Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7765839

DOES MICROFINANCE EFFICIENCY COMPLEMENT IN ITS COST OF LENDING? A STOCHASTIC FRONTIER ANALYSIS APPROACH.

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Abstract
Microfinance institutions (MFIs) have emerged as a useful tool to eradicate poverty by giving financial services to the poor. Among these institutions that attain efficiency may obtain the ability to perform its operations at an optimal cost or lower cost relative to its peer companies. The study focused mainly on examining the association between microfinance efficiency, and its cost of lending to identify that, does MFI efficiency complements in its lending cost? The study employs a data envelopment analysis (DEA) to analyze the microfinance efficiency and stochastic frontier analysis (SFA) to explore the presence of any relationship between microfinance efficiency and its lending cost to the clients. Additionally, sensitivity analysis, robust regression and Granger causality tests were conducted to examine the direction of causality between these two variables. The finding of our study evidences a negative association between microfinance efficiency and its cost of lending. The results are relevant to policymakers, shareholders, donors, funders, etc. By taking strategic steps to enhance the MFI efficiencies to access low cost and faster finance and it could complement its cost of lending through facilitating funding at a low cost to the poor.

Keywords- Microfinance efficiency, stochastic frontier analysis, cost of lending.

1. Introduction

Poverty eradication is one of the prime development objectives in the economic progress of any country(World Bank Bulliten, 2000);(Tufa, 2021);(Yendaw, 2022).Even though various financial institutions exist under the umbrella of the financial system, they were unsuccessful in getting ahead in the mission of 'banking with poor'(Amha, 2007);(Roy and Goswami, 2013);(Chowdhury et al., 2018); (Ferdousi & Mahmud, 2019);(Angeles et al., 2019);(Boateng & Poku, 2019);(Atarah et al., 2021). The poor are considered to be risky due to the lack of collaterals. They are underprivileged from the formal financial services due to lack of

income, vulnerability to income fluctuations, powerlessness as they have very few choices and little control. The Microfinance institutions (MFIs) emerged as one of the preeminent tools and has recognized as one of the best solutions to provide financial services to the poor by giving a small amount of collateral-free loans by following a self-disciplined group lending system(Zeller and Sharma, 1998); (Sharma, 2014); (Tundui & Tundui, 2018) ;(Tufa, 2021);(Yendaw, 2022).It helps in promoting income generation activities, protects their income and empowers them to gain self sustainability (Ahmed et al., 2017); (Akinyemi & Adejumo, 2018); (Agyapong & Attram, 2019); (Ali & Yousuf, 2019); (Tufa, 2021); (Yendaw, 2022).A large number of MFIs are able to reach millions of clients aiming at bringing changes in their economic growth through new business ventures or expanding businesses, uplifting their socio-cultural status through improving quality of life, children nutrition and education. Furthermore, MFIs empowers people, especially women through these services as they gain more power in household and community. It also gives a personal and psychological boost up as they feel more confident in taking new challenges or risks .Therefore, the efficiency of these institutions is of considerable significance in attaining sustainable development. To attain the double bottom-line objective of sustainability and outreach(Gutierrez-Goiria, San-Jose and Retolaza, 2017);(ZahidMahmood et al., 2017);(Rezaei-Moghaddam et al., 2019).The main challenge for MFIs is to achieve efficiency and productivity that can be enhanced through both minimizations of cost and maximization of revenue relative to the volume of business produced.

Typically, MFIs provide a small amount of collateral-free loans to the poor by following a group monitoring system with a joint liability contract. They put up the borrowers with a stringent scheduled repayment system and showed evidence of good repayment records(Kono and Takahashi, 2010); (Hoque & Nahid, 2015); (Hoque et al., 2016); (Kapinga & Montero, 2017); (Israr & Saleem, 2018); (Khanam et al., 2018); (Li, 2019); (Mujahid et al., 2019); (Mayanja et al., 2021); (Pareek et al., 2022).However, collateral-free lending practices make MFIs charge higher interest rates to make themselves financially self-sustainable(Garmaise and Natividad, 2013);(Yimga, 2018).Moreover, MFIs offer credits, but most of them do not accept any deposits from the public. They borrow funds from various sources and lend these funds to the poor in small amounts without any collateral. MFIs pay the interest rate for the borrowed funds, and they charge a little higher rate of interest during the lending process to the clients to generate revenue to attain financial sustainability. The difference between these two interest rates is the operational revenue for MFIs.

MFIs efficiency is mainly depending on the optimum utilization of resources. Cost efficiency is the vital measure that enhances the ability of MFIs to operate at a lower cost. MFIs that are located on the efficient frontier line sets as a benchmark in cost structure by showing a noteworthy comparison with its peer group MFIs. However, the practical way of performing business operations will reflect in optimum utilization of resources, which can affect the cost per loan made(Abate, Borzaga and Getnet, 2014). There are two major influencing factors in MFIs operations are its efficiency and operational cost. The expenses incurred for providing the services can be termed as operating cost, which includes cost per loan made. The total cost comprises the cost of borrowed capital, operating cost, and cost of personnel. It can be further broken down into salaries and benefits of loan officers and managers, office and administrative expenses, etc.

MFIs that are located in the efficient frontier are working on full efficiency. The resultant of this shows an optimum economy of scale and optimal cost of operations. Consequently, it can boost up the profit by ploughing back the profit into the business. The MFIs can maintain the low debt-equity ratio, which sustainably reduces interest expenses. On another side, the efficiency of MFIs can influence healthy portfolio quality which helps in the sourcing of monetary funds to from banks and other financial institutions at a lower interest rate due to excellent credit scores or ratings(Annim, 2012).Since it enhances the credibility in raising funds at a cheaper rate of interest, do these benefits reflect on charging the lower lending cost to the poor? The focus of our study is to explore the tradeoff between MFIs efficiency and the cost of lending to clients.

We found a countable number of evidence of researches related to overall MFIs. Prominent Studies related to its dual bottom line objective such as social and financial objective, efficiency and productivity, cost efficiency(Farooq and Khan, 2014);(Soltane Bassem, 2014);(Widiarto and Emrouznejad, 2014);(Galvez-Alinsunurin and Alinsunurin, 2015);(Nurzahira, Tahrim and Tahir, 2015);(Gutiérrez-Nieto *et al.*, 2017);(Bibi *et al.*, 2018);(Boubaker*et al.*, 2019);(Ferdousi, 2020)**,**studies related to the impact assessment of MFI services on poverty reduction, women empowerments, on quality of life(Roy and Mohanty, 2020);(Macha, Chong and Chen, 2019)etc and so on. However, the existing MFI efficiency literature has mainly focused on various dimensions such as social efficiency or outreach, financial efficiency or sustainability and many other determinants such as size of the MFIs, age, gender, governance, ownership type etc. Most of the studies have focused on identifying the determinants, trade-offs that influence MFIs efficiency. Very few shreds of evidence have explored the consequences of MFI efficiency(Wijesiri, 2016). However, surprisingly no studies have investigated the implications of MFI efficiency on its cost of lending. Therefore, the current research has focused on filling the research gap by exploring the significance of MFI efficiency on its cost of lending?

