GENDER EFFECTS ON MICROFINANCE SOCIAL EFFICIENCY: A ROBUST APPROACH INCORPORATING UNDESIRABLE OUTPUTS

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Gender Effects on Microfinance Social Efficiency: A Robust Approach Incorporating Undesirable Outputs

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Abstract: This study investigates the impact of gender diversity at both the strategic and operational levels on the social efficiency of microfinance institutions (MFIs). Specifically, we assess how the presence of women on boards and among loan officers influences MFIs' ability to deliver social outcomes, particularly in serving female borrowers, considering the portion of the loan portfolio that is delinquent or overdue as an undesirable output. Using a novel robust nonparametric frontier estimation method developed by Daraio and Simar (2024), we estimate both efficiency scores and their derivatives, allowing for a more nuanced evaluation of marginal effects and returns to scale. Our analysis draws on a cross-sectional dataset of 346 MFIs worldwide, incorporating directional distance functions and conditional efficiency frontiers based on external gender-related variables. The findings reveal that while the direct effect of gender composition on inputs and outputs is limited, there is a significant joint and non-linear impact of female board and loan officer representation on mitigating the negative effects of portfolio delinquency. These results underscore the importance of integrated gender diversity across strategic and field levels in enhancing the social performance of MFIs and provide actionable insights for policymakers aiming to promote inclusive financial practices.

JEL: C14, C13, C33, D24, O47.

Keywords: OR in developing countries, Microfinance performance and gender effect, undesirable output, nonparametric frontier estimation, marginal effects

1 Introduction and objectives

Since its inception, microfinance has played a pivotal role in poverty alleviation and the economic empowerment of women through enhanced financial inclusion. Microfinance refers to the provision of financial services (including credit, savings, and insurance) to low-income populations who typically

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lack access to traditional banking services. One of the fundamental objectives of microfinance remains the achievement of social efficiency, that is, the ability of microfinance institutions (MFIs) to sustainably improve the living conditions of their beneficiaries in an optimal way. In recent years, the literature has extensively analyzed the factors of social efficiency in microfinance, with particular attention paid to the role of MFI governance.

In this context, the issue of inclusive governance and the composition of operational teams has attracted growing interest, particularly from a gender perspective (Hossain et al. (2024), Díaz-Martín et al. (2022), Adalessossi (2024)). The participation of women in governance bodies as well as within operational teams, particularly as loan officers, has attracted significant interest from researchers, regulators, and donors. Much research has focused on the role of women as a potential lever for improving the social performance of microfinance. A key question is whether women's representation in the governance bodies of microfinance institutions, both at the strategic level (boards of directors) and the operational level (loan officers), enhances their social performance. One of the most scrutinized dimensions of social performance is the ratio of active female borrowers to the total number of active borrowers (Schreiner (2002)). It is naturally expected that the presence of women at strategic and operational levels will improve women's access to credit (Fall et al. (2021); Strøm et al. (2014)).

At the strategic level, numerous studies highlight that the presence of women on boards of directors can positively influence the strategic decisions and social awareness of an organization. Using a stochastic frontier approach on a panel of 250 microfinance institutions (MFIs), Hartarska et al. (2014) show that gender diversity in top management can lead to both social and financial benefits. Similarly, Mori et al. (2015), in their analysis of East African MFIs, conclude that having women on boards enhances the social performance of these institutions. Périlleux and Szafarz (2015) find that female-dominated boards promote social orientation in Senegalese financial cooperatives. Ghosh and Guha (2019), in the context of India, has shown that an increase of woman directors at the board level increase female clients of MFIs. At the operational level, research also indicates that female loan officers may strengthen the social impact of microfinance (Fall et al. (2021) Boehe and Cruz (2013), Beck et al. (2018) Bibi et al. (2018). They possess a deeper sensitivity and stronger understanding of local realities, enabling them to build trust with clients more easily—an essential factor in enhancing the social performance of MFIs (Hossain et al. (2024)). Beck et al. (2018) study the impact of female loan officers on repayment rates in Albania and found that female loan officers had lower arrears than their male counterparts. Bibi et al. (2018) analyze the effect of gender and governance on the efficiency of South Asian MFIs. They find that female loan officers are positive determinants of MFI efficiency. In contrast, van den Berg et al. (2015), studying a Mexican MFI, show that male loan officers were more efficient. The advantage of women loan officers is attributed to their closer connection with microfinance clients. Their heightened sensitivity to local contexts and their ability to build trust more easily with clients are seen as key factors in improving the social performance of MFIs.

However, few studies have simultaneously examined the combined influence of women's presence in both governance roles and among loan officers. Most existing research focuses on one level or the other. This study aims to address that gap by investigating the joint effect of women's participation at both levels on the social performance of microfinance institutions. Specifically, we ask whether the presence of women in both strategic and operational roles serves as a synergistic lever to enhance the social impact of microfinance. Using an empirical approach based on nonparametric production frontiers estimation, we explore whether these two forms of female participation function in a complementary or independent manner, and to what extent they contribute to strengthening the social mission of MFIs.

Another aspect of this study is the consideration of portfolio quality. Most studies estimating social efficiency neglect to take portfolio quality into account. An MFI with a credit expansion policy runs the risk of degrading the quality of its portfolio. So, while the presence of women in microfinance governance bodies may produce a greater quantity of credit for women, it may also lead to a deterioration in portfolio quality. Several studies have explored how loans granted to women affect repayment performance and, consequently, the quality of MFIs portfolios (e.g., D'espallier et al. (2011); Armendáriz and Morduch (2010)). However, within the literature on efficiency frontier estimation, which is the focus of our study, very few works consider the impact of undesirable outputs. The limited studies that do incorporate undesirable outputs in non-parametric frontier approaches (e.g., Pal and Mitra (2018)) typically lack a detailed analysis of how these factors influence different efficiency parameters. Even scarcer are studies examining the relationship between gender and social efficiency while accounting for undesirable outputs. In the context of microfinance, undesirable or "bad" output usually refers to the portfolio at risk (PAR), the portion of the loan portfolio that is delinquent or overdue, an indicator of portfolio quality. This raises two key questions: What is the impact of this undesirable output on the social efficiency frontier? And how does the presence of women on the board or among loan officers influence the relationship between undesirable output and social efficiency?

This study differs from the usual work in several respects. Firstly, it seeks to highlight the interaction between the strategic and operational levels of gender on social performance. To the best of our knowledge, this study is the first to show whether the effect of women's presence on boards of directors is stronger when linked to the operational level (loan officers). Secondly, this study is one of the few to analyze the effect of gender on social performance by taking portfolio quality into account. In so doing, it sheds further light on the effectiveness of women's decisions in financing female microfinance clients. Just looking at the number or quantity of financing granted to women is one thing, but seeing whether this financing is granted efficiently (portfolio quality) is quite another.

Methodologically, the study advances the field by employing robust nonparametric approaches, offering a more flexible framework for performance evaluation. Our work is the first application of Daraio and Simar (2024) methodology in the microfinance sector. This novel approach improves efficiency estimation robustness using advanced nonparametric techniques that significantly enhance existing models. The flexible nonparametric adjustment employed here refines the efficiency frontier estimation without assuming an arbitrary functional form. Unlike conventional approaches that often impose restrictive structural assumptions, the local linear modeling framework used in this study enables a smoothed parametric adjustment, which more accurately captures the shape of the nonparametrically estimated frontier. This ensures that the estimated frontier is not merely reflecting the central tendency of the data but is effectively modeling the boundaries of the production set.

A key advantage of this methodology is its flexibility in handling multi-output and multi-input settings. Unlike stochastic frontier models, which require an explicit specification of the inefficiency distribution (e.g., half-normal, exponential, or gamma), the directional distance function approach adopted here allows researchers to define custom benchmark directions. In this study, we use the median of inputs and outputs as the reference direction, ensuring that efficiency is evaluated along meaningful trajectories relevant to microfinance institutions' operational realities.

Furthermore, the robust frontier approximations introduced in this study enable statistical inference on the efficiency estimates, allowing the derivation of confidence intervals for the estimated coefficients. This contributes to a more rigorous evaluation of the role played by gender diversity variables in determining social efficiency. By incorporating external-environmental variables directly into the model, the approach effectively captures the heterogeneity across MFIs, distinguishing efficiency variations attributable to institutional differences from those driven by external operating conditions.

The findings reveal that a higher percentage of female board members and female loan officers allows to reduce the impact of gross loan delinquency on social performance. In addition, it seems important to strenghten simultaneously the presence of female board members and female loan officers in order to have an effective impact on social performance. In particular, there is a significant joint and non-linear impact of female board and loan officer representation on mitigating the negative effects of portfolio delinquency.

The empirical findings from this analysis offer a more precise and statistically robust understanding of how gender diversity influences microfinance efficiency. The applied estimation technique provides robust coefficient that takes into account the observed impact of female representation on boards and among loan officers. As a result, this study provides a methodological advancement in the field of microfinance efficiency analysis while delivering new policy-relevant insights for practitioners and regulators aiming to optimize social efficiency in financial inclusion programs.

