bases. So, it is suggested as a good candidate for measuring operational risk. Shang and Hossen (2013) also found that such model can help to identify the serious risks and may include information about the causes of risk exposure or factors that have a significant impact on it. Fuzzy inference system takes each risk factor level and evaluates them simultaneously in order to infer their joint contribution to operational risk indicator.

3.1 Fuzzy logic

In the real world, decision-making generally takes place in fuzzy environments under judgment uncertainties (Belhaj and Tkiouat, 2015). To deal with such situations, fuzzy logic (Zadeh, 1965) is an adequate solution. It provides flexibility for reasoning and takes into account inaccuracy, subjectivity, uncertainty, and imprecision (Dernoncourt, 2013).

The literature about using fuzzy logic for the microfinance problems is rather limited. For example, Lozano and Fuentes (2010) propose a fuzzy model to evaluate the social impact of a microcredit program. Aboulaich *et al.* (2013) and Abdulrahman *et al.* (2014) implement fuzzy logic models for Microcredit Scoring to reduce the loan default among the MFIs.

To formulate input data to an output, fuzzy logic includes membership function, fuzzy logic operators and If-then rules (Nobari *et al.*, 2012). The choices made by the designer of a fuzzy system such as defining the membership functions and the decision matrix are based mainly on the advice of the expert or statistical data (Dernoncourt, 2013). A fuzzy logic system is established based on several steps summarized in Table no. 4.

Table no. 4 – Fuzzy logic system establishment

Step	Description
1	Select the key indicators that affect the dependent variables.
2	Create fuzzy sets for both independent and dependent variables, and then specify the degree of truth that each variable belongs to a certain fuzzy set using the membership functions.
3	Establish the inference rules in the system
4	Generate the output fuzzy set of the dependent variable based on the independent variables and the inference rules, and then a numerical value of the output fuzzy set is calculated by the defuzzification operation.
5	Use the model results to make decision.

Source: Dernoncourt (2013)

3.2 Fuzzy logic based FMEA model

The general form of the fuzzy logic based FMEA model is illustrated in Figure no. 5. Both the input and output variables of the fuzzy system are divided into a number of fuzzy sets and then the membership degree that each variable belongs to a certain fuzzy set is specified using membership functions (see Table no. 5).

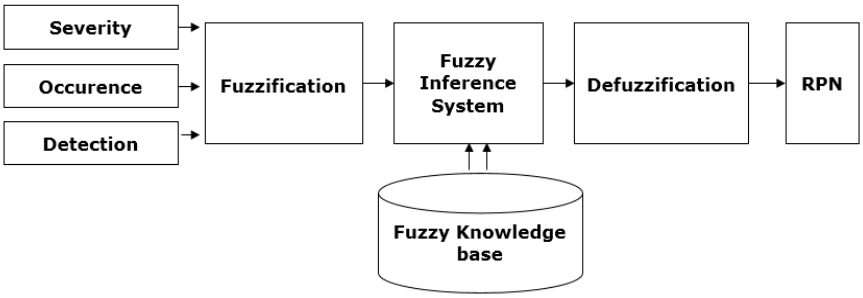


Figure no. 5 – The fuzzy FMEA model

For the inputs variables, trapezoidal functions are used and both triangular and trapezoidal membership functions are used for the output variable RPN. Triangular and trapezoidal membership functions are recommended due to their simplicity as well as many other advantages (Pedrycz, 1994; Barua *et al.*, 2013). The trapezoidal membership function depends on four parameters, a, b, c, and d, as illustrated in Figure no. 6. While the triangular membership function is defined by three parameters, a, m, and b, where a < m < b (see Figure no. 7).

$$f(x;a;b;c;d) = \begin{Bmatrix} 0, & x \le a \\ \frac{x-a}{b-a} & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c} & c \le x \le d \\ 0, & d \le x \end{Bmatrix};$$

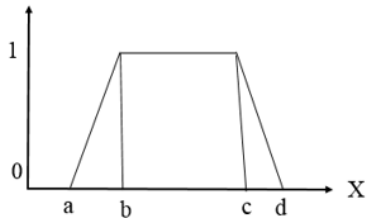


Figure no. 6 – The shape of trapezoidal membership function

$$f(x;a;m;b) = \begin{cases} 0 & x \le a \\ \dfrac{x-a}{m-a} & a \le x \le m \\ \dfrac{b-x}{b-m} & m \le x \le b \\ 0 & x \ge b \end{cases}$$

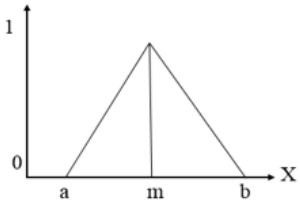


Figure no. 7 – The shape of triangular membership function

Based on the membership functions of the input variables, 75 inference rules are generated; the RPN variable is described in terms of the three risk indicators. i.e. severity, occurrence, and detection (Tables no. 6, no. 7 and no. 8). To get a numerical value of the RPN related to each risk, defuzzification is done using centroid method.