The current study contributes to the literature in two ways .In the first stage of analysis the study has evaluated the microfinance efficiencies by adopting data envelopment analysis followed by computation of inefficiencies variable wise .The researchers have also conducted sensitivity analysis to evaluate the robustness of the data .In the second stage the study has used the study focused mainly on examining the association between microfinance efficiency, and its cost of lending to identify that does MFI efficiency complements in its lending cost. The study employs stochastic frontier analysis (SFA) to explore the presence of any relationship between microfinance efficiency and its lending cost to the clients. Additionally, robust regression and Granger causality tests were conducted to examine the direction of causality between these two variables.

The remaining part of the paper is organized as follows. Section 2 highlights the literature review and research gap supported by the model used and methodology in section 3 and section 4, followed by finding and conclusion in section 5 and section 6.

2. Literature Review

We have presented the literature review section under three subheads.

2.1. Studies related to MFIs

However, there is extensive work on efficiency and productivity measurements in financial institutions, research in the area of MFIs is still in its infancy, and it is mounting rapidly(Yimga, 2018). The recent works of literature on performance measurement of microfinance has been

assessed in terms of efficiency and productivity. Performance measurement usually assessed either on an intelligent measurement system or on subjective indicators. Traditionally these assessments were made using the Yaron framework. But by far, the most popular methods used for performance measurements to study efficiency and productivity are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The effectiveness of MFIs depends mainly on two indicators, namely outreach and sustainability. Social efficiency is measured in terms of outreach, and financial sustainability is measured in terms of sustainability(Cuéllar-Fernández *et al.*, 2016). Various studies have contributed in investigating the trade-off between dual objectives(Annim, 2012) and multiple determinants influencing efficiency and productivity such as ownership status, size of MFI, the role of government invention, the impact of gender and governance, etc.(Bassem, 2014);(Abul *et al.*, 2016);(Cuéllar-Fernández *et al.*, 2016);(Wijesiri, 2016);(Bibi *et al.*, 2018) .

2.2. Studies related to MFI efficiency

(Gutierrez-Nieto *et al.*, 2007)conducted a study on Social efficiency in microfinance institutions on 16 Asian MFIs. The significant finding of the study is found a positive relationship between efficiency in supportive women and combat poverty.(Bassem, 2008)evaluated the efficiency of 35 MFIs in the Mediterranean applying DEA. The survey revealed that the size of the MFIs has a negative effect on their efficiency since the MFIs of medium size are more efficient than the eminent.

(Kabir Hassan, Sanchez and Ngene, 2012) evaluated scale and technical efficiencies in MENA region MFIs to trace the sources of inefficiencies using DEA with dynamic Malmquist productivity index (MPI).The main findings of the study showed that technical efficiency is low for MFIs, regardless of the approach used.(Annim, 2012)conducted a study on microfinance efficiency to identify the trade-offs and complementarities between the objective of MFIs and their performance perspective related to Social Vs financial efficiency, external environment using DEA and SFA. The researcher used the data of 164 MFIs across the world. The main findings of the study showed that social efficiency is enhanced if MFIs target women clients.

(Ben Abdelkader, 2012) conducted a study on MFIs efficiency in the MENA region. The researcher used a bootstrap –DEA approach to establish the trade-off between legal status and efficiency with 61 MENA (Middle East North Africa) MFIs. The result revealed that efficiency significantly differs by legal status.(Servin, Lensink and Finance, 2012)conducted a study to examine the trade-off between ownership and technical efficiency of MFIs. The researcher found the empirical evidence using315 MFIs over18 countries from Latin America applying SFA. The results showed that non-government organizations and cooperatives have much lower interfirm and intrafirm technical efficiencies than NBFCs indicating the importance of ownership type for technical efficiency.

(Singh and Goyal, 2013)conducted a study on technical efficiency and its determinants of Indian MFIs. The researcher used a firm-level analysis using DEA. Tobit regression model also examined the factors affecting efficiency. The finding of the study revealed that the output of MFIs could be increased without increasing the quantum of inputs.(Farooq and Khan, 2014)examined the social and financial efficiency of MFI in Pakistan applying DEA. The findings of the study revealed that NGOs and NBFI were more efficient based on the achievements of social and financial objectives of microfinance.

(Mahmood *et al.*, 2014)examined the efficiency analysis of conventional Vs Islamic MFIs taking 12 MFIs of Pakistan using DEA. The results showed that Islamic MFIs have been more efficient as compared to traditional NGO MFIs.(S Kablan, 2014)conducted a study on Social efficiency and financial efficiency using DEA with 104 MFIs of WAEMU zone. The result revealed that risk has a positive impact on social efficiency and a negative impact on financial efficiency. Outreach has a negative and significant impact on profitability.(Soltane Bassem, 2014)evaluated technical efficiency of 33 MENA region MFIs. The study showed that the industry as a whole had exhibited a decline in technological changes. There has been deterioration in the performance of best practicing MFIs. It is found that MFIs have experienced mainly an increment of pure technical efficiency rather than an improvement in optimum size.

(Galvez-Alinsunurin and Alinsunurin, 2015)conducted a study to examine the trade-off between legal status and the efficiency of 69 MFIs in the Philippines using DEA. The result showed that non-NGO MFIs are more efficient than NGO MFIs.(Nurzahira, Tahrim and Tahir, 2015)conducted an efficiency study of major MFIs in Bangladesh and also assessed the role of government intervention. DEA Malmquist index was used on 15 MFIs of Bangladesh. The result of the study signified that MFIs are experienced excellent efficiency progress due to pure efficiency and also meant that major MFIs have less capacity to work at their optimal scale.(Wijesiri, Viganò and Meoli, 2015)researched 36 MFIs of Sri Lanka using a two-stage double bootstrap DEA approach. According to the results, most of the MFIs found to be inefficient both financially and socially. Age and capital –to-assets are important determinants of financial efficiency whereas age, type of the institution and return on assets are the vital determinants of social efficiency.