The remainder of this article is structured as follows. Section 2 presents the methodological framework. Section 3 describes the data and Sections 4 and 5 present and discuss the empirical results. Section 6 concludes and outlines implications for policy and future research.

2 Methodology

Existing methodologies in the frontier production literature present certain limitations. Current nonparametric approaches fail to provide point estimates of coefficients measuring marginal rates of substitution, or coefficients reflecting the impact of external influences, which our approach addresses. In contrast, parametric models encounter several challenges, including restrictive assumptions regarding error distributions, predefined functional forms, and the inability to estimate individual effects (coefficients). Therefore, our study not only extends empirical analysis but also introduces, for the first time in microfinance research, a nonparametric efficiency method that estimates marginal rates of substitution, other coefficients of production and evaluates the influence of external factors on efficiency without restrictive assumptions while allowing for coefficient estimation at the unit level. We adopt a novel methodology introduced by Daraio and Simar (2024) to measure the sensitivity of the efficient frontier to inputs, outputs, and external variables. Unlike conventional approaches, this method does not assume a specific functional form for the efficient frontier or a predefined efficiency distribution. Instead, it employs smoothed approximations of nonparametric frontier models. This technique builds upon the nonparametric conditional framework (see, e.g., Daraio and Simar (2007b)), enabling the estimation of local coefficients representing the impact of external factors, denoted as Z.

Since the foundational work of Farrell (1957), efficiency measurement has followed two primary approaches: parametric and nonparametric. These methods evaluate efficiency by considering the relationship between inputs (resources) and outputs (outcomes). Nonparametric methods, such as Data Envelopment Analysis (DEA), are advantageous because they do not impose a predetermined functional form on the efficient frontier. DEA assumes convexity and free disposability, meaning that resources can be reduced or eliminated at no cost, while Free Disposal Hull (FDH) only requires free disposability. On the other hand, parametric approaches require explicit functional assumptions regarding the efficient frontier and inefficiency distribution. Despite this constraint, the latter facilitate the estimation of economic coefficients, including sensitivity parameters that quantify efficiency variations concerning inputs and external influences (see Fried et al. (2008) for an overview).

Our research investigates how MFIs attain efficiency and the role of external factors in shaping this efficiency. To accomplish this, we utilize a hybrid methodology introduced by Daraio and Simar (2024) (hereafter referred to as DS). This method applies to envelopment estimators previous ideas developed in Simar and Wilson (2023) in the context of nonparametric stochastic frontiers. This approach integrates the strengths of both parametric and nonparametric techniques, enabling the estimation of derivatives, marginal rates of substitution, and other coefficients of economic significance. Crucially, it provides local linear approximations for nonparametric efficiency frontiers.

2.1 Estimating coefficients in nonparametric frontier models

We recall here the DS methodology in a multi-inputs and multi-outputs setting, first without environmental factors. The environmental factors will be introduced inthe model in a second stage. Consider the set T of technically feasible inputs ($x \in \mathbb{R}^p$) and outputs ($y \in \mathbb{R}^q$) combinations defined as follows:

$$T = \{(x, y) \in \mathbb{R}^{(p+q)} |\ x \ \text{ can produce } \ y\}. \tag{2.1}$$

The efficiency frontier T^∂ consists of the optimal input-output combinations such that:

$$T^\partial = \{(x,y) \in R^{(p+q)} | \ \{\gamma^{-1}x, \gamma y) \notin T, \forall \gamma > 1\}. \tag{2.2}$$

Different methods can be used to quantify the efficiency of a given unit (x, y) by measuring the distance of the unit to the frontier T^∂. The directional distance (introduced by Chambers et al. (1998)) is the most flexible measure and can be formulated as follows:

$$\delta(x,y) = \sup\{\theta \mid (x - \theta d_x, y + \theta d_y) \in T\}, \tag{2.3}$$

where $d_x \in \mathbb{R}^p_+$ and $d_y \in \mathbb{R}^q_+$. The distance is assessed along a direction vector d defined by $d' = (-d'_x, d'_y)$, ensuring an additive measurement of efficiency deviations. If $(x, y) \in T$, then $\delta(x, y) \geq 0$. If $\delta(x, y) = 0$, the observation (x, y) lies on the efficiency frontier T^∂.

We denote (x^∂, y^∂) the projection of (x, y) on the efficient frontier T^∂ in the direction d. The projection is defined as follows:

$$x^\partial = x - \delta(x,y)d_x \ \text{ and } \ y^\partial = y + \delta(x,y)d_y. \tag{2.4}$$

A robust analysis based on order$-m$ efficiency estimation has also been implemented to deal with extreme values and outliers in the dataset. Order$-m$ efficiency $\delta_m(x, y)$ was introduced by Cazals et al. (2002) as a robust alternative to traditional full-frontier efficiency measures. Instead of comparing a decision-making unit (DMU) against the entire observed production frontier, the order$-m$ method evaluates it relative to a random subset of m peers that produce at least the same output level and less than the same input level (see Simar and Vanhems (2012)). This method relies on the expected minimum input level (or maximum output level) of m randomly drawn firms, providing a less extreme benchmark than traditional full-frontier methods (see more details e.g. in Daraio and Simar (2007a)). The efficient points related to the order$-m$ frontier are defined as:

$$x^\partial_m = x - \delta_m(x,y)d_x \ \text{ and } \ y^\partial_m = y + \delta_m(x,y)d_y. \tag{2.5}$$

The parameter m can be considered as a trimming parameter to control the robustness relative to extreme data points and outliers. In empirical applications, one common approach to selecting m is by plotting the percentage of data points lying outside the order$-m$ frontier as a function of m. This allows researchers to choose a value of m that aligns with a target level of robustness. The larger the value of m, the closer the order-m efficiency score approaches the Free Disposal Hull (FDH) efficiency score (Daraio and Simar (2007a)).

One great advantage of order-m method is that it allows to prove asymptotic normal distributions and prove the validity of bootstrap in order to derive confidence intervals.

Consider a sample of observations $(X_i, Y_i)_{\{i=1,\dots,n\}}$. Nonparametric FDH and order$-m$ frontiers can be computed as well as the associated nonparametric efficiency estimators $\hat{\delta}_n(x, y)$ and $\hat{\delta}_{m,n}(x, y)$ (see Daraio et al. (2020) for computational details). The efficiency measures are estimated using a nonparametric directional distance function (DDF) approach, which evaluates the distance of an observation from the efficient boundary through a given direction $d = (-d_x', d_y')'$. In our application, the directional vectors used for estimation are:

$$d_x = \text{median}(X)', \quad d_y = \text{median}(Y)',$$

which corresponds to a classical reference direction.

We can also compute the estimated distances for all the original data points: $\hat{\delta}_n(X_i, Y_i) = \hat{\delta}_i$ and $\hat{\delta}_{m,n}(X_i, Y_i) = \hat{\delta}_{m,i}$ for each unit $i = 1, \ldots, n$.

The DS methodology consists of the following steps:

1. First of all, transform the dataset through the following rotation:

$$\begin{bmatrix} V_i \\ U_i \end{bmatrix} = R_d \begin{bmatrix} X_i \\ Y_i \end{bmatrix},$$

where R_d is a non-random rotation matrix $r \times r$ (with $r = p + q$) defined by:

$$R_d = \begin{bmatrix} S_d' \\ d'/\|d\| \end{bmatrix},$$

and S_d is a $r \times r - 1$ matrix of orthonormal basis for the direction d. In particular, we have $S_d' S_d = I_{r-1}$ and $S_d' d = 0_{r-1}$.[1] This transformation (see DS for details) results in a new coordinate system, with $V_i \in \mathbb{R}^{r-1}$ and $U_i \in \mathbb{R}$ such that the coordinate U_i is parallel to the direction d and the remaining coordinates V_i are orthogonal to d. This rotation R_d allows to transform (x, y) of the original space into a new system where the distance to the frontier can be expressed by a scalar-valued equation.

2. Then, the observed rotated values $(U_i)_{i=1,\ldots,n}$ are projected onto the estimated nonparametric frontier, yielding:

$$\hat{U}_i^{\partial} = U_i + \|d\| \hat{\delta}_i, \tag{2.6}$$

where $\|d\|$ denotes the euclidean norm of the direction vector d. Similarly, we define $\hat{U}_{m,i}^{\partial}$ the rotated value projected on the order$-m$ estimated frontier.

3. Finally, we construct a nonparametric frontier approximation by applying local linear regression on the sample $(V_i, \hat{U}_i^{\partial})$[2]. More precisely, the local linear regression is performed by fitting the $\hat{U}_i^{\partial}$ on V_i at the estimated points $\hat{U}_i^{\partial}$ using the weighted least squares optimization:

$$\min_{\alpha,\beta} \sum_{i=1}^{n} K_h(V_i - v) \left(\hat{U}_i^{\partial} - \alpha - \beta'(V_i - v) \right)^2, \tag{2.7}$$

[1] I_{r-1} denotes the identity matrix of size $r - 1$ and 0_{r-1} the $(r-1)-$dimensional vector of zeros.
[2] A similar process can be done for the order$-m$ frontier.

where K_h is a kernel function weighting observations near v, h denotes the bandwidth parameter selected via cross-validation (see Li & Racine, 2007 for further details), and α and β are the coefficients to be optimized. The solutions of Equation (2.7) can be written $\hat{\alpha}(v)$ and $\hat{\beta}(v)$. The coefficient $\hat{\alpha}(v)$ can be interpreted as a smoothed estimate of the frontier at the point v and the coefficients $\hat{\beta}(v)$ approximate the first derivative of the estimated frontier at the point v.