Table no. 5 – Parameters of the inputs and outputs membership functions

	Variable	Membership function type	Parameter
Input variable: Detection	L: Low	Trapezoidal	[0 0 1 1.5]
	M: Medium	Triangular	[1, 2.5, 4]
	H: High	Trapezoidal	[3 3.5 5 5]
Input variables: Severity and Occurrence	VL: Very Low	Trapezoidal	[0,0,1,2]
	L: Low	Trapezoidal	[1,2,3,4]
	M: Medium	Trapezoidal	[3,4,6,7]
	H: High	Trapezoidal	[6,7,8,9]
	VH: Very High	Trapezoidal	[8,9,10,10]
Output variable: RPN	LT: Lowest	Trapezoidal	[0,0,100,150]
	LR: Lower	Triangular	[100,150,200]
	L: Low	Triangular	[150,200,250]
	M: Medium	Triangular	[200,250,300]
	H: High	Triangular	[250,300,350]
	HR: Higher	Triangular	[300,350,400]
	HT: Highest	Trapezoidal	[350,400,500,500]

Table no. 6 – Fuzzy computation of the output RPN (Det: L)

RPN		Occ				
		VL	L	M	H	VH
Sev	VL	LT	LT	LT	LR	LR
	L	LT	LR	LR	LR	L
	M	LT	M	M	M	M
	H	LR	L	M	H	H
	VH	LR	L	M	H	H

Table no. 7 – Fuzzy computation of the output RPN (Det: H)

RPN		Occ				
		VL	L	M	H	VH
Sev	VL	L	L	L	M	M
	L	L	L	M	M	H
	M	M	M	HR	HR	HR
	H	H	H	HR	HT	HT
	VH	H	H	HR	HT	HT

Table no. 8 – Fuzzy computation of the output RPN (Det: M)

RPN		Occ				
		VL	L	M	H	VH
Sev	VL	LR	LR	LR	L	L
	L	LR	LR	L	L	M
	M	LR	L	H	H	H
	H	L	M	H	HR	HR
	VH	L	M	H	HR	HR

4. RESULTS AND DISCUSSION

Based on the established set of inference rules, the FLIS can infer all the attainable operational risk indicator results in any combination of the key risk factors (see Figure no. 8).

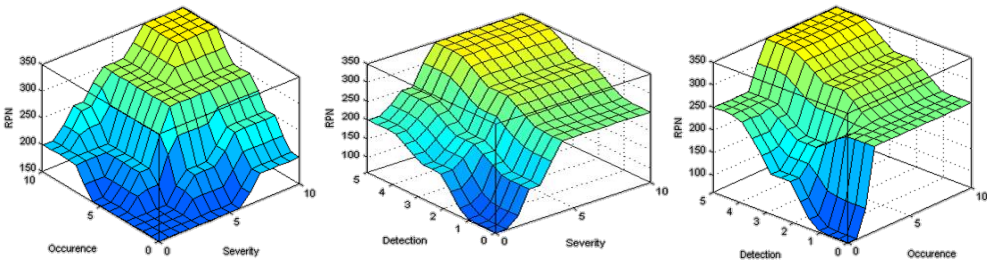


Figure no. 8 – RPN as a combination of the different risk factors

Figure no. 9 shows a comparison of risks priority ranking according to traditional FMEA and fuzzy inference system. Table no. 9 shows the 10 serious risks ranked according to FLIS based FMEA. We notice that the risks ranking is different from that based on classical FMEA. For instance, the classical FMEA puts inadequate business analysis in the third place while it is placed in the second place according to FLIS based FMEA model.