(Abul *et al.*, 2016) done a research to examine financial and social efficiency between conventional MFIs and Islamic MFIs using DEA, on 231 MFIs. The results revealed that conventional MFIs surpassed Islamic MFIs in financial and social efficiency.(Gebremichael and Gessesse, 2016)examined the trade-off between technical efficiency and ownership type applying SFA and DEA approach. The researcher used the data of 34 MFIs from Africa. They found that African MFIs are technically inefficient, and there is a significant difference in efficiency performance among different ownership types of MFIs.(Cuéllar-Fernández *et al.*, 2016)examined the trade-off between Social efficiency and legal status using DEA .Data was gathered from 403 MFIs from Sub Saharan Africa, Latin America, Caribbean, Eastern Europe, and Asia Pacific region. They confirm a high positive correlation between social and economic efficiency as a point of the paradox of social cost.

(Gutierrez-Goiria, San-Jose and Retolaza, 2017) surveyed the social efficiency of 89 MFIs from various regions of Asia, Africa, Latin America, Eastern Europe. They confirm that there is a significant and positive relationship between efficiency in supporting women and efficiency in fighting poverty. They found that NGOs are more socially efficient than the other organizational structure.(Wijesiri, Yaron and Meoli, 2017)conducted research on financial and social efficiency using DEA using420 MFIs from Latin America, Asia, Africa, Eastern Europe region. They also evaluated the trade-off between the efficiency with its determinants such as age and size of MFIs. The results were indicating that most of the MFIs are financially and socially inefficient, and it finds that older MFIs perform better than the younger ones in terms of achieving the financial objective and inefficient in outreach objective.

(Bibi *et al.*, 2018)conducted a study to evaluate the impact of gender and governance on MFI efficiency. The researcher used DEA with double bootstrap truncated regression approach on South Asian MFIs data. The main findings of the study showed that South Asian MFIs are more financially efficient than socially efficient. The regression results revealed that female loan officers are positive determinants of MFIs efficiency. The research showed a strong association between MFI governance and efficiency.(Pal and Mitra, 2018)conducted a study on the efficiency of MFIs integrating undesirable output, i.e. problem loans (Non-performing loans) using DEA, directional distance function (DDF) taking data of 64 large MFIs across the globe. The result of the study reveals that problem loans are the critical component for computing efficiency of MFIs. In this study, our main focus is on cost efficiency and interest rates. MFI efficiency literature related to cost efficiency and interest rates are very limited and discussed below in 2.3 subhead.

2.3. Studies related to MFI cost efficiency and interest rates

(Garmaise and Natividad, 2013) had examined the relationship between cheap credit, lending operations with the influence of international politics. The researcher has studied the impact of low rate financing market financing on MFIs operations and performance. However, cheap credit leads to higher profitability for MFIs and prompts a shift towards non-commercial loans but has no increase in total overall lending to the poor. (PW Roberts, 2013)analyzed the relationship between the interest rate and the profit orientation of MFIs. The results concluded that stronger for-profit orientation MFIs shows a higher interest rate for MFI clients.

(Janda and Zetek, 2014) had investigated the microeconomic factors that influence the MFI's interest rates in Latin America and the Caribbean. The researcher had reviewed the approaches to set MFIs interest rates .one approach can be by taking the risk factor of MFIs and second these costs can be minimized through cost saving, improved efficiency, and sharing top practices.(Abate, Borzaga and Getnet, 2014) had examined the tradeoff between cost efficiency and outreach using SFA in MFIs of Ethiopia. The findings of the study showed that it is challenging to attain cost efficiency and outreach simultaneously.

(Cuéllar-Fernández *et al.*, 2016) had investigated the factors of margin in MFIs using nine years of panel data adapting a banking model. The findings of the study reveal that operating cost, size, age are the key variables to determine margin. The largest and oldest MFIs have the lowest margin, whereas the larger and young MFIs have a higher margin.

(Nwachukwu *et al.*, 2018) have investigated various elements of interest rate in MFIs are Age, scales, and organization charter. The key findings of the study are large scale lending lower interest rates only for those MFIs that already hold legal banking status and age has a negative impact on interest rate regarding scale and charter type of MFI.(Yimga, 2018) investigated the effect of cost efficiency on microfinance growth by taking 953 MFIs across 101 countries across the globe, making a data set from 2003 to 2013. The results of the study revealed that MFIs with aggressive growth consistently found to be cost-inefficient.

Surprisingly none of the studies have investigated the consequence of MFI efficiency on the cost of lending. The question is very appropriate that does efficient MFIs compliments on its cost of the loan to clients. MFIs efficiency is an essential component to determine the cost of lending for providing financial services to the clients at a minimum cost. Therefore, our study has mainly focused on an empirical investigation to fill the research gap.

The study contributes to the MFI literature in two ways. Firstly, it investigates the associations between MFIs efficiency and their lending cost to the clients using a SFA proposed by (Battese and Coelli, 1995).Although SFA estimates production function in consort with technical inefficiency, our primary focus is on investigating the effect of MFI efficiency on its cost of lending. Therefore, we hypothesize that MFI efficiency gets the capability to operate at a lower cost and also leads to attaining funds at a lower rate of interest. Thus, it can lend at a lower rate of interest to the clients. Our study is to test the null hypothesis that there is no association between MFI efficiency and its cost of lending. Secondly, the study also performed the robustness check by conducting generalized least square estimation along with maximum likelihood estimation with fixed effect. Furthermore, the panel Granger causality test was conducted to investigate the causal relationship between MFI efficiency and its cost of lending and to provide managerial implications related to it.

3. Methodology

DEA is a most efficient tool in measuring productivity and efficiency of a group of peer DMUs (Saimohini,Lavanya,2021).it is mainly based on mathematical programming models that incorporates multiple inputs and multiple outputs of DMUs .The analysis method is mainly based on relative comparison .DEA is a non parametric technique of evaluation and it doesn't require any functional form .It computes efficiency scores through which it provides all benchmarking information also. It is essential approach for setting benchmark to improve the DMUs performance from time to time. The current study has adopted DEA, directional distance function (DDF) method with undesirable output. DEA, DDF was introduced by Fare et al (1996); Fare and Gross Kopf (2004) with undesirable output treatment which allows desirable output acceleration and undesirable output deceleration concurrently. In this study, we have used the direct approach of treating undesirable output in its original form.

3.1. Model used for first stage of analysis

For our study, we have used distance directional function was presented by (Fare & Gross Kopf et al. 1997 proposed by Chung et al 1997) and used as a factor in novel productivity index that model combined production of good outputs and bad outputs acclaims firm for the decrease in bad outputs and increases the good outputs. This study uses this model for efficiency measurement which explicitly permits for crediting a decrease in undesirable output i.e. it strives to increase good outputs and decrease bad outputs concurrently. We define the variables in our study as follows.