4. The estimated coefficient $\hat{\alpha}$ and derivative $\hat{\beta}$, initially expressed in terms of v, can be subsequently transformed back to the original input-output space (x, y) using a one-to-one transformation (for additional details, refer to DS).

This methodology facilitates the estimation of nonparametric frontier coefficients, which capture the variation in relevant economic quantities (e.g. marginal rates of substitution). Unlike traditional approaches, this method smooths coefficient estimates without imposing restrictive assumptions on the efficiency frontier's functional form or inefficiency distribution. Moreover, it enables the computation of efficiency derivatives with respect to inputs and outputs, followed by an estimation of their dependence on external factors. Notably, this framework does not generate a single average derivative for the entire dataset. Instead, it provides localized estimates for each unit, allowing a detailed visualization of distribution patterns and a comprehensive assessment of the impact of external factors.

2.2 Including environmental factors

The previous presentation can be adapted in the presence of environmental factors $Z \in \mathbb{R}^k$, which in our application includes the percentage of female board members and the percentage of female loan officers. Following Cazals et al. (2002), Daraio and Simar (2005) and Daraio and Simar (2007a), we define the conditional attainable set:

$$T^z = \{(x, y) \in \mathbb{R}^{(p+q)} |\ x \text{ can produce } y \text{ when } Z = z\}. \tag{2.8}$$

By definition, $T^z \subseteq T$. Most often, the inclusion is strict (see Simar and Wilson (2007)) with means that the environmental factors affects the production set and its frontier. In that case, it is more appropriate to define a conditional efficiency measure:

$$\delta(x, y|z) = \sup\{\theta \mid (x - \theta d_x, y + \theta d_y) \in T^z\}. \tag{2.9}$$

Nonparametric estimators have been proposed by Cazals et al. (2002) and Daraio and Simar (2005). Consider again a sample of observations $(X_i, Y_i, Z_i)_{\{i=1,\ldots,n\}}$. From Equation (2.9), using Daraio et al. (2020), we estimate a conditional nonparametric FDH efficiency measure $\hat{\delta}(X_i, Y_i|Z_i)$ for each unit $i = 1, \ldots, n$. Let's summarize the DS methodology in the presence of environmental variables:

1. First of all, the transformation of (X_i, Y_i) into (U_i, V_i) remains the same and is not impacted by the environmental variables Z.

2. Then, the variables Z are introduced in the projection of the observed rotated values $(U_i)_{i=1,\ldots,n}$ onto the estimated conditional frontier, yielding:

$$\hat{U}_i^{\partial}(Z_i) = U_i + \|d\|\hat{\delta}(X_i, Y_i|Z_i). \tag{2.10}$$

   Similarly, we define $\hat{U}_{m,i}^{\partial}(Z_i)$ the rotated value projected on the order$-m$ estimated conditional frontier.

3. Finally, the local linear regression is performed by fitting the $\hat{U}_i^{\partial}(Z_i)$ on V_i at the estimated points $\hat{U}_i^{\partial}(Z_i)$ using the weighted least squares optimization:

$$\min_{\alpha,\beta} \sum_{i=1}^{n} K_h(V_i - v) \left(\hat{U}_i^{\partial}(Z_i) - \alpha - \beta'(V_i - v) \right)^2 . \tag{2.11}$$

   The estimated coefficients are again denoted $\hat{\alpha}$ and $\hat{\beta}$.

The statistical properties of the resulting estimators have been described in DS. In summary, we have consistent estimators $\hat{\alpha}$ and $\hat{\beta}$ converging to the best local approximation to the true frontier. In addition, for the order$-m$ case, we prove convergence with $\sqrt{n}$ rate to a normal distribution, which allows to perform bootstrap approximation (see DS for details).

3 Data

3.1 Sample

The data used in this study comes from the Microfinance Information Exchange (MIX), a key source of understanding the financial inclusion and microfinance sectors, and the most widely used database in microfinance research (Fall et al. (2021), Fall et al. (2023); Tadele et al. (2018)). Currently, the MIX platform discloses information on more than 2,500 key MFIs around the world. In this study, we use a sample of 346 MFIs In this study, we use a sample of 346 MFIs observed in the year 2017. This sample is spread across several regions and several for-profit MFIs, NGOs and mutual or savings and credit cooperatives, as ahown in Table 1.

Region	MFIs institutional forms			
	Shareholder or for profit MFIs	**Nonprofit MFIs**		**Total**
		Credit Unions/ Cooperatives	NGO	
Sub-Saharan Africa	35	5	15	55
East Asia and the Pacific	28	2	9	39
Eastern Europe and Central Asia	43	1	3	47
Latin America and The Caribbean	41	33	30	104
Middle East and North Africa	3	0	12	15
South Asia	33	1	52	86
Total	**183**	**42**	**121**	**346**

Table 1: MFI distribution by institutional form and region.

3.2 Model and variables selection

This study employs a robust nonparametric frontier efficiency model to analyze the social efficiency of microfinance institutions (MFIs), incorporating gender diversity in governance and loan officer roles. As in Fall et al. (2021), the model follows a production framework where MFIs utilize resources to generate social outputs while facing delinquency constraints. The efficiency estimation is conducted using a directional distance function approach, which allows for flexible measurement of deviations from the efficiency frontier.

We consider *two inputs*: personal expenses X_1 and operating expenses X_2, and *two outputs*: one desirable and one non desirable. The desirable output Y is the percentage of female borrowers, which serves as a measure of financial inclusion. It refers to the percentage of females that currently have a credit balance with the MFI. This variable is commonly used as an indicator of the social performance of microfinance (see Bibi et al. (2018)). To assess the outreach of microfinance services, the literature commonly relies on three key indicators: the number of clients, which reflects the breadth of outreach; the proportion of active female borrowers relative to total active borrowers; and the average loan size, which indicates the depth of outreach (see Schreiner (2002)). Among these, the percentage of female borrowers is considered the most relevant for evaluating social performance, as it best captures the depth of microfinance outreach.

The undesirable output BY is the gross loan portfolio that has been delinquent for one month or more and acts as an additional input. Specifically, this is the value of all outstanding loans for which one or more principal installments are more than 30 days overdue.

We also include in the model *two gender-related external factors* that may influence efficiency: the percentage of female board members Z_1 and the percentage of female loan officers Z_2. See Figure 1 which shows the boxplots of the two external variables.

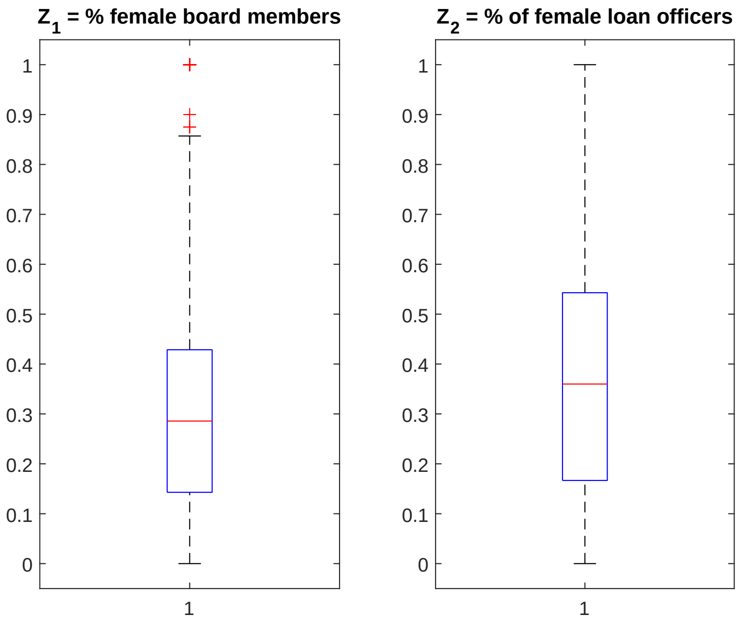

Figure 1: Boxplots of the external variables Z_1 (percentage of female board members), and Z_2 (percentage of female loan officers).

Table 2 provides some descriptive statistics of the main variables used in our study.