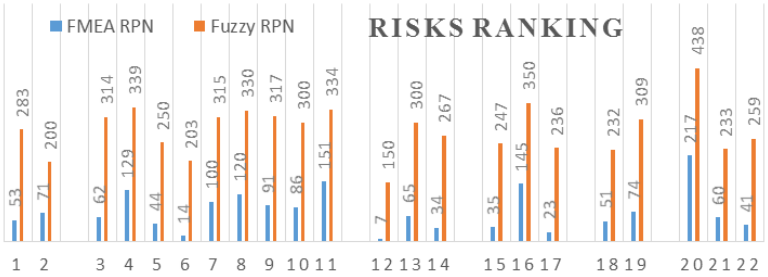


Figure no. 9 – Ranking MLP risks according the FMEA and fuzzy RPN

Table no. 9 – Ranking the principal risks of the MLP according to fuzzy RPN

Risk	Fuzzy RPN	Rank
Aggressive collection practices	438	1
Inadequate business analysis	350	2
Lack of training	339	3
Lack of communication between staff	334	4
Lack of skill	330	5
Fraud	317	6
Bad working conditions	315	7
poor communication with clients	314	8
Bad loan conditions	309	9
Bad dealing with clients	300	10
Lack of transparency	300	10

According to the 10 top potential risks highlighted by the fuzzy logic based FMEA approach (Table no. 9), we suggest that Moroccan MFIs need to take certain remedial

actions to improve the performance of their lending process. Specifically, the Moroccan MFIs need to focus on:

- Improving recruitment and hiring policy: The MFIs are encouraged to develop job profiles notably for loan officers who represent the primary contact point with customers. That would help the MFIs hiring the right people in terms of technical, organizational and personal competencies. The MFI needs to make sure that loan officers establish good relationships between customers and the institution.
- Staff training and coaching: Staff training is a key point to ensure good quality and to provide better service. It should emphasize on customer service, soft skills, technical competencies and ethical behavior. The MFIs personnel should also be aware of the company mission, vision, and strategy.
- Selecting the right target customers: In order to target the right customers and address their needs, MFIs are required to fully understand the operational environment and define the target market. Hence, they would be able to deliver successful products and services.
- Customer relationship management: The MFIs have to be customer oriented and maintain good customer service relations. They are urged to make sure that clients understand their rights and responsibilities as microfinance customer; adopt customer oriented culture throughout the organization; establish an effective mechanism for customer complaint resolution; also set preventive and corrective plans.
- Business analysis: A good business analysis would help the MFI determine the eligibility of the applicant and to place the appropriate conditions such as the amount of loan and the repayment terms. Therefore, the MFIs need to gather sufficient information about the applicant project or business and then analyze the elements bellow :
  - The business activity, the potential market, the effect of seasonal fluctuations and price variation etc.
  - The innovative aspect of the business and its creativity.
  - The business profitability, taking into consideration the family needs.
  - The economic conditions affecting that type of business.
  - The ability of the applicant to manage the business.
- Staff involvement in the organization: Involving staff means creating an environment where employees feel they are encouraged to participate, discuss problems and issues; share knowledge and experience; participate in solving problems; and understand the importance of their contribution and role in the organization. Through staff involvement, MFIs should be able to enhance productivity and innovation, minimize miscommunication throughout the organization and keep full awareness of customers' expectations.
- The working environment improvement: Satisfied employees are more likely to produce quality work. The MFIs should provide a working environment that is challenging and enjoyable for the workforce. Good working conditions lead to higher productivity, a higher motivation of the employee and to fewer turnovers.
- Fraud risk management: With the aim of addressing fraud risk accurately, the MFIs should enhance corporate governance, establish an adequate internal control system and be fair in the treatment of their employees.

5. CONCLUSION AND PERSPECTIVES

Studies concerning operational risks in MFIs are scarce. Furthermore, to the best of our knowledge, there is no study that quantifies the MLP related risks. Firstly, this paper presented a

framework to apply six-sigma tools and techniques, particularly FMEA in Microfinance industry. The aim was to identify, assess and prioritize risks associated to MLP, giving an example from Moroccan MFIs. In a second stage, the FMEA is combined with fuzzy logic in order to improve the credibility of the expert judgment, and identify the critical risks accurately.

To validate the findings of the study, a series of interviews was conducted with a number of Moroccan microfinance stakeholders; who confirmed the appropriateness of the obtained results.

There are, nevertheless, numbers of limitations to this research; first, the subjective nature of the FMEA and fuzzy logic makes the results evaluation quite difficult. Second, the developed approach is unable to define causal links between the different risks and their impact on customers' satisfaction and the MFI financial performance; we intend to deal with those issues in future works.

Acknowledgements
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