$X = (X_1, X_2, \ldots\ldots\ldots\ldots X_n) \in\in R_+^N$ Input

$O = (O_1, O_2, \ldots\ldots\ldots\ldots, O_n) \in\in R_+^M$ Desired output

$U = (U_1, U_2, \ldots\ldots\ldots\ldots .., U_n) \in\in R_+^J$ Undesired output

The technology comprising of all possible (X, O, U) is denoted by

$P(X) = \{(X, O, U): |X \text{ can produce } (O, U)\}\{(X, O, U): |X \text{ can produce } (O, U)\}$ (1)

The model that reduction of bads can be done in the following conditions (Fare 2007)

i. Weak disposability of undesirable output as

$(O, U) \subset P(X) \subset P(X)$ And $0 \leq \theta \leq 1$ $\theta \leq 1$ imply $(\theta\theta O, \theta U) \subset \theta U) \subset P(X)$

I.e. the desirable and undesirable output can contract proportionally by θ

ii. Freely disposability of desirable output as
(O, U)$\in P(X) \in P(X)$ And O' $\leq\leq$ O imply (O', $U) \in U) \in$P(X)

I.e. the inputs are not reduced, then the undesirable output will not contract.

iii. Null joint i.e. no bad is by producing zero good outputs.
(O, U)$\in P(X) \in P(X)$ And U' = 0 imply O= 0

i.e the undesirable output cannot be avoidable until there is production.
In added words, reduction of bad output is expensive that leads to weak disposable, of undesirable output. However, the decrease in bads is feasible only if goods proportionally decline, specified a fixed level of inputs. The current study combines three inputs as X (assets, operational cost, and number of employees), two desirable outputs as O (gross loan portfolio, number of active borrowers) and two undesirable outputs as U (NPL) and we adapted a directional vector g = (g_L,g_B, g_N) that enables us to expand desirable output and decrease undesirable output, without unnecessarily increasing the quantity of input i.e the desirable output such as gross loan portfolio (L) and number of active borrowers (B) would be expanded in g_L and g_B direction and the undesirable output NPL (N) would contract in g_N direction. According to Fare et al 2005 and 2007 the directional vector can be defined as

$\overrightarrow{D}\overrightarrow{D}_p$(X,O,U ; g_L, g_B,g_N)= max$\{\beta\{\beta$: (O+βg_L, O+βg_B, U- β$g_N \subset\subset$P($X)\}X)\}$
(2)
Where β is denoted as maximum possible expansion and contraction of desirable and undesirable output in a specific direction.
The directional distance function is specified as g = (g_L,g_B, - g_N) to increase good outputs and decrease bad outputs concurrently .
So, the DEA using DDF model can be presented as

$\overrightarrow{D}\overrightarrow{D}_p$(X_0,O_0,U_0 ; g_{L0}, g_{B0} , - g_{N0}) = max β =β^*
Where $\sum_{K=1}^{n} Z \sum_{K=1}^{n} Z_k$ $L_k \geq (1+\beta)L_0$
$\sum_{K=1}^{n} Z \sum_{K=1}^{n} Z_k$ $B_k \geq (1+\beta)B_0$
$\sum_{K-1}^{n} Z \sum_{K-1}^{n} Z_k$ $N_k \geq (1-\beta)N_0$
$\sum_{K=1}^{n} Z \sum_{K=1}^{n} Z_k$ $X_k \leq X_0$
$Z_k \geq 0$, k = 1,…….,k , $\sum_{K=1}^{n} Z \sum_{K=1}^{n} Z_k = 1$
(3)
Here, the number of MFIs k= 1,2,….,n, the subscript 0 refers to the MFI under observation and Z_k indicates the intensity level of MFI activities.

3.2. Model used for second stage of analysis

The input and output variables were selected after a detailed review of MFI efficiency literature. (World Bank Bulliten, 2000), (Bassem, 2014),(Haq, Skully and Pathan, 2010),(Kabir Hassan, Sanchez and Ngene, 2012),(Annim, 2012),(Farooq and Khan, 2014),(Bassem, 2014),(Wijesiri et al. 2017). We have used SFA to compute cost efficiency scores. It decomposes inefficient term and random error which are represented as measurement errors

through measuring the distance from the efficient frontier .The random errors are assumed to be normal distribution and inefficiency term half normal distribution .We have considered the MFIs under production approach as most of them do not accept any deposits from public. The total cost information along with three input prices such as the price of staff members ,the price of handling loan portfolio and the quantity of loan portfolio i.e. gross loan portfolio are being used to estimate the technical inefficiency component .We have adapted trans log stochastic cost frontier analysis as proposed by Battese and Coelli in 1995in this study. The functional form is given below.

$$\ln (TC_{it}) = \beta_0 + \beta_1 \ln (CPS_{it}) + \beta_2 \ln (CPL_{it}) + \beta_3 \ln (GLP_{it}) + \beta_4 \ln (CPS^2_{it}) + \beta_5 \ln (CPL^2_{it}) + \beta_6 \ln (GLP^2_{it}) + \beta_7 (\ln CPS * \ln CPL)_{it} + \beta_8 (\ln CPS * \ln GLP)_{it} + \beta_9 \ln (\ln GLP * \ln CPL)_{it} + v_{it} - u_{it} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where TC = total expenses, CSP =unit price of staff members, CPL= unit price of handling loan portfolio, GLP= gross loan portfolio, u_{it}= inefficiency term, v_{it} = random error for ith MFI and t period. Furthermore, adapting maximum likelihood estimator by Battese and coelli, 1995we have estimated the MFI specific technical inefficiency component as presented below. The technical inefficiency term is assumed by MFI size, age, and MFI ownership.MFI size depends on the MFIs asset size, which can be classified as large and small, Age classified as young and mature. MFI ownership is mainly classified as a non-banking financial corporation (NBFCs), credit cooperatives, banks, non-government organizations (NGOs) and others.

$$U_{it} = \delta_0 + \delta_1 \text{MFI Size} + \delta_2 \text{age} + \delta_3 \text{ownership} + w_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The term v_{it} captures the random error term of the i^{th} MFI at time t and $u_{it}$are the non-negative random variables independently distributed of the i^{th} MFI at time t. w_{it} is an (m*1) vector of unknown coefficient of MFI specific variables that vary over time and represented by the truncation of the normal distribution with 0 mean and variance. δ is the unknown coefficient vecto r(1*m) of MFI specific variables.