	Mean	Standard Deviation	Minimum	Maxi
Input 1: Operating expenses	12,903,425	26,713,959	1,083	290,000,000
Input 2: Number of employees	939	2,298	2	26,147
Output Y: Percentage of Female borrowers	63	26	6	100
Bad Output BY: Delinquent gross loan portfolio for one month or more	5,161,505	14,629,257	0	140,000,000
Z_1: % of female board members	32%	26%	0%	100%
Z_2: % of female loan officers	38%	28%	0%	100%

Table 2: Descriptive evidence. The operating expenses include expenses not related to financial and credit loss impairment, such as personnel expenses, depreciation, amortization and administrative expenses. The number of employees corresponds to the number of individuals who are actively employed by an entity. This number includes contract employees or advisors who dedicate a substantial portion of their time to the entity, even if they are not on the entity's employee roster. Source: MIX Market

As in Fall et al. (2021) and Fall et al. (2023), since the two inputs X_1 and X_2 are strongly correlated, we aggregate both inputs (see Daraio and Simar (2007a) and Wilson (2018) for an overview of dimension reduction), and obtain a unique input dimension that allows limiting the effect of this correlation in the frontier estimation. We check that the correlations between the initial inputs and the aggregated input are strong enough (93% for both), as well as the percentage of inertia (88%).

Note that, before being processed, all variables have been scaled by their empirical standard deviation to improve the numerical stability in the computation of smoothing parameters. And inputs and outputs are also log-transformed to reduce the effects of extreme values.

4 Findings

The objective of this section is to analyze the impact of the undesirable output BY and external factors Z_1 and Z_2 on the efficiency level and the production frontier. In particular, compared to Fall et al. (2021), we are able to derive partial derivatives of the social performance (the output Y) with respect to input, bad output or gender external variables. We can now comment on marginal rates of substitution or economies of scale, which was not possible until now in a nonparametric setting.

In order to compute robust order$-m$ frontier estimations, we first need to fix the value of the smoothing parameter m. Figure 2 shows the result of the sensitivity analysis in order to select the value of m.

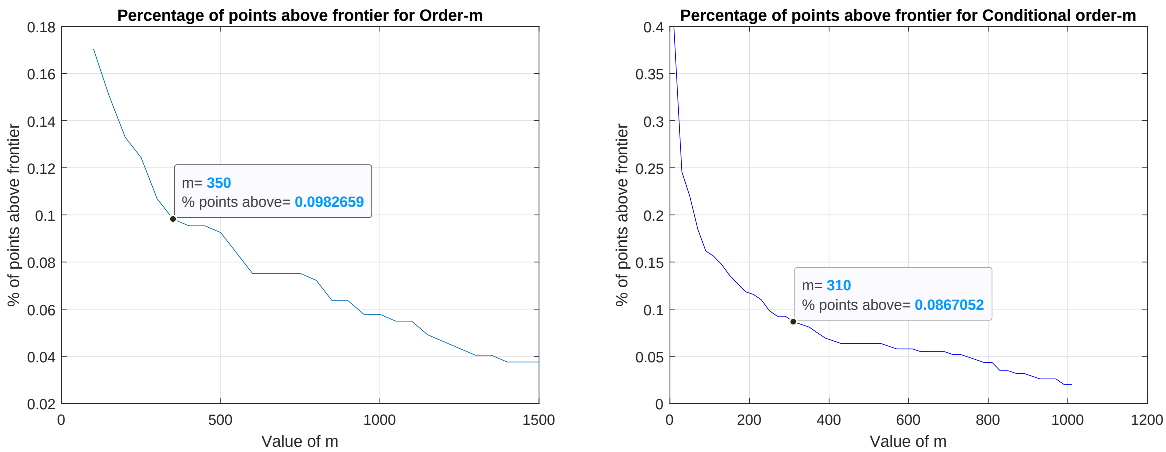

Figure 2: Plots for the choice of the value of m. The horizontal axis represents the values of m and the vertical axis gives the percentage of points outside the order$-m$ frontier. On the left, the frontier is non-conditional and on the right the frontier is defined conditionally to the external factors.

On the left plot of Figure 2 (unconditional frontier), the elbow effect is around the value of $m = 350$ for which almost 10% of observations lie above the order-m frontier. On the right plot (conditional frontier), the elbow is at the value $m = 310$, with only 8.6% of points are located above the frontier (more details on how to select the value of m can be found in Daraio and Simar (2007a)). Note that the results are rather robust to small variations of the value of m.

Figure 3 shows the distribution of efficiency scores, conditional and non conditional to the external factors Z_1 and Z_2, for the full FDH frontier and also the robust order$-m$ frontier.

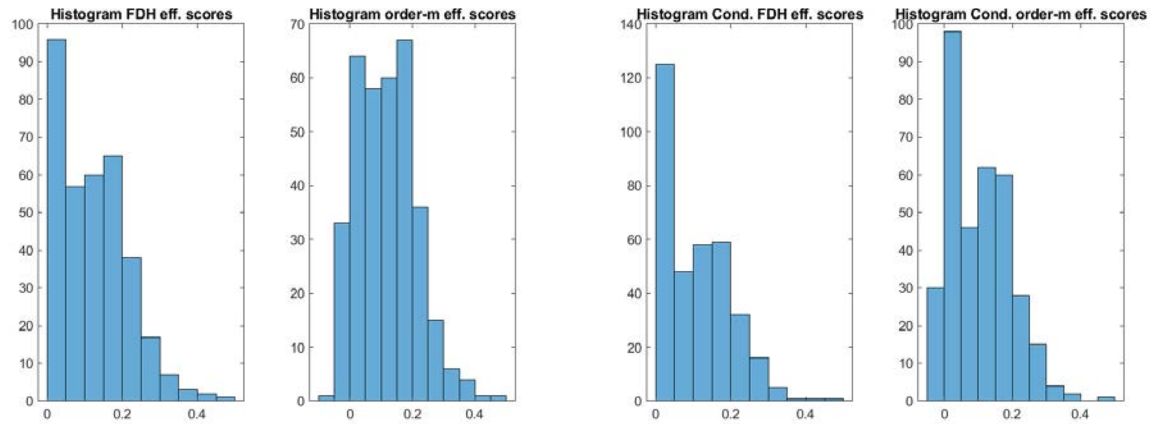

Figure 3: Histograms of FDH efficiency scores and order$-m$ efficiency scores. The two left plots represent non-conditional scores whereas the two right plots give the conditional scores with respect to the external variables.

We can observe for the FDH efficiency scores an accumulation at the efficiency value 0, which correspond to efficient MFIs (these points are on the frontier). On the contrary, for the order$-m$ efficiency scores, negative values of efficiency are allowed, which correspond to MFIs above the frontier considered as "super-efficient". We can note on all distributions a right hand-side skew that reveals the presence of a few very inefficient MFIs. Moreover, the distributions differ for conditional and non conditional efficiency scores, with shows that taking into account for gender impact efficiency levels. The differing distribution of efficiency scores between the conditional and unconditional frontiers appears to underscore the influence of considering women's presence in governance bodies (Z_1 and Z_2) on the social efficiency frontier of microfinance.

We now analyze the marginal effects of aggregate input X, bad output BY and output Y on efficiency scores, which evaluate the distance of each MFI to the production frontier. The larger the efficiency score, the more inefficient the MFI. It is worth noting that these results represent significant contributions of our paper, as the technical tools required to compute them had not been previously explored. In particular, the boxplots illustrate the distribution of the impact on each MFI, offering a much deeper analysis and understanding of the phenomenon compared to relying solely on a global average coefficient.

An efficient score close to 0 indicates that the MFI is close to efficiency. Figure 4 shows the boxplots of the estimated derivatives of conditional efficiency scores with respect to X, BY and Y. The left plot shows FDH estimations and the right plot shows robust order$-m$ estimations.

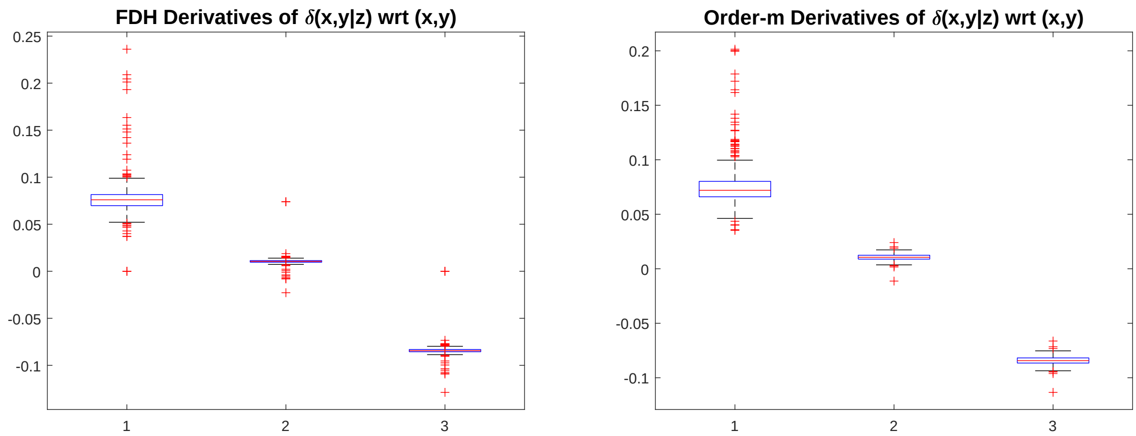

Figure 4: Derivatives of efficiency levels with respect to the aggregate input X (1), the bad output BY (2) and the output Y (3). On the left, efficiency measures are derived from the FDH full frontier, on the right, efficiency measures are derived using the order-m frontier.