3.3. Data collection

Data were gathered from the Microfinance Information Exchange (MIX) market website. The MIX market collects profiles of MFIs from various sources, then these facts genuinely get audited and checked to ensure accuracy. We have selected the MFIs which have complete information. In our study, we have used Indian MFIs for 2013-2017.We have used the minimization of input, i.e., input-oriented condition, to determine efficient frontier. MFIs are considered as quasi banks since most of the MFIs do not accept any deposits from the public. Therefore, we have processed the data using a production approach(Nghiem et al.2006),(Bassem, 2008),(Haq, Skully and Pathan, 2010) and an input-oriented model with a true fixed effect. Our primary focus was only on establishing the relationship between MFI efficiency and the cost of lending but not to focus on inefficiency causes. We have employed a broadly used efficiency measurement technique, SFA, for calculating the efficiency of MFIs. Along with the efficiency frontier, it also decomposes the inefficiency term and random errors.

4. Data analysis and results

The study has taken three input and three outputs. The output can be further grouped in to desirable and undesirable output .In this study the researcher has used three inputs such as Assets (A), operational cost (O)and personnel(P) and three outputs out of which two are

desirable outputs are Gross loan portfolio(G) to measure financial outreach and the number of active borrowers (B)to measure social outreach and one is undesirable output that is NPL or Portfolio at risk(L).Though we use three inputs and three outputs, our dataset is adequately large in order to address the concerns of degrees of freedom .It also provides a distinctive capability to our model to generate more efficient results. According to Cooper William W et. al., 2007 the number of DMUs (Decision making units) shall not be less than three times of the number of inputs and outputs. The descriptive statistics and correlation analysis have presented in table no 1and 2.

Table no –1 Descriptive statistics of variables

		Inputs			outputs		
Year	**Statistics**	***Personnel (p) (number)***	***Assets(A) ($)***	***Operating expense(OE)($)***	***Gross Loan Portfolio(L)($)***	***Number of active borrowers (N)***	***Portfolio at risk > 30 days (N)***
2013	Mean	764.95	46837932.26	3664336.99	47762742.43	303519.29	0.0218
	Standard Deviation	1557.59	99480074.57	8517670.86	109200245.90	766975.37	0.0954
	Minimum	15.00	285152.00	14936.00	128012.00	1181.00	0.0001
	Maximum	8932.00	467470378.00	52316217.00	532849633.00	4963046.00	0.5836
2014	Mean	884.07	66360580.54	4656730.46	65649841.15	363923.15	0.0237
	Standard Deviation	1806.63	155681445.40	10912603.57	148236339.80	873949.51	0.0946
	Minimum	16.00	393869.00	11281.00	13591.00	46.00	0.0001
	Maximum	9698.00	796149049.00	52465754.00	671791873.00	5325244.00	0.6340
2015	Mean	1143.13	100356597.60	6328973.47	110323648.20	457470.60	0.0286
	Standard Deviation	2168.60	263314337.00	16149619.33	273105399.00	988200.10	0.1197
	Minimum	9.00	496048.00	25955.00	79610.00	581.00	0.0001
	Maximum	11154.00	1711720925.00	106209402.00	1659513301.00	4636669.00	0.8530
2016	Mean	1572.33	155865506.40	10737408.54	143760224.20	562838.43	0.0521
	Standard Deviation	3028.75	390558854.20	28457876.31	337453860.00	1133876.43	0.1142
	Minimum	23.00	376110.00	26541.00	5194.00	3252.00	0.0001
	Maximum	16357.00	2278871415.00	195366945.00	1974730188.00	5888750.00	0.8530
2017	Mean	1863.17	169747248.30	12231328.33	169383436.00	619417.03	0.0360

	Standard Deviation	3497.95	388264807.00	31140450.62	381157396.90	1219380.17	0.1081
	Minimum	23.00	375285.00	42720.00	286998.00	2770.00	0.0002
	Maximum	19357.00	2278871415.00	195366945.00	1974730188.00	6188000.00	0.8530

Table 2 Correlation coefficient matrix of input and output variable

	P	***A***	***O***	***L***	***B***	***N***
P	1.0000					
A	0.9234*** (0.0000)	1.0000				
O	0.9564*** (0.0000)	0.8602*** (0.0000)	1.0000			
L	0.9757*** (0.0000)	0.9566*** (0.0000)	0.9364*** (0.0000)	1.0000		
B	0.9733*** (0.0000)	0.8652*** (0.0000)	0.9603*** (0.0000)	0.9538*** (0.0000)	1.0000	
N	0.2209* (0.0622)	0.0699 (0.5596)	0.3599*** (0.0019)	0.2214* (0.0616)	0.2113* (0.0748)	1.0000

5. Data analysis and findings

The study focused mainly on examining the association between microfinance efficiency, and its cost of lending to identify that does MFI efficiency complements in its lending cost. The study employs a data envelopment analysis (DEA) to analyze the microfinance efficiency. The researcher has adopted DEA, DDF with undesirable output in order to attain more accurate results by taking 72 Indian MFIs using five years panel data. By applying the model efficiency and inefficiency scores were computed. Moving average of efficiency scores were also computed in order to nullifying any one-year abnormality.

Figure 1 Efficiency scores accounting for undesirable output using DDF

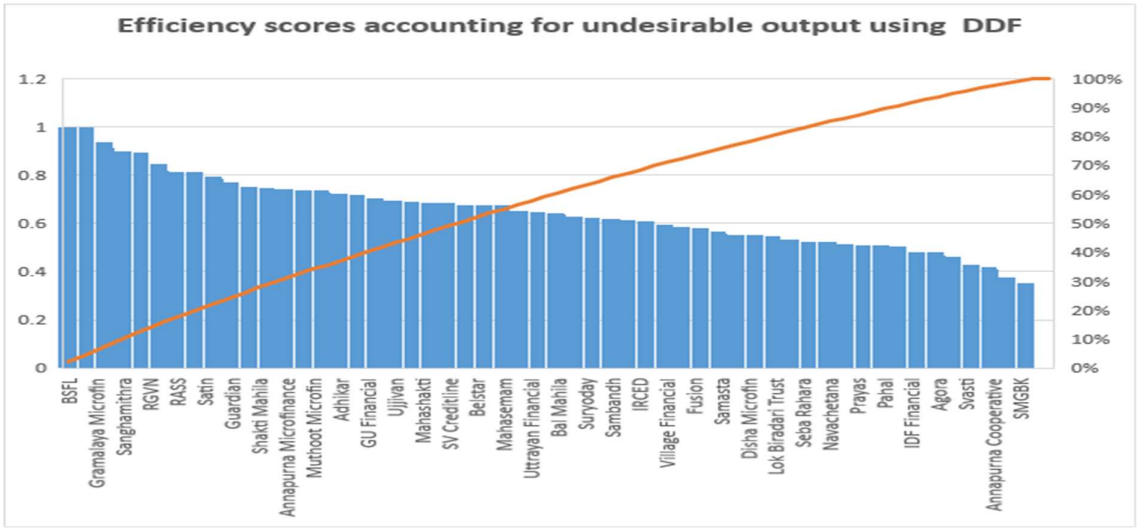


Figure 2 showing input inefficiency scores MFIs

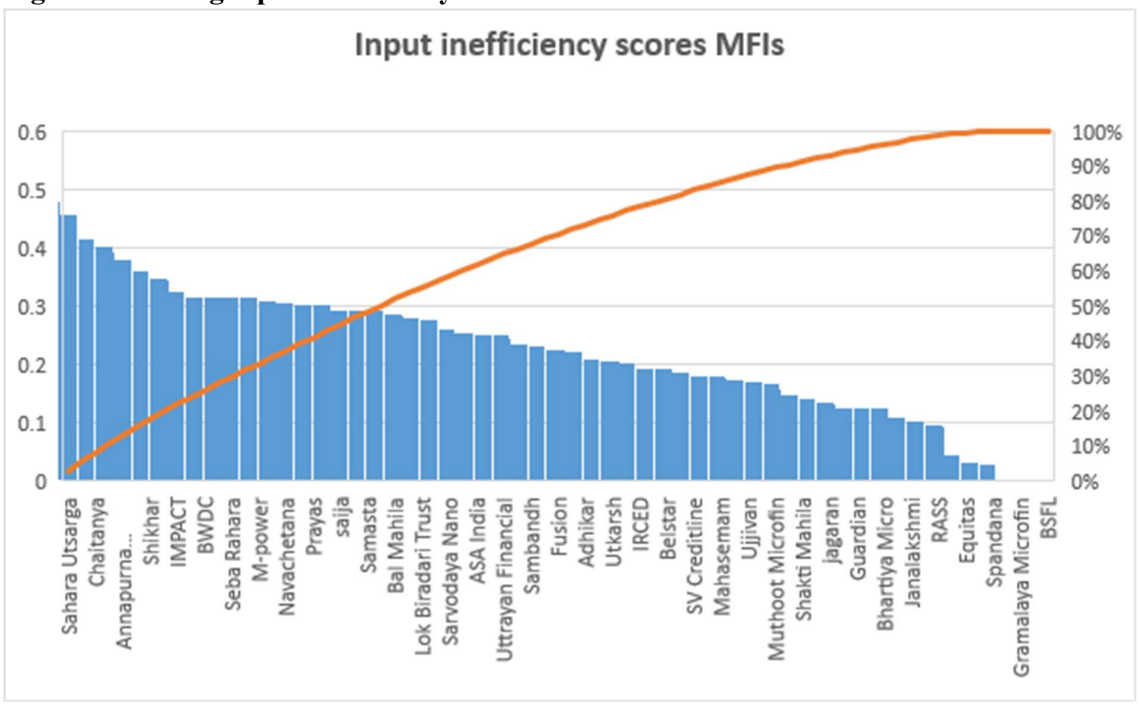


Figure 3 Undesirable output inefficiency scores of MFIs

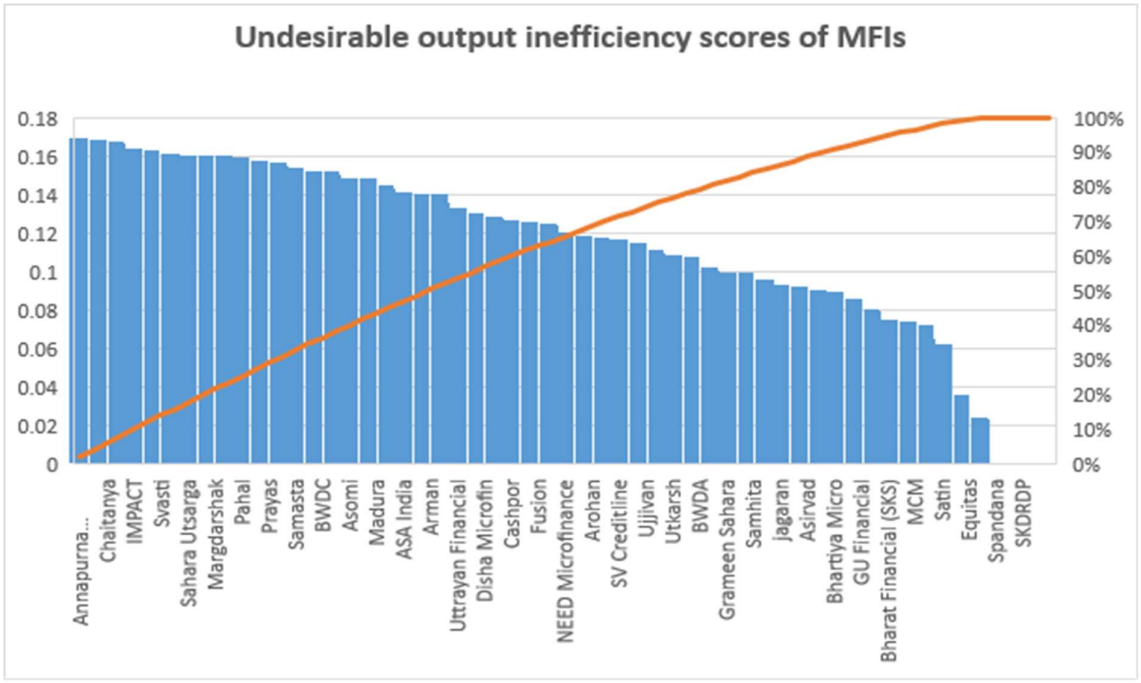
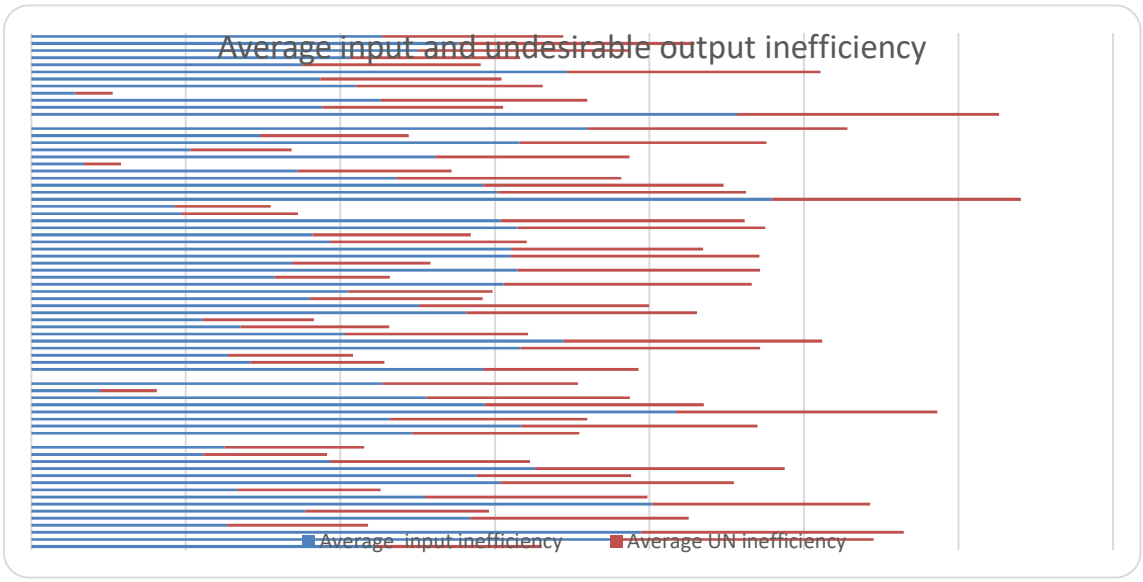