As expected, we observe that the efficiency derivatives are on average positive with respect to input and bad output and negative with respect to output. Inefficiency levels increase as input or bad output increase (the derivative with respect to X and BY is positive), while inefficiency decreases when the output increases. We also note a decreasing marginal effect of input X and bad output BY on the efficiency level as both partial derivatives are (positive and) less than one. It means that when the amount of input or bad output increases, the relative increase of inefficiency will be lower.

An increase in staff numbers and operational expenses in microfinance, holding other factors constant, leads to higher social inefficiency. A similar effect is observed with undesirable output, any growth in the risky loan portfolio raises the level of social inefficiency. In contrast, social inefficiency decreases as the number of active female borrowers increases. This means that the marginal effects of both input and undesirable output are positive but those of the undesirable output are smaller. This means that increasing staff, operational expenses, or risk levels initially leads to greater social inefficiency in microfinance. As the MFI allocates more resources and assumes more risk, its distance from the efficiency frontier increases, indicating lower efficiency.

Table 3 shows the results of the bootstrap confidence intervals for efficiency derivatives: $\partial\delta_m(x,y|z)/\partial x$ (fourth and fifth columns), $\partial\delta_m(x,y|z)/\partial BY$ (sixth and seventh columns) and $\partial\delta_m(x,y|z)/\partial y$ (eighth and ninth columns) for 20 institutions randomly selected (to save space).

Table 3: 95% bootstrap confidence intervals (lower and upper bounds) for $\partial\delta_m(x,y|z)/\partial x$ (fourth and fifth columns), $\partial\delta_m(x,y|z)/\partial BY$ (sixth and seventh columns) and $\partial\delta_m(x,y|z)/\partial y$ (eighth and ninth columns), with $m = 310$. Bootstrap with $B = 1000$ replications. Columns two and three report respectively the type of institution and the region where it is located.

N	Type	Region	$\partial\delta_m(x,y\|z)/\partial x$		$\partial\delta_m(x,y\|z)/\partial BY$		$\partial\delta_m(x,y\|z)/\partial y$	
1	NGO	South Asia	0.006	0.056	0.017	0.083	-0.090	-0.076
2	NGO	South Asia	-0.002	0.063	0.014	0.104	-0.102	-0.080
3	Bank	South Asia	0.004	0.066	0.013	0.088	-0.093	-0.080
4	NGO	South Asia	0.003	0.066	0.013	0.092	-0.095	-0.081
5	Rural Bank	South Asia	0.010	0.043	0.019	0.065	-0.085	-0.073
6	Bank	South Asia	0.011	0.054	0.020	0.074	-0.084	-0.072
7	NBFI	Eastern Europe and Central Asia	-0.009	0.126	0.010	0.177	-0.111	-0.085
8	Credit Union / Cooperative	Eastern Europe and Central Asia	-0.006	0.089	0.012	0.147	-0.106	-0.082
9	NBFI	Eastern Europe and Central Asia	-0.008	0.045	0.019	0.119	-0.109	-0.073
10	NBFI	Eastern Europe and Central Asia	-0.006	0.135	0.011	0.200	-0.106	-0.084
11	NGO	Africa	0.005	0.063	0.014	0.087	-0.092	-0.079
12	NGO	Africa	0.006	0.055	0.016	0.081	-0.090	-0.077
13	NGO	Africa	0.005	0.069	0.016	0.101	-0.091	-0.077
14	Credit Union / Cooperative	Africa	0.002	0.064	0.011	0.085	-0.095	-0.084
15	NGO	Africa	0.007	0.057	0.017	0.079	-0.088	-0.075
16	NGO	Africa	0.009	0.049	0.018	0.071	-0.087	-0.074
17	NBFI	Latin America and The Caribbean	0.006	0.045	0.019	0.081	-0.090	-0.073
18	NGO	Latin America and The Caribbean	-0.008	0.086	0.010	0.143	-0.109	-0.085
19	Credit Union / Cooperative	Africa	0.009	0.055	0.019	0.076	-0.087	-0.074
20	NBFI	Africa	0.001	0.071	0.011	0.096	-0.097	-0.084

We observe that all institutions except units # 2,7,8,9,10 and 18 (that include zero in the estimated confidence intervals of $\partial\delta_m(x,y|z)/\partial x$) show results statistically significant at 95%. Overall, we observe that the estimated quantities showed in Table 3 (and also 4 hereafter) have the expected signs. This confirms the significant decreasing marginal effects of conditional efficiency scores with respect to the input X and the bad output BY.

The marginal effects of input (operational expenses and staff in MFIs), bad output (risk), and output are confirmed for almost all MFIs in the bootstrap analysis. However, for the marginal effect of X, we note a different behavior for certain MFIs. For the MFIs shown in the table, we see that the confidence intervals are not significant. These are mainly MFIs from Eastern and Central Europe (4 MFIs out of the 4 selected for this region) and one Latin American MFI out of the 2 selected. Microfinance in these two regions seems to have a different nature with respect to social orientation. The MFIs there are more commercial in nature, which may explain this difference. However, additional empirical investigation should be carried out to consolidate this evidence, with a larger sample size for the targeted regions (see Table 1 with sub-sample size for each region).

We now investigate the marginal effects of input X and bad output BY on the social performance Y at frontier points. Figure 5 shows the rate of change in the social performance of MFIs as the input change. On average, the values are positives and less than one which means that there is evidence of decreasing returns to scale. The marginal effect of an increase in resources (X) on the proportion of women financed is positive but smaller than 1, meaning that an increase of one unit of input, at the MFI level, results in a smaller than one increase in the MFI's social outcome.

Figure 6 provides a similar analysis for the bad output, with a reduced impact of the bad output variation on the social performance. Therefore, the marginal increase of social output is on average lower, compared to the increase of input or bad output.

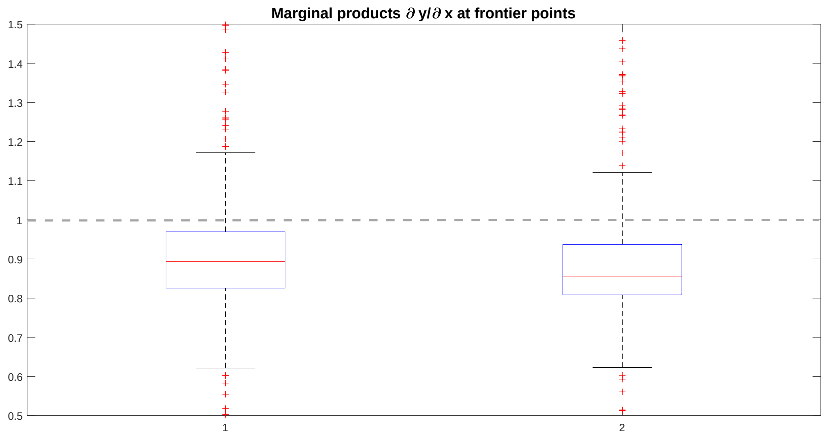

Figure 5: Distribution of the marginal products $\partial y/\partial x$ at frontier points. FDH estimation on the left and order$-m$ on the right.

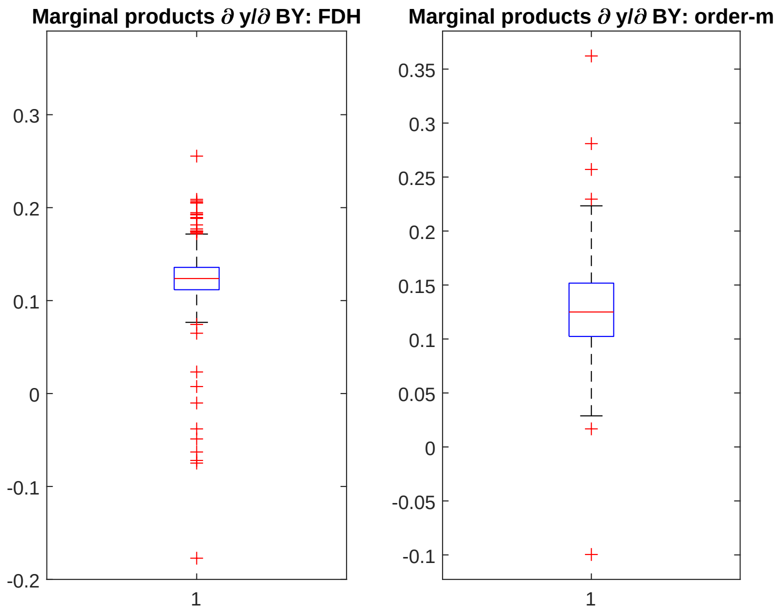

Figure 6: Boxplots of the marginal products $\partial y/\partial BY$ at frontier points. FDH estimation on the left and order$-m$ on the right.

Table 4 reports the 95% bootstrap confidence intervals around marginal effects of social performance at the frontier for 20 randomly chosen institutions from different regions and of different types.