Figure 4 showing average input and undesirable output inefficiency



5.2 .Robustness check of DEA results using Sensitivity analysis

DEA is a useful tool for analyzing the efficiencies of DMUs. The results of this assessment are very sensitive to small errors and outliers present in the sample. For instance DMUs in a study produce two outputs. One DMU is extremely competent in producing one output and average in producing the other one. There is a possibility that it may appear in an efficient frontier line as an efficient unit and it will reflect as a benchmarking unit for inefficient DMUs. Therefore sensitivity analysis is needed to evaluate the robustness of the data in the sample. Various

methods are used by the researchers to perform the robustness test such as window analysis, bootstrapping and variations in the number of inputs and outputs.

In the current study, we have adapted the variations in the number of inputs and outputs method which is not yet used in any of the earlier MFI efficiency studies. We have created three models for assessing the results .Our main focus is given on social and financial efficiency related outputs.

5.2.1. Model 1

We have taken two inputs i.e. personnel and total operating cost and two outputs i.e. number of active borrowers and gross loan portfolio. The number of active borrowers indicates the social efficiency or outreach of MFIs and the gross loan portfolio represents the financial efficiency or sustainability of MFIs. The result of model 1 shows that the average efficiency score of MFIs is 0.5406 and lowest score is 0.1431. Four MFIs are found to be efficient and the remaining 68 MFIs assessed to be inefficient over five years study period.

5.2.2. Model 2

In this model personnel and total operating cost taken as inputs, the same as model 1 and one output i.e. number of active borrowers for computation of efficiency scores. Our main focus is to evaluate the sensitivity of this output by ignoring gross loan portfolio output. Here the average efficiency score0.4729 and the lowest score is 0.1311. Only one MFI is found to be efficient on ground of outreach .The omission of one output results showed that 21 MFIs showed a decrease and 51 MFIs showed an increase in efficiency score as compared to model 1.

5.2.3. Model 3

In this model also personnel and total operating cost taken as inputs, the same as model 1 and model 2and one output i.e. gross loan portfolio for calculation. Our main focus is to calculate the sensitivity of this output by ignoring the number of active borrowers output. Here the average efficiency score 0.4303 and the lowest score is 0.2202.No MFIs are efficient on ground of financial sustainability .The omission of number of active borrower output results showed that 12 MFIs showed a negative deviation in their results and are showing a lower efficiency scores as compared to model 1.Practically 60 MFIs showed a better performance on financial sustainability ground.

To draw the evidences of robustness and stability of our data we have computed Karl Pearson correlation. The correlation coefficient ranges from 0.7254 to0.8298.As Karl Pearson coefficient works on raw data and it ignores the presence of any outliers furthermore we have computed spearmen's rank correlation among the three models .Spearmen's correlation is a non-parametric correlation and it works on ranking and any outliers don't influence the results.The coefficient denoted as ρ ranges between 0.6959 to 0.8031. It is shown in table no6 .The results of nonparametric correlation coefficient ρ are very closer to parametric correlation coefficient r. This indicates the absence of any outliers and irregularities in the data. The highly positive correlation values interpreted the robustness of our models.

Table- 3 Pearson and Spearman rank correlation among the Model 1 ,model 2 and model 3

	Model 1	**Model 2**	**Model 3**
Model 1	1.000 ,1.000		
Model 2	0.8298*,0.8031* 0.0000	1.000,1.000	
Model 3	0.7716*,0.7243* 0.0000	0.7254*,0.6959* 0.0000	1.000,1.000

@ 5%Significant level

5.3. Second stage of analysis

We have employed a broadly used efficiency measurement technique, SFA, for calculating the efficiency of MFIs. Along with the efficiency frontier, it also decomposes the inefficiency term and random errors. We have used the SFA approach proposed by (Battese and Coelli, 1995)(Kumbhakar et al. .2015)for measuring the efficiency of MFI; we get technical inefficiency simultaneously. Firstly, in our study we have estimated the efficiency scores applying cost frontier. The efficiency scores measures the each MFIs cost performance. We observed the average efficiency score as 0.7821, minimum and maximum efficiency scores as 0.5901 and 1 respectively. We have presented the estimated inefficiency with respect to cost frontier in table no 1 .The results of the table 1 shows the estimation of inefficiency component with reference to equation 1 .We have estimated the coefficient of (β_1) unit price of staff members, (β_2) unit price of handling loan portfolio and (β_3) gross loan portfolio. These coefficient carries a positive sign as increase of these variables adversely affect the total cost, as it results to increase in total cost.

We have also added MFI specific control variables that are MFI size, age, and MFI ownership as shown in equation 2. In order to estimate the inefficiency components with respects to MFI specific variables we have created dummy variables representing size ,age and ownership of MFIs .The estimated results were presented in table 1. The findings of the table- 4 shows the positive coefficients with respects to MFI specific determinants. These positive signs represent a positive relation between the variables. As the gross loan portfolio increase the total cost decreases and the increase in cost related to staff and handling loans leads to increase in total cost .Hence ,through minimizing and monitoring these components would result in reduction of total cost .Similarly, the estimates related to MFI specific coefficients show a positive indication as desirable results .The coefficients associated with the MFI ownership status such as NBFI,NGO ,banks ,credit cooperative and others dummy shows a positive coefficients as their technically efficient in total cost management.

Table 4 Maximum likelihood parametric stochastic frontier estimation

Estimates of inefficiencies	**coefficient**	**z**	**p>(z)**
LN CPS	0.4715442	8.21	0.021
LNCPL	-0.8754303	-13.65	0.000
LNGLP	-0.2086271	-7.94	0.000
LNCPS SQ	0.895615	9.81	0.000

LNCPL SQ	0.0288315	1.62	0.106
LNGLP SQ	0.0040292	4.21	0.000
LN CPS LN CPL	-0.0919883	-3.14	0.002
LN CPL LN GLP	-0.0093271	-1.23	0.220
LN GLP LN CPS	-0.0270385	-4.83	0.000
Cons	-22.249397	-6.23	0.000
Determinants of inefficiency	**coefficient**	**z value**	**p>(z)**
MFI specific determinants			
MFI age	0.478	3.27	0.212
MFI size	0.754	5.24	0.095
MFI ownership status			
NBFI	0.0078	0.15	0.000
NGO	0.0841	0.11	0.000
bank	0.1011	0.95	0.004
credit cooperative	0.0054	0.09	0.085
others	0.0145	0.12	0.078
constant	1.2786	6.33	0.000

5.4.1. Regression analysis

In this study, our prime focus was only on establishing the relationship between MFI efficiency and the cost of lending. We have computed robust regression by keeping the dependent variable cost of lending. The results shown in table no 5. The findings of the table show that the cost of lending and MFI efficiency are negatively associated. As the efficiency score increases, the cost of lending decreases. We also found that the estimated coefficient is significant. We have hypothesized that there is no linear relationship exist between these two variables. We have used the two-tail test at (n-2) degrees of freedom. The standard error is estimated as 2.010 at 70 (n=72) degrees of freedom. As the computed t value is higher than the critical value at 5% level of significance, we fail to accept null hypothesis. Hence the findings of our regression (shown in table no-2) show a significant negative relationship between cost of lending and MFI efficiency.

Table 5 Regression table

Efficiency Score	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]
Cost of lending	-3.864016	2.010564	-1.999	0.044	-8.149431 .4213995
_cons	28.91228	1.332304	21.701	0.000	26.07254 31.75202

5.4.2. Granger causality test

Although regression analysis examines the dependency of cost of lending on MFI efficiency, it does not infer the causality. Therefore, we have investigated the existence of causality direction between MFI efficiency and the cost of lending and by conducting the Granger causality test. To perform the Granger causality test, we have followed the Value auto

regression (VAR) frame work. Four lag lengths were found to be optimal for our study. The results shows the causal direction is from MFI efficiency score to cost of lending as the estimated chi square statistic are significant at 5%.On the other hand there is no reverse causality exist from cost of lending to MFI efficiency ,as the chi square values are statistically insignificant (shown in table no 6). The findings indicates the existence of causality between MFI efficiency and the cost of lending, where as there is no causality exist between cost of lending and MFI efficiency.

Table 6 Granger causality test

Granger causality Wald tests					
Equation		chi2	df	Prob > chi2	decision
Efficiency score	Cost of lending	1.9382	2	0.079	Do not reject
Efficiency score	All	1.9382	2	0.079	Do not reject
Cost of lending	Efficiency score	4.84592		0.379	Reject
Cost of lending	All	4.84592		0.379	Reject

6. Conclusion

Microfinance institutions play a crucial role in sustainable development growth. It helps the rural poor to access financial services without having any collaterals .It works with group lending mechanism where social capital work as a security . Therefore, the functionality of MFIs involves high operational cost. In order to attain sustainability and outreach it has to operate at full efficiency.

Efficiency measurement using the " DEA model is to measure the relative efficiency of decision-making units by means of comparison with other best organizations "(Emrouznejad & Yang, 2018). The efficiency measurements reflect on the performance of MFIs and can draw vital implications for policymakers. In the current study context to measure efficiency of MFIs, DEA is the most useful and appropriate tool. This is a multi-criteria decision making tool that could increase MFI performance recognizing the preeminent practice and ranking them based on their efficiency level

The present study was designed to study the efficiency of MFIs using NPL as an undesirable output. This paper used the directional distance function of DEA through accounting non-performing loans as an undesirable output. Furthermore, we have decomposed the inefficiencies into input inefficiency and undesirable output inefficiency. The result of our study is evidence that there is less focus given to inefficiencies as they show a consistent graph over the study period. Instead of unseeingly pursuing the growth by ignoring undesirable outputs (NPL), the MFI industry should account for it in efficiency measurements. Furthermore, we have conducted sensitivity analysis with DEA to check the robustness of our DEA results. The results specify the robustness of our model. Therefore for enhancing MFIs efficiency for sustainable development, it should give high priority to minimizing both input inefficiencies & undesirable output inefficiencies.

The cost of lending is one of the vital components for the MFIs and its clients, but the question regarding its association with MFI efficiency remains unexplored. The efficiency of MFIs

reflects on attaining overall efficiency, which helps the institutions to operate at optimum cost. In turn, the cost per loan made will be minimized, along with increase inefficiency. The resultant of this shows optimum economies of scale and optimal cost of operations. As a outcome of which it can boost up the profit by ploughing back the profit into the business the MFIs can maintain the low debt-equity ratio, which sustainably reduces interest expenses. Additionally, due to excellent performance results, these institutions will be able to generate funds quickly at a lower cost. This will result in a lower cost per loan to MFIs. Therefore, MFIs efficiency is an essential component in determining the cost of lending information by assessing the cost per loan. So that the purpose of MFIs to eradicate poverty through providing financial services to the poor will be fulfilled at a minimum cost and may result a lower burden to the clients.

In this research, we have mainly focused on answering the research question that does MFI efficiency complements its cost of lending? We have used Indian MFIs data for over 5 years. The results of our works showed an association between the efficiency scores and the cost of lending, but the association is found very low. It is found that higher efficiency lowers the cost of lending in very few MFIs; however, it varies with the ownership status. Additionally, we have performed the Granger causality test to check the direction of causality between MFI efficiency and its cost of lending. The result specifically showed that MFI efficiency causes the cost of lending, where as the cost of lending does not cause efficiency.

The findings are relevant to policymakers, shareholders, donors, funders, etc. From a positive perspective, if the MFIs take appropriate measures to enhance its efficiencies, it could undoubtedly complement in its lending cost to the clients. As a whole, it will create a win-win situation to both MFIs by facilitating the access to more readily low-cost funding and its clients by complementing in lending cost, where most MFI clients suffer from high-interest rate burdens. Thus policymakers should take strategic steps to enhance the MFI efficiencies to access low and faster finance. In turn, it could complement its cost of lending through facilitating finance at a low cost to the poor.

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