Table 4: 95% bootstrap confidence intervals (lower and upper bounds) for the rates $\partial y/\partial x$ (fourth and fifth columns), $\partial y/\partial BY$ (sixth and seventh columns) evaluated at conditional order-m frontier points, with $m = 310$. Bootstrap with $B = 1000$ replications. Columns two and three report respectively the type of institution and the region where it is located.

N	Type	Region	$\partial y/\partial x$		$\partial y/\partial BY$	
1	NGO	South Asia	0.725	0.964	0.026	0.223
2	NGO	South Asia	0.776	1.109	-0.102	0.166
3	Bank	South Asia	0.805	0.969	0.028	0.162
4	NGO	South Asia	0.809	0.994	0.001	0.159
5	Rural Bank	South Asia	0.596	0.787	0.100	0.255
6	Bank	South Asia	0.725	0.901	0.104	0.265
7	NBFI	Eastern Europe and Central Asia	1.217	1.820	-0.175	0.115
8	Credit Union / Cooperative	Eastern Europe and Central Asia	1.050	1.521	-0.133	0.145
9	NBFI	Eastern Europe and Central Asia	0.492	1.327	-0.289	0.241
10	NBFI	Eastern Europe and Central Asia	1.519	1.993	-0.078	0.107
11	NGO	Africa	0.788	0.968	0.032	0.176
12	NGO	Africa	0.707	0.918	0.045	0.204
13	NGO	Africa	0.889	1.137	0.036	0.196
14	Credit Union / Cooperative	Africa	0.759	0.908	0.015	0.124
15	NGO	Africa	0.742	0.924	0.057	0.225
16	NGO	Africa	0.663	0.842	0.083	0.233
17	NBFI	Latin America and The Caribbean	0.611	0.960	0.026	0.253
18	NGO	Latin America and The Caribbean	0.953	1.433	-0.166	0.115
19	Credit Union / Cooperative	Africa	0.714	0.901	0.082	0.243
20	NBFI	Africa	0.843	1.014	-0.007	0.124

Units with confidence intervals that include zero show a non statistically significant estimation of their marginal rates. It appears that 7 out of the 20 units reported in Table 4 do not have any statistical significant impact of the bad output (BY) on the output (Y). Overall, this still confirms the significant decreasing marginal effects of social performance with respect to the bad output BY.

The next figures investigate the impact of gender on the input, the bad output, and the social performance. Figures 7, 8 and 9 show the partial derivatives of the input, bad output and output with respect to the two gender variables Z_1 and Z_2.

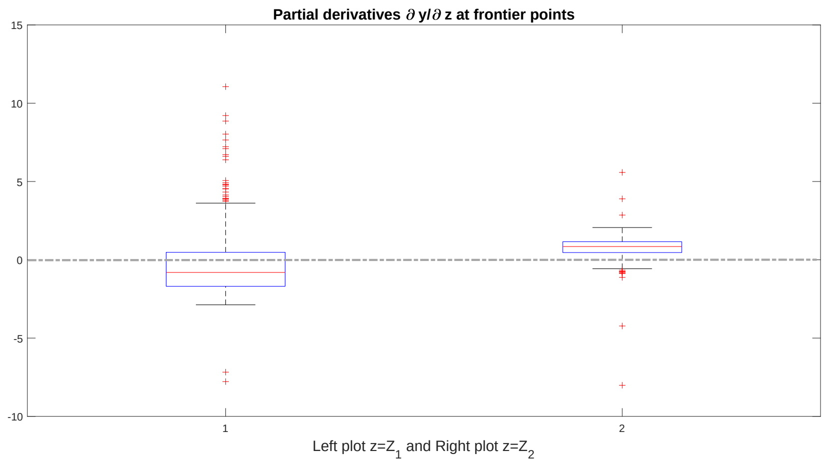

Figure 7: Distribution of the marginal products $\partial y/\partial Z$ at frontier points.

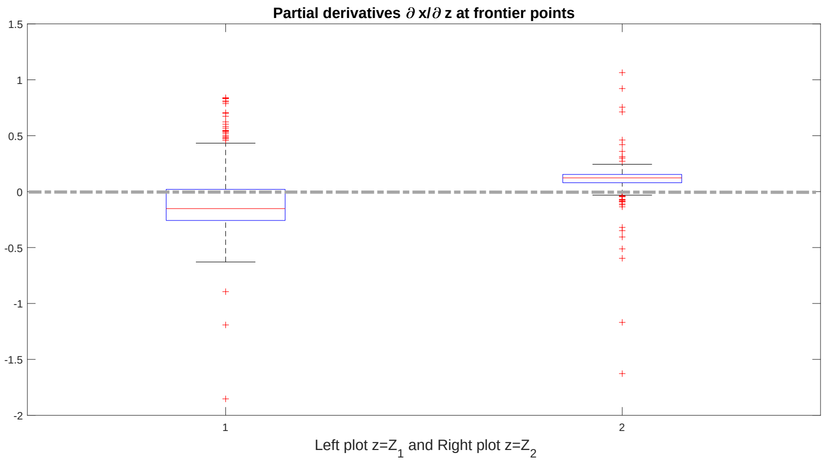

Figure 8: Distribution of the marginal products $\partial x/\partial z$ at frontier points.

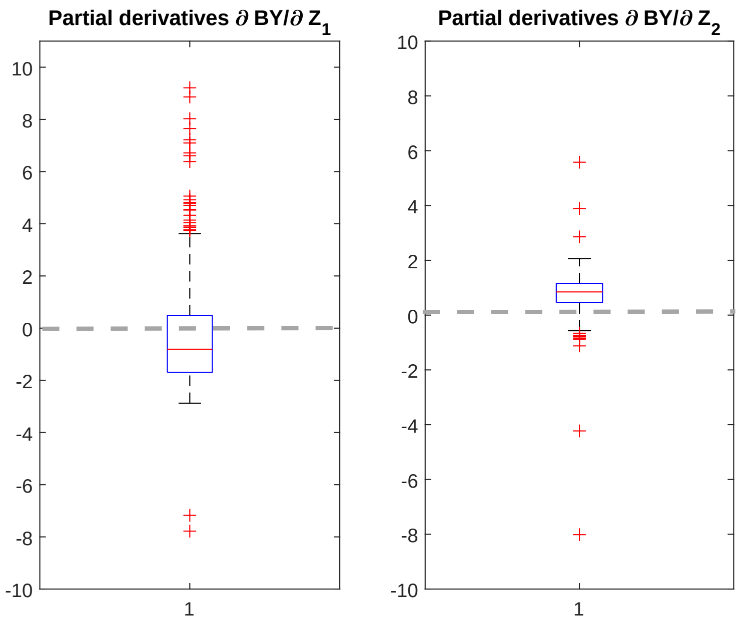

Figure 9: Distribution of the marginal products $\partial BY/\partial z$ at frontier points.

The effect of the percentage of women in the board (Z_1) and the percentage of female loan officers (Z_2) is quite similar for the three variables Y, X and BY with derivatives close to 0. Therefore, the results do not reveal a strong direct impact of gender on the outputs or the inputs. We still note the negative impact of the % of female board members and the positive impact of the % of female loan officers on the two outputs and the input. Note, however, a group of outliers with opposite behavior. We point out that, thanks to the methodology applied here (see Section 2), we are able to analyze the marginal effects on each MFI, which allows for a much richer analysis and better understanding of the diversity of the MFIs behavior, compared to standard average analyses.

The median effect of the presence of female board members on the percentage of female borrowers (Figure

7, boxplot on the left) is negative. However, there are several MFIs outliers with a positive effect. On the other hand, the median effect of the presence of female loan officers on the percentage of female borrowers ((Figure 7, boxplot on the right) is positive. We note again a few outliers with negative effect.

Similar effects are obtained for the portfolio at risk and the resources implemented (staff and operational expenses) (see figures 9 and 8).

Figure 10 shows the 3D fit of the partial derivatives of social performance on the frontier with respect to the external factors Z_1 and Z_2 and complete the analysis of the external variables effects. We can note first that the effects of both external factors on the marginal rates are non linear.

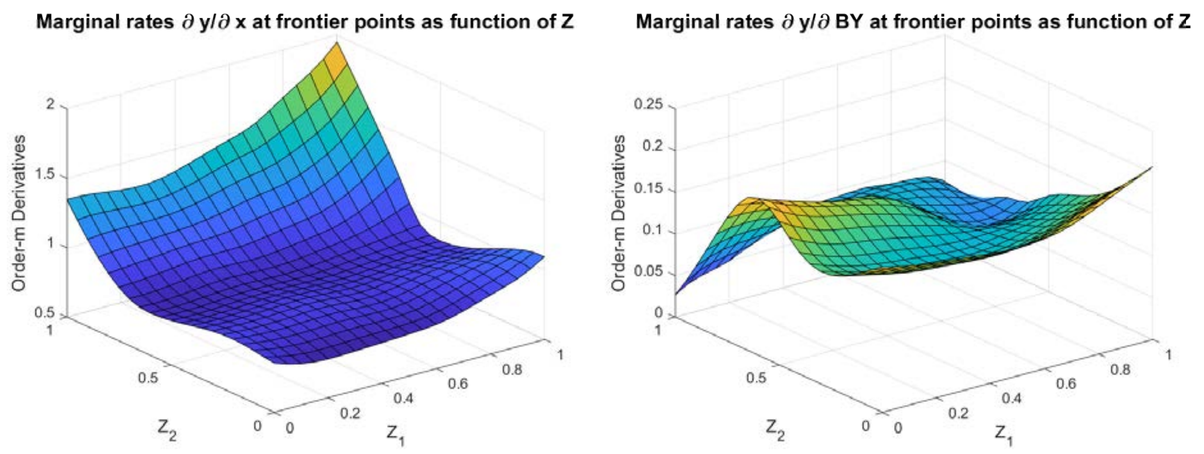

Figure 10: 3D fit of the partial derivatives of output at frontier points wih respect to external factors Z_1 and Z_2. The left plot shows the 3D fit of the partial derivative of Y with respect to the aggregate input X, and the right plot shows the 3D fit of the partial derivative of Y with respect to the bad output BY.

We see on the left plot that the marginal effect of input on social performance varies with both the level of female representation on the board and loan officers. The return to scale is globally increasing for both the percentage of female on board and loan officers. We also see a joint impact of Z_1 and Z_2 on the return to scale. The positive impact of female loan officers is strengthened when the percentage of female on board increases. Similarly, the positive impact of female on board is strengthened when the percentage of female loan officers increases.

We also see on the right plot that the marginal effect of bad output on social performance varies non-linearly with female representation on the board and with the percentage of female loan officers. Globally, increasing the percentage of female loan officers or female on board reduces the impact of bad output on the social performance. But, the effects are not linear. We observe first that increasing the percentage of female loan officers increases the impact of bad output on the social performance, but this effect disappears after a threshold value and the the impact of bad output on social performance decreases to almost zero (inverted U-shape). The percentage of female on the board increases the effect of bad output on the social performance for small percentages of female loan officers. This effect is strongly reduced when the percentage of female loan officers increases.

Therefore, we can conclude that a higher percentage of female board members and female loan officers allows to reduce the impact of gross loan delinquency on social performance. In addition, it seems important to strenghten simultaneously the presence of female board members and female loan officers in order to have an effective impact on social performance. In particular, increasing the number of female on the board without increasing the number of female loan officers may increase the effect of the bad output on social performance.

5 Discussion

An analysis of the social performance of MFIs operating on the efficiency frontier reveals that the presence of women in both strategic and operational governance roles influences the financing of women—though the effect is not particularly strong when these roles are considered in isolation. Social performance varies depending on the level of female representation on boards of directors and among loan officers, with increasing returns to scale observed for both groups. These findings suggest that women's participation in microfinance governance plays a critical role in improving social performance, especially in targeting female clients.

This conclusion aligns with numerous studies, including Fall et al. (2021), Bibi et al. (2018), Vishwakarma (2017), Périlleux and Szafarz (2015), Mori et al. (2015), Strøm et al. (2014), D'espallier et al. (2011), Mersland and Strøm (2009), and Hartarska (2005). For example, Fall et al. (2021), using a global sample, find that the presence of women in strategic (board) and operational (loan officer) positions positively affects the social performance of MFIs, as measured by the share of female borrowers. Bibi et al. (2018) similarly observe that having female loan officers is a key determinant of both financial and social performance. In the Indian context, Vishwakarma (2017) report that women's participation in senior management positively impacts MFIs' social performance. Périlleux and Szafarz (2015), studying 36 financial cooperatives in Senegal, find that boards dominated by women are more socially oriented. Further supporting this view, Mori et al. (2015) show that MFIs with a higher proportion of female board members perform better in both the depth and breadth of their outreach. Hartarska et al. (2014) demonstrate that MFIs led by women have significantly greater outreach and that promoting gender diversity at the top levels of management enhances both social and financial outcomes. Strøm et al. (2014) find that female leadership correlates with a larger female client base. Similarly, D'espallier et al. (2011) conclude that MFIs with strong female representation, among clients, staff, or management, tend to exhibit stronger social orientation and better loan repayment rates. Mersland and Strøm (2009) also identify a positive link between female board representation and both social and financial performance. Lastly, Hartarska (2005) argue that policies promoting board diversity are appropriate, as female representation improves the outreach depth and breadth of microfinance.

The relatively limited impact of female representation at either the strategic or operational level alone has a logical explanation. Female board members may influence strategic decisions to better target women, but without strong implementation at the operational level, these decisions may not translate into effective action. Conversely, female loan officers might prefer to serve women clients, but without strategic guidance from leadership, their efforts may remain limited in scope. This is supported by the results on the joint effect of women's presence at both governance levels.

The findings also indicate that the combined presence of women on the board of directors and in operational roles has a stronger impact on returns to scale. Specifically, the positive effect of female loan officers on women's access to finance is amplified when the proportion of women on the board is high. Likewise, the beneficial influence of female board members on social performance, measured by the percentage of female borrowers, is strengthened when there is a high representation of women among loan officers. This result supports the conclusions of Fall et al. (2021), who find that the strategic influence of women in governance can only truly enhance social efficiency and improve outreach to women when there is also strong female representation at the operational level. However, their analysis consider the effects of strategic and operational representation separately, rather than examining their combined impact. One of the central arguments of this article is that women's presence on the board can shape MFI policies to better target female clients.

Yet, strategic decisions alone are not sufficient; effective implementation at the operational level is essential. A decision made at the top can fail to achieve its intended outcomes if not properly executed on the ground. For initiatives aimed at improving women's access to finance to succeed, it is crucial that women are also well represented among loan officers. Similarly, the efforts of female loan officers are more impactful when supported by strategic direction from a gender-diverse board.

This insight carries significant policy implications. It underscores the importance of promoting women's representation across all levels of microfinance governance. Their involvement in both strategic decision-making and operational execution enhances the likelihood that MFIs will fulfill their social mission, particularly in serving and empowering women. The positive impact of women on the social performance of microfinance can be attributed to several key factors. Women play a vital role in helping MFIs achieve their social objectives, particularly in expanding financial access to female clients. According to resource dependence theory (Hillman and Dalziel (2003); Pfeffer and Salancik (2015)), board members serve as crucial links to external resources that enhance organizational performance. In this context, women on microfinance boards bring valuable social and relational capital, as well as human capital—such as skills, expertise, experience, and knowledge—that contribute to more effective decision-making aligned with both social and financial goals. Women are often deeply rooted in the communities MFIs serve, maintaining close relationships with clients and strong community ties. Their presence on boards introduces diversity, which is essential for independent, balanced, and prudent decision-making (Adams and Ferreira (2009)). Mersland and Strøm (2009) note that female board members possess insights and capabilities that help MFIs better tailor their services to client needs. Moreover, women on boards act as important oversight agents, ensuring that institutions stay true to their mission.

In many cases, MFIs receive support from donors or public subsidies aimed at fighting poverty and empowering women. However, some institutions may drift from these goals, opting instead for a profit-oriented approach that prioritizes wealthier, lower-risk clients. This divergence creates an agency problem, where the interests of management may not align with those of donors or intended beneficiaries. From an agency theory perspective (Jensen and Meckling (1976)), the inclusion of women in governance structures serves as a mechanism to reduce such conflicts of interest. Their presence helps reinforce accountability and ensures that MFIs adhere to their social commitments.

Recent literature further supports this view. For instance, Mirza et al. (2020) emphasize that women's participation on boards helps mitigate agency issues and fosters stronger institutional discipline. Similarly, Ebissa and Asfaw (2024) find that the presence of female loan officers significantly enhances the social performance of microfinance institutions in Africa.

The results also indicate that the presence of women in microfinance governance helps reduce the overall negative impact of undesirable output on social performance. This aligns with evidence showing that women on boards of directors and among loan officers positively influence the social effectiveness of microfinance institutions. Women mitigate the adverse effects of bad output in two key ways.

First, at the strategic level, women on boards encourage MFIs to adopt more cautious risk-taking policies. Their influence leads to less risky decisions, which helps prevent significant deterioration in portfolio quality. Second, at the operational level, female loan officers leverage their close relationships with clients and contextual knowledge to provide more effective monitoring, improving loan repayment rates.

Additionally, the fact that women in decision-making roles promote financing for female clients further helps reduce portfolio risk. Numerous studies have demonstrated that loans extended to women tend to have better repayment rates (D'espallier et al. (2011); Armendáriz and Morduch (2010)). For instance, D'espallier et al. (2011), analyzing data from 350 MFIs across 70 countries, found that a higher share of female clients correlates with lower portfolio risk. Armendáriz and Morduch (2010) also argue that targeting women acts as a strategic mechanism—similar to solidarity lending or progressive repayment incentives—to improve repayment performance. Moreover, Boehe and Cruz (2013) showed that women's membership positively affects MFI performance through improved debt repayment.

6 Conclusion

In this study, we analyze the efficiency of MFIs based on their social performance, two inputs (personnel and operating expenses) and a bad output (the gross loan portfolio that has been delinquent for one month or more). We also account for external gender effects and include two additional variables in our analysis: the percentage of female board members and the percentage of female loan officers. Using a recent approach developed by Daraio and Simar (2024), we combine nonparametric conditional techniques (to allow for more flexibility in the shape of the frontier) and parametric approximations to derive pointwise values of derivatives of efficiencies with respect to various variables: output, input, bad output, external variables. We also compute partial derivatives at the frontier to check for a potential economy of scale.

Compared to Fall et al. (2021), the methodology we apply in this work uncovers much more complex phenomena and interaction effects that were not captured in the earlier analysis. Our results indicate that the variable gross loan delinquency acts as a bad output and reducing it allows to achieve higher social performance. Indeed, we observe decreasing returns to scale between the social performance, the inputs, and the bad output. An increase in inputs or in bad output increases the social performance, but to a lesser extent. The impact of both external gender variables on inputs and output levels is rather small, meaning that these variables do not impact much the frontier level. However, we note a strong indirect impact on the marginal rates of social performance with respect to inputs and bad output. The results reveal a joint positive impact of both gender variables to reduce the impact of bad output on social performance. And returns to scale are significantly improved when both the percentage of female board members and the percentage of female loan officers are simultaneously increased.

This study reveals several important findings. First, the combined presence of women at both strategic and operational levels has a strong and positive impact on the social effectiveness of microfinance, whereas their presence at either level alone produces only a weak positive effect. This underscores the vital role that women's joint involvement across these levels plays in achieving the social goals of microfinance institutions. The significant influence of this joint effect confirms that women's participation in governance is a key driver of social performance. At the strategic level, women's involvement ensures that decision-making better reflects the needs of female clients, while their presence at the operational level facilitates effective implementation of empowerment policies defined at the strategic level. Second, the study highlights the detrimental effect of undesirable output—such as poor portfolio quality—on social performance. Since bad output behaves like an input, reducing it improves social effectiveness, illustrating how a risky loan portfolio can undermine microfinance's social mission. Third, the negative impact of bad output is mitigated by the presence of women in governance roles, further emphasizing their importance in safeguarding social objectives. Together, these findings call for MFIs to reconsider their internal policies by integrating gender as a core element of institutional development. Promoting female leadership and leveraging women's skills across all organizational levels is not only a matter of fairness but also a strategic approach to enhancing the social impact of microfinance.

Declarations of interest

None.

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References

Adalessossi, K. (2024). What are the determinants of the financial and social performance of mfis in togo? does gender borrower matter on financial performance? *Finance Research Letters*, 62:105192.

Adams, R. B. and Ferreira, D. (2009). Women in the boardroom and their impact on governance and performance. *Journal of financial economics*, 94(2):291–309.

Armendáriz, B. and Morduch, J. (2010). *The economics of microfinance*. MIT press.

Beck, T., Behr, P., and Madestam, A. (2018). Sex and credit: Is there a gender bias in lending? *Journal of Banking and Finance*, 87.

Bibi, U., Balli, H. O., Matthews, C. D., and Tripe, D. W. (2018). Impact of gender and governance on microfinance efficiency. *Journal of International Financial Markets, Institutions and Money*, 53:307–319.

Boehe, D. M. and Cruz, L. B. (2013). Gender and microfinance performance: Why does the institutional context matter? *World Development*, 47:121–135.

Cazals, C., Florens, J.-P., and Simar, L. (2002). Nonparametric frontier estimation: a robust approach. *Journal of Econometrics*, 106(1):1–25.

Chambers, R. G., Chung, Y., and Färe, R. (1998). Profit, directional distance functions, and nerlovian efficiency. *Journal of optimization theory and applications*, 98(2):351–364.

Daraio, C. and Simar, L. (2005). Introducing environmental variables in nonparametric frontier models: a probabilistic approach. *Journal of Productivity Analysis*, 24(1):93–121.

Daraio, C. and Simar, L. (2007a). *Advanced robust and nonparametric methods in efficiency analysis: Methodology and applications*. Springer Science & Business Media.

Daraio, C. and Simar, L. (2007b). Conditional nonparametric frontier models for convex and nonconvex technologies: a unifying approach. *Journal of Productivity Analysis*, 28(1-2):13–32.

Daraio, C. and Simar, L. (2024). Approximations and inference for envelopment estimators of production frontiers. *Journal of Productivity Analysis*, 62(2):197–215.

Daraio, C., Simar, L., and Wilson, P. W. (2020). Fast and efficient computation of directional distance estimators. *Annals of Operations Research*, 288(2):805–835.

Díaz-Martín, S., Feria-Dominguez, J. M., and Naranjo-Gil, D. (2022). Are microfinance institutions' financial performance gender driven? evidence from argentina. *Business Strategy & Development*, 5(3):197–208.

D'espallier, B., Guérin, I., and Mersland, R. (2011). Women and repayment in microfinance: A global analysis. *World development*, 39(5):758–772.

Ebissa, T. T. and Asfaw, A. S. (2024). Gender diversity and profit efficiency of microfinance institutions: A sub-saharan study. *Plos one*, 19(8):e0307758.

Fall, F. S., Tchakoute Tchuigoua, H., Vanhems, A., and Simar, L. (2023). Investigating the unobserved heterogeneity effect on outreach to women: lessons from microfinance institutions. *Annals of Operations Research*, pages 1–22.

Fall, F. S., Tchuigoua, H. T., Vanhems, A., and Simar, L. (2021). Gender effect on microfinance social efficiency: A robust nonparametric approach. *European Journal of Operational Research*, 295(2):744–757.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A (General)*, 120(3):253–281.

Fried, H. O., Lovell, C. K., and Schmidt, S. S. (2008). *The measurement of productive efficiency and productivity growth*. Oxford University Press.

Ghosh, C. and Guha, S. (2019). Role of gender on the performance of indian microfinance institutions. *Gender in Management: An International Journal*, 34(6):429–443.

Hartarska, V. (2005). Governance and performance of microfinance institutions in central and eastern europe and the newly independent states. *World development*, 33(10):1627–1643.

Hartarska, V., Nadolnyak, D., and Mersland, R. (2014). Are women better bankers to the poor? evidence from rural microfinance institutions. *American Journal of Agricultural Economics*, 96(5):1291–1306.

Hillman, A. J. and Dalziel, T. (2003). Boards of directors and firm performance: Integrating agency and resource dependence perspectives. *Academy of Management review*, 28(3):383–396.

Hossain, M. I., Mia, M. A., and Dalla Pellegrina, L. (2024). A systematic review of gender diversity and its impact on the performance of microfinance institutions. *Future Business Journal*, 10(1):9.

Jensen, M. C. and Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics*, 3(4):305–360.

Mersland, R. and Strøm, R. Ø. (2009). Performance and governance in microfinance institutions. *Journal of Banking & Finance*, 33(4):662–669.

Mirza, S. S., Majeed, M. A., and Ahsan, T. (2020). Board gender diversity, competitive pressure and investment efficiency in chinese private firms. *Eurasian Business Review*, 10(3):417–440.

Mori, N., Golesorkhi, S., Randoy, T., and Hermes, C. (2015). Board composition and outreach performance of microfinance institutions: Evidence from east africa. *Strategic Change*, 24(1):99–113.

Pal, D. and Mitra, S. K. (2018). The efficiency of microfinance institutions with problem loans: A directional distance function approach. *Computational and Mathematical Organization Theory*, 24(3):285–307.

Périlleux, A. and Szafarz, A. (2015). Women leaders and social performance: evidence from financial cooperatives in senegal. *World Development*, 74:437–452.

Pfeffer, J. and Salancik, G. (2015). External control of organizations—resource dependence perspective. In *Organizational behavior 2*, pages 355–370. Routledge.

Schreiner, M. (2002). Aspects of outreach: A framework for discussion of the social benefits of microfinance. *Journal of international development*, 14(5):591–603.

Simar, L. and Vanhems, A. (2012). Probabilistic characterization of directional distances and their robust versions. *Journal of Econometrics*, 166(2):342–354.

Simar, L. and Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*, 136(1):31–64.

Simar, L. and Wilson, P. W. (2023). Nonparametric, stochastic frontier models with multiple inputs and outputs. *Journal of Business & Economic Statistics*, 41(4):1391–1403.

Strøm, R. Ø., D'Espallier, B., and Mersland, R. (2014). Female leadership, performance, and governance in microfinance institutions. *Journal of Banking & Finance*, 42:60–75.

Tadele, H., Roberts, H., and Whiting, R. H. (2018). Microfinance institutions' transparency in sub-saharan africa. *Applied Economics*, 50(14):1601–1616.

van den Berg, M., Lensink, R., and Servin, R. (2015). Loan officers' gender and microfinance repayment rates. *The Journal of Development Studies*, 51(9):1241–1254.

Vishwakarma, R. (2017). Women on board and its impact on performance: Evidence from microfinance sector. *Indian Journal of Corporate Governance*, 10(1):58–73.

Wilson, P. W. (2018). Dimension reduction in nonparametric models of production. *European Journal of Operational Research*, 267(1):349–